Aalto University
School of Business

GENDER DIFFERENCES IN RECOGNITION OF COAUTHORED RESEARCH

Evidence from the Italian Academia

Master's Thesis
Claudia Troccoli
Aalto University School of Business
Economics

Spring 2017

Aalto University School of Business

Aalto University, P.O. BOX 11000, 00076 AALTO
www.aalto.fi

Abstract of master's thesis

Author Claudia Troccoli	
Title of thesis Gender Differences in Recognition of Coauthored Research. Evidence from the Italian Academia	
Degree Master of Science in Economics and Business Administration	
Degree programme Economics	
Thesis advisor Natalia Zinovyeva	
Year of approval 2017	**Number of pages** 51 **Language** English

Abstract

I use data from Italian National Qualification evaluations to analyse whether women and men receive differential credit for their coauthored work. National-level committees assess applicants' research quality, and a positive assessment is a requirement for promotion to associate and full professorship in Italian universities.

I find that, conditional on the candidates' individual characteristics and publications' average quality, the returns to an extra last- and middle-authored publication are, respectively, 35% and over 50% lower for women. On the other hand, I find no gender differences in the returns to single- and first-authored publications.

The evidence is consistent with the possibility that women are evaluated differently from men in the presence of information asymmetries and stereotypes.

Heterogeneity analysis reveals that gender differences in the attribution of credit for coauthored work emerge only in applications for associate professorship, where information asymmetries are larger. Moreover, stereotypes in science seem to penalise women when they undertake leadership roles as heads of labs, as women appear to suffer a last-authorship penalty in STEMM fields (science, technology, engineering, mathematics and medicine).

Additionally, using data on all publications in the Italian academia from the past twenty years, I explore whether observed coauthorship patterns are consistent with the possibility that women anticipate a coauthorship disadvantage. I find some support for the hypothesis that women might strategically engage in coauthorship in the presence of potential information asymmetries and stereotypes. In fact, in smaller fields, there are no gender differences in the propensity to coauthor, whereas in larger ones, women have fewer coauthors than men. In STEMM fields where authors are listed alphabetically, the gender difference in the share of female coauthors is consistently larger than in STEMM fields where authors are listed according to contribution.

Keywords economics, academic evaluations, coauthorship, gender discrimination, information asymmetries, stereotypes

In Loving Memory of my Mum

Contents

1. Introduction

Despite the increase in the past decades in the number of women that obtain university degrees and complete PhD programmes, the situation for women at the top ranks of the academic ladder has not been improving at the same pace. For example, in Italy, between 2005 and 2014, the share of women among full and associate professors has only risen from 17% to 21% and from 33% and 36%, respectively, whereas women made up 48% of PhD graduates in both years.[1]

Researchers have tried to explain the persistent underrepresentation of women in academia. Some have focused on providing supply-side explanations, that is, in identifying gender differences in productivity and efficiency, personality and behaviour.[2] Another strand of the literature tries to understand whether discrimination by those responsible for academic promotions is a potential reason for the observed slower career progress of women in academia (e.g. Bagues, Sylos-Labini and Zinovyeva, 2017; De Paola and Scoppa, 2015).

A recent paper belonging to the latter strand has suggested that information asymmetry plays a role in the less favourable promotion decisions to tenured positions for women and therefore in their slower career progress (Sarsons, 2017a; 2017b). When researchers collaborate on a project and there is no clear signal of who put the most effort or whether equal merit should be assigned to each author, men and women are treated differently, with women receiving less recognition for their coauthored research. Sarsons collected data on economists that entered tenure track positions in the top 30 PhD-granting institutions in the USA between 1975 and 2004 and found that, controlling for institution, subfield and differences in productivity, female researchers with coauthored papers were relatively less likely to be promoted to tenure, especially if they coauthored with men.

In this thesis, I test Sarsons's hypothesis that there are gender differences in the returns to single- and co-authored publications. I use a dataset of academic evaluations in Italy, the National Scientific Qualification, as used by Bagues et al. (2017). This nation-wide examination was

---

[1] http://www.istruzione.it/allegati/2016/Focus_Gender-Accademic_rev03.pdf

[2] For example, the productivity of female researchers might be negatively affected by the traditional family roles, according to which women take care of the household and the children (Ginther and Kahn, 2004; Krapf, Ursprung and Zimmermann, 2014). Devoting excessive time to non-promotable tasks and taking it away from research activity might also explain the lower promotion rates of women (Vesterlund, Babcock, Recalde and Weingart, 2015). There is also a number of personality and behavioural characteristics of women that might lower their chances of promotion. For example, some studies have found that women are simply less likely to apply for promotions (Bosquet, Combes and García-Peñalosa, 2013; De Paola, Ponzo and Scoppa, 2015).

introduced from 2012 as a screening device for aspiring associate and full professors to increase transparency in their promotion process and to limit previously widespread nepotism in universities.

Since these kinds of academic evaluations are based exclusively on research output, they are better suited to study promotion decisions and returns to publications, in comparison with actual promotions, as the latter may be based also on factors other than research skills, such as teaching quality and professional networks. I have access to the application package sent by the candidates (the academic CV with the publications) on which the evaluators based their decisions. I supplement this information with several quality measures of the publications.

A further advantage is that the data cover all academic disciplines and evaluations to different positions. This allows me to exploit fields' heterogeneity in terms of potential information asymmetries regarding candidates' quality and of potential stereotypes against women, and to explore whether information about candidates' quality is better for applicants to senior positions than for applicants to junior positions.

Information asymmetries might be larger in fields in which the tradition is to list publications' authors in alphabetical order rather than according to contribution. In such cases, in fact, it is difficult for those responsible for evaluations to assess the input of each author and the quality of the applicant, particularly if the committee members do not belong to the same research subfield as the candidate.

The variety of academic disciplines also permits to study whether stereotypes might explain why women are penalised for their coauthored research. The expectation is to observe a larger coauthorship penalty for women in scientific and in less feminised fields, where stereotypes against women might be stronger (Reuben, Sapienza and Zingales, 2014) and where evaluators might be less informed about the quality of female candidates.

I observe that publications' quantity, all quality indicators and individual characteristics are strongly correlated with success. Overall, there is evidence of coauthorship penalties for women, as found by Sarsons (2017a; 2017b). I differentiate coauthored publications depending on the position of the author because the returns might differ by academic discipline. For example, in many fields, first-authorship is a signal of a significant contribution into the publication. On the other hand, the last author position is prestigious only in labwork-intensive fields, where it is reserved for the head of the lab. Conditional on the candidates' individual characteristics and publications' average quality, women with the same number of last- and middle-authored publications are less likely to receive a positive evaluation, whereas I find no gender differences in the returns to single- and first-authored publications. Specifically, I find that, for women, the returns to an extra last- and middle-authored publication are, respectively, 35% and over 50% lower than for men.

Taken together, these results are consistent with the possibility that women are evaluated differently from men in the presence of information asymmetries and stereotypes. Heterogeneity analysis provides further evidence in support of this idea. In fact, for applicants to full professorship, there are no gender differences in the returns to all types of coauthored publications. On the other hand, gender differences are significant in the returns to different types of coauthored publications in evaluations to associate professorship: a slightly significant first-authorship premium (35%) and large and significant penalties for last- and middle-authorship (40% and almost 70%, respectively).

They are consistent with evaluators interpreting differently the signals provided by single- and co-authored publications of male and female candidates. They might place relatively more importance on the work single-authored by women because it is considered a clearer signal of their quality than a coauthored publication. Faced with the uncertainty regarding who contributed the most in the work, evaluators might assign less merit to the female coauthor, when she is listed as last or middle author. Conversely, they might consider a man's single- and co-authored publication to be equivalent in demonstrating the candidate's quality, because, in coauthored publications, they might assume that the major contribution was made by the male coauthor.

Unlike in Sarsons (2017a; 2017b), signalling author's contribution through the position in the list of authors does not seem to be associated with smaller penalties. I find gender differences in the returns to middle-authored publications in STEMM fields where authors are listed according to contribution. However, I find that no gender differences exist in the returns to all types of publications in STEMM fields with alphabetical norms. [3]

Finally, stereotypes in science seem to penalise women when they undertake leadership roles as heads of labs, as women appear to suffer a last-authorship penalty in scientific fields.

Additionally, I explore whether observed coauthorship patterns are consistent with the possibility that women anticipate a coauthorship disadvantage. In fact, even though collaboration might

[3] Throughout the text, I use the term "STEMM" to refer to science, technology, engineering, mathematics (STEM), with the addition of medicine.

increase the chances of producing a high-quality publication and in turn enhance the possibility of promotion, the researcher has to give up full credit for the publication without knowing how those responsible for promotions will attribute merit for the work. Following the adoption approach, we would expect that, if there were a coauthorship penalty for women and they were aware of it, more women would solo-author or coauthor only with their female colleagues.

I describe gender differences in coauthorship patterns by field, using a newly assembled dataset of all publications in the Italian academia from the past twenty years, IRIS. This more comprehensive dataset has one key advantage over the data from the National Scientific Evaluation. While the latter is a self-selected sample of researchers and associate professors that went up for evaluation, the former includes all university staff, from doctoral students to full professors. For this reason, it might shed more light on gender differences in the decisions to coauthor, the size of teams and their gender composition.

Overall, I find that women coauthor less (they have fewer coauthored publications and fewer coauthors on average) and have more female coauthors than men. However, the observed gender differences in coauthorship patterns are largely explained by gender segregation across academic fields. When even broad field controls are included, women appear to have a larger share of coauthored publications than men and, although they still have fewer coauthors, the size of the difference is substantially reduced. However, on the one hand, the inclusion of field controls helps clarify whether the observed gender differences are due to different authorship traditions within fields. On the other hand, it confounds potential gender sorting into fields and subfields that might be due exactly to different characteristics of the fields, in terms of potential information asymmetries and stereotypes.

The higher overall presence of men in academia implies that, in any given department, women have fewer potential female colleagues to collaborate with, in comparison with men. Therefore, I take account of the availability of female coauthors by controlling for the gender composition of the departments. I also exploit field heterogeneity to understand whether coauthorship decisions differ depending on the degree of potential information asymmetries and gender stereotypes.

Strikingly, when comparing tendency to coauthor with their female department colleagues, I find that women coauthor less with members of the same gender, even when controlling for the number of available male and female potential coauthors.

Heterogeneity analysis provides some support for the hypothesis that women might strategically engage in coauthorship in the presence of potential information asymmetries and stereotypes. In larger fields, they have fewer coauthors and more female coauthors than men, and relatively more with respect to women in smaller fields. In STEMM fields where authors are listed alphabetically, the gender difference in the share of female coauthors is consistently larger than in STEMM fields where authors are listed according to contribution. Finally, women in STEMM fields have more coauthored publications than their male peers, but significantly fewer coauthors, whereas women in humanities do not differ from men in their tendency to coauthor.

The remainder of this thesis proceeds as follows. Section 2 reviews the relevant literature on coauthorship patterns and returns to publications. In Section 3, I give an account of the Italian system of evaluations of prospective professors and of research quality at the university level. Section 4 describes the National Scientific Qualification dataset and the IRIS database of publications. In Section 5, I estimate gender differences in the returns to publications and explore whether coauthorship penalties for women emerge where potential information asymmetries and stereotypes are stronger. In Section 6, I describe gender differences in coauthorship patterns and analyse whether they differ depending on the characteristics of the fields. Finally, Section 7 concludes.

2. Literature review

Coauthorship is becoming increasingly more common, even in disciplines where single-authorship used to be the norm. Wuchty, Jones and Uzzi (2007) found that, between 1950 and 2000, the average number of authors per publication had been increasing over time in medicine, biology, physics, mathematics, psychology, engineering, social sciences, arts and humanities. They also found that teams play an increasingly important role in the production of high-quality research, in terms of citations.

The increase in the incidence of coauthorship was documented also in other disciplines, such as chemistry (Cronin, Shaw and La Barre, 2004), psychology and philosophy (Cronin, Shaw and La Barre, 2003), and biology, where it rose from around 30% in the 1950s to over 80% in the mid-1990s (Laband and Tollison, 2000).

In economics, coauthorship has been on the rise for many decades. In the 1950s, less than 10% of papers published in top journals were multi-authored. In 1993, this share had risen to around 45% (Hudson, 1996). Similar findings were made by Heck and Zaleski (1991), that analysed articles cited in the Journal of Economic Literature over the period 1969-89 and found that the share of coauthored ones had risen from 15% to 36%.

Analysing papers from thirteen social sciences journals between 1984 and 1994, Endersby (1996) found that the share of coauthored papers was around 50% and only around half of the papers in each journal followed an alphabetical listing of authors. The exception was in economics, where as much as 80% of the papers listed authors in alphabetical order.

Researchers have speculated on the reasons for the observed increase in coauthorship. According to Jones (2009), specialisation and teamwork are direct consequences of the progress of science. The cumulation of knowledge has made it increasingly difficult for an individual to master all the skills necessary to make their own contribution to science. For this reason, individuals tend to specialise and team up with others who have complementary skills, or similar skills to exploit synergies. The “division-of-labour” hypothesis is widely agreed upon (Barnett, Ault and Kaserman, 1988; McDowell and Melvin, 1983). For example, the development in econometric techniques and in statistical software that took place from the 1970s increased the possibilities of carrying out more comprehensive studies, but requires researchers with different skillsets to work together (Hudson, 1996). In fact, Laband and Tollison (2000) found that the incidence of coauthorship rises with the length of articles and with its quantitative content.

These hypotheses are consistent with Wuchty et al.'s (2007) finding that coauthored research receives more citations than single-authored publications and with Durden and Perri (1995), who found that coauthorship increased overall and per-capita research output.[4]

Durden and Perri (1995) also pointed out how the academic system of promotions of "publish or perish" could be linked with more widespread coauthorship, because coauthorship allows increasing individual researchers' annual publications count.

This observation would not be valid if the returns to coauthored publications were lower than single-authored publications, as found by Sauer (1988). In fact, estimating an earning function for academic economists, he found that the return to a coauthored paper is equally shared among the coauthors, so that for each coauthor it is equivalent to 1/n of a single-authored publication of comparable quality, if there are n coauthors. What would still remain to determine, however, would be whether it takes a researcher the same time to produce one single-authored paper and n coauthored publications with (n-1) coauthors. Hamermesh (2013) cast doubt on whether Sauer's finding would still be valid nowadays, proposing that one reason for coauthoring is that the returns to coauthored papers are in fact higher than of single-authored publications. This possibility is reinforced by a survey of university chairmen, from which it appeared that the weight given to coauthored publications was in fact higher than one over the number of authors (Liebowitz and Palmer, 1983 cited in Sauer, 1988).

The incentive structure of academia based on number of publications also increases the opportunity cost of time on reviewing colleagues' papers (Barnett et al., 1988; Hamermesh, 2013). In the past, department colleagues were available to extensively review manuscripts written by others for no reward other than a short mention at the bottom on the first page of the paper. Now, their time is limited, so they are willing to spend time on their colleagues' work only in exchange for being listed as coauthors.

---

[4] Benefits from scientific collaboration can accrue to the scientific community as whole, for example in the form of new ideas generated by the interaction with eminent scientists. Azoulay, Graff Zivin and Wang (2010) studied the effects of sudden deaths of superstar scientists on the research output of their collaborators and found a lasting reduction of 5-8% in their quality-adjusted publication rates. They attribute this effect to the "loss of an irreplaceable source of ideas" (p. 552). In fact, the effect is more consistent among coauthors that work on similar topics.
On the other hand, in a subsequent paper, Azoulay, Fons-Rosen and Graff Zivin (2015) find that, whereas the sudden deaths of a superstar scientist was detrimental to the productivity of close collaborators', outsiders could step in, bringing fresh ideas into the field.

It might also be that researchers, by maximising the number of papers produced over a period of time through coauthoring, could increase their chances of getting published, given the random component involved in journals' reviewing process (Barnett et al., 1988).

A further point to consider is that currently much of research funding is granted to teams rather than to individual researchers. For example, of the numerous EU funded research schemes, only a small proportion are destined for non-collaborative research, whereas the vast majority is reserved for projects whose partners come from at least three different countries (The Royal Society, 2016).

Next to explanations related to "optimal allocation of resources", coauthorship decisions might be determined by individual preferences and the availability of fruitful partnerships, which could also involve a "fun" component, mostly when the coauthor is based in a different city or even country (Hamermesh, 2013). In this respect, even the decrease in travel prices might have spurred the increase in long distance collaborations, together with the new technologies that made communication and data transmission easier (Hamermesh and Oster, 2002). However, Laband and Tollison (2000) found that female economists are less likely to engage in it. Boschini and Sjögren (2007) also found that all-female teams are more likely to be long-distance collaborations than are gender-mixed teams, suggesting that coordination costs might be larger for teams composed of males and females than for all women-teams.

Gender differences in coauthorship patterns have also been studied. Analysing articles published between 1991 and 2002 in three top economics journals, Boschini and Sjögren (2007) found that female economists tend to single-author significantly more than men. Exploiting the variation in the presence of women across subfields in economics, they found that, the higher the share of women in the subfield, the larger the difference between men and women in the propensity to form teams with other women. Hamermesh's (2013) findings were in line with Boschini and Sjögren's (2007). He found that women are less likely to coauthor and that, over the sixty years covered by the data, this tendency had not changed. On the other hand, McDowell, Singell and Stater (2006) found that, overall, women do not coauthor differently from men. Only when they publish in top journals, women tend to coauthor more than men, suggesting that coauthorship might represent a strategy to improve the quality of the paper when aiming to prestigious journals.

West et al. (2013) studied coauthorship trends in scientific fields, where the ordering of authors signals the relative contribution and is connected with returns to publications. They found that, in comparison with their representation within the respective field, women are not evenly represented across author positions. Before 1990, they were underrepresented among first authors. This gap shrunk subsequently, but a new gap in last-authorship opened. They speculate that one reason might be that men are more effective at negotiating their position in the list of authors, causing for example the underrepresentation of women in first-author positions.

According to McDowell and Smith (1992), same-sex coauthorship, particularly common in economics, explains the lower publishing rates of women, because they have fewer potential coauthors. This seems to explain also their finding that women self-select into larger departments. Most importantly, they find that no distinction is drawn between single- and co-authored publications when deciding over promotion and salaries. This contributes to women's lower promotion rates and slower career advancement, as they tend to have fewer publications in comparison with their male colleagues.

In this respect, a recent paper by Sarsons (2017a; 2017b) suggests that the returns to different types of publications might differ according to author's gender. Specifically, she claims that, when no information regarding the input of each author into a coauthored publication is conveyed, for example because authors are listed in alphabetical order, the work is mostly attributed to the male coauthor(s). Sarsons analyses promotions to tenure of a sample of economists that entered tenure-track positions in the top 30 PhD-granting universities in the USA between 1975 and 2004. She obtained directly from their CVs information on the publications, whether these were single- or co-authored and on the gender of the coauthors.

She finds that each solo-authored paper increases the probability of getting tenure by 7.5 p.p. for both male and female researchers, whereas the effect of an additional coauthored paper is 7.7 p.p. and 2 p.p. for men and women, respectively. Strikingly, if the coauthor is male, the marginal effect of an extra coauthored paper published by a woman is found to be almost zero. These results attracted a lot of media attention and the study was featured in The New York Times (Wolfers, 2016) and widely discussed in the social media.

Nevertheless, the study has a number of limitations. The sample size is rather small, with around 550 economists, of which less than a quarter are women, which means that the statistically significant effect found is extremely large.

Moreover, an arguably arbitrary rule was applied to decide whether professors were denied tenure when they moved to a lower-quality university. The schools were divided into groups of three equally ranked institutions, so that whenever a professor would move to a slightly lower-quality university, he or she would be classified as having been denied tenure.

Finally, to measure researchers' quality, Sarsons used citation counts and constructed an index based on the journals that published their research. All journals were assigned a score ranging between 1 and 86 according to the position in the RePEc/IDEAS ranking and the score obtained by each publication was added up. In this way, it is implied that, for example, two publications from the 43th-ranked journal are equivalent to one paper in the top journal. Given that a study using identification based on observables requires very good and reliable controls, the arbitrarily constructed quality measure reduces the credibility of the results.

3. Institutional background

3.1. Academic promotions in Italy

In Italy, before researchers and associate professors aspiring to move up the academic career ladder can apply for a professorship chair in an Italian university, they must participate in a country-level evaluation.

With the university reform passed at the end of 2010, the National Scientific Qualification (*Abilitazione Scientifica Nazionale*) was introduced in order to increase transparency in the promotion process to associate and full professorship in all academic fields, thanks to which it was hoped to reduce the high level of nepotism in many universities (De Paola and Scoppa, 2015). In fact, before the introduction of the reform, each university could independently hire professors, setting their own requisites that were frequently decided ad hoc to fit the CV of the preferred candidate. Academic and research qualities were often overlooked, in favour of family ties and seniority (Durante, Labartino and Perrotti, 2011). According to the new law, universities are still responsible for the recruitment of professors through a similar process, but an essential requirement is the success in the National Scientific Qualification.

Only full professors based in Italian and international universities can apply to serve as evaluators and are selected on the basis of their research output by ANVUR, the agency for the evaluation of the university system and research. They are randomly assigned to committees of five members that evaluate all applicants to both associate and full professors in the relevant academic field. Each committee is made up of one evaluator from a foreign university and four from Italian universities, with the requirement that at most one evaluator can come from each university.

In order to participate as candidates, researchers submit their CVs and publications, on which basis only the committee is to evaluate them. Additionally, ANVUR collects information on the average productivity of associate and full professors in each field in the previous ten years.[5]
The committee is then requested to take into account for the evaluation how the candidates' productivity in the previous ten years compares to such measures.

The final outcome is a pass or fail decision accompanied by five individual reports by each member of the committee, as well as a group report on the evaluation criteria and how these have been

[5] As measured by: number of articles published in scientific journals, number of citations and the H-index (for scientific fields); number of articles published in high-quality scientific journals, number of articles and book chapters and number of published books (for social sciences and humanities).

applied. The implication of a negative outcome is that the applicant cannot participate in subsequent evaluations for the following two years.

3.2. University funding

A further change brought about by the 2010 reform regards the incentive system to academic research at the university level. According to the law, funding to universities is partly attributed on the basis of their research output. 40% of the annual ministerial funds for universities are assigned depending on the periodical evaluations of research quality of the professors carried out by ANVUR on behalf of the Ministry of Education, Universities and Research.[6] In recent years, there have been two waves of evaluations of research quality (*VQR, Valutazione della Qualità della Ricerca*), one in 2011 and one currently ongoing, that covered research published in the period 2004-2010 and 2011-2014, respectively. For the VQR, ANVUR obtains information on the publications through the IRIS databases developed by CINECA, the agency in charge of collecting information on universities. These databases are constantly kept up-to-date by universities and research centres' research staff, from doctoral students to full professors, who are required to input their publications into their personal page. However, considering that that the introduction of the information system for the cataloguing of research dates to less than fifteen years ago and, for the purposes of the National Scientific Qualification, only research from the previous ten years counts for the measurement of the candidates' productivity, most researchers do not input all of their previous publications into the IRIS system.

Under this system, the incentives to produce research for academics are two-fold. Their research quality determines their chances to pass the National Scientific Qualification, and their research output, being directly linked with university funding, increases their possibilities of obtaining a promotion within the university.

[6] http://attiministeriali.miur.it/anno-2016/luglio/dm-06072016.aspx

4. Data

I use two sets of data from the Italian academia: information from the first edition of the National Scientific Qualification, as in the study by Bagues et al. (2017), and IRIS, a newly assembled dataset of all publications of the past twenty years in Italian universities. The former is used to study the returns to publications for male and female applicants and the latter to describe gender differences in authorship patterns in different academic fields. Additionally, I obtain information on the annual composition of each university department from the CINECA website, where information on the staff of 70 Italian universities and 6 research institutes, their sub-units, faculties and departments is collected on a yearly basis.[7]

4.1. National Scientific Qualification

4.1.1. The dataset

The dataset contains information on 69,020 applications to associate and full professorship in 184 academic disciplines (in Italian, *Settore Concorsuale, SC*), the gender composition of the evaluating committees and the outcome of the evaluations.

For each applicant, there is information on their gender, current position and academic subfield (in Italian, *Settore Scientifico Disciplinare, SSD*), and the academic discipline and position applied for. As for the research output, the total number of items in the CV (such as books, conference proceedings, book chapters, journal articles, patents) is included, as well as the number of journal articles and the share of single- and co-authored publications, that are further classified into first-, last- and middle-authored. The share of articles published in high-quality scientific journals and the Article Influence Score (AIS) measure the quality of publications. High-quality journals are classified separately for scientific fields and for humanities and social sciences. Q1-journals are the top-quartile journals in scientific fields according to Web of Science. For humanities and socials sciences, high-impact A-journals are defined by ANVUR, given that in many of these fields research is typically published in local Italian language journals that are not listed in Web of Science. For each applicant, there is also information on the average number of coauthors and female coauthors.

[7] See http://www.cineca.it/en/content/about-us for the list of members.

4.1.2. Descriptive statistics

Table 1 shows the outcome of the applications by gender and by position applied for. Most of the 69,020 applications in the dataset were submitted by men. Almost 10,000 were withdrawn before evaluation; of the remaining, 42.8% were successful. Compared to men, more women withdrew their application (16.7% vs. 12.8%). Their success rate was also lower, with 41.4% of the applications that were not withdrawn receiving a positive evaluation, as compared to 43.7% of men's. Female applicants to full professorship withdrew relatively more often than men, in comparison with female applicants to associate professorship. On the other hand, the gender difference in the rate of success is smaller and less significant among applicants to full professorship than to associate professorship.

For the analysis, I use the subsample of applicants that did not withdraw from the evaluation.

Table 1 – Applications

	Number of applications	Withdrawals	Conditional Success
All	69020	0.143	0.428
Male	42745	0.128	0.437
Female	26275	0.167	0.414
p-value		0.000	0.000
Associate professorship			
All	47426	0.134	0.427
Male	27780	0.118	0.437
Female	19646	0.155	0.412
p-value		0.000	0.000
Full professorship			
All	21594	0.164	0.432
Male	14965	0.147	0.437
Female	6629	0.202	0.421
p-value		0.000	0.053

Notes: the table shows the total number of applications and the share of withdrawals, by position applied for and by gender. The rate of conditional success is calculated over the non-withdrawn applications. The last row of each panel shows the p-value of a t-test of difference in means between male and female candidates.

Table 2 describes the CVs of candidates that proceeded to the evaluation stage by gender and by position applied for. The values are standardised among the applicants to each position and field to have zero mean and unit standard deviation. The average standard deviation of each pool of applicants is also shown in the table. Overall, female candidates have weaker CVs in comparison with male applicants participating in the same evaluation: they publish less and especially fewer journal articles. Only for what concerns middle-authored publications, they do better than their male peers. In their first-authored publications, they have a higher number of coauthors, whereas their last-authored publications have on average fewer authors than men's. In all kinds of publications, they have a larger share of female coauthors than men.

To measure publications' quality, I use the share of articles published in A-journals and in Q-journals out of all journal articles, the AIS and the share of journal articles out of all publications.[8] Male applicants' publications are generally better than women, except for humanities and social sciences. In these fields, there are no gender differences in the proportion of articles published in A-journals. Female applicants to associate professorship have even a higher share of single-authored A articles. On the other hand, in scientific fields, female applicants to associate professorship have a lower share of single- and middle-authored Q1 articles, whereas all coauthored publications of female candidates to full professorship are less often published in Q1-journals. In comparison with men, the average AIS of female candidates and their share of articles out of all publications are always lower.

[8] In the main analysis, I create the variable Cat1, that combines A articles and Q1 articles, providing comparable metrics for candidates in scientific fields and in humanities and social sciences.

Table 2 – Applicants' CVs

	All non-withdrawn applicants					Applicants for associate professorship				Applicants for full professorship			
	Mean	SD	Male	Female	p-value	Mean	Male	Female	p-value	Mean	Male	Female	p-value
Research experience	15.68	6.47	-0.01	0.01	0.03	13.81	-0.001	0.002	0.76	19.95	-0.02	0.04	0.00
# Publications	66.72	49.80	0.04	-0.06	0.00	54.88	0.04	-0.06	0.00	93.66	0.03	-0.08	0.00
# Journal articles	39.12	30.80	0.06	-0.10	0.00	31.28	0.06	-0.09	0.00	56.96	0.05	-0.12	0.00
# Single-authored Publications	16.45	19.33	0.06	-0.10	0.00	14.04	0.06	-0.09	0.00	21.95	0.04	-0.11	0.00
# First-authored Publications	14.70	15.74	0.02	-0.04	0.00	12.01	0.02	-0.03	0.00	20.82	0.02	-0.05	0.00
# Last-authored Publications	8.95	11.96	0.03	-0.04	0.00	6.17	0.03	-0.04	0.00	15.27	0.02	-0.06	0.00
# Middle-authored Publications	26.66	22.32	-0.01	0.02	0.00	22.70	-0.01	0.02	0.01	35.66	-0.01	0.01	0.23
% A articles (Single-authored)	0.28	0.28	-0.02	0.03	0.00	0.27	-0.03	0.04	0.00	0.30	-0.01	0.02	0.19
% A articles (First-authored)	0.28	0.35	0.01	-0.01	0.40	0.26	0.01	-0.01	0.61	0.30	0.01	-0.02	0.46
% A articles (Last-authored)	0.28	0.35	0.02	-0.04	0.02	0.27	0.01	-0.01	0.42	0.30	0.04	-0.09	0.00
% A articles (Middle-authored)	0.29	0.37	-0.01	0.01	0.53	0.28	0.00	0.00	0.99	0.33	-0.02	0.04	0.26
% Q1 articles (Single-authored)	0.41	0.38	0.01	-0.02	0.12	0.40	0.02	-0.04	0.01	0.43	-0.003	0.01	0.59
% Q1 articles (First-authored)	0.48	0.30	0.01	-0.03	0.00	0.48	0.01	-0.01	0.16	0.48	0.02	-0.07	0.00
% Q1 articles (Last-authored)	0.46	0.33	0.01	-0.02	0.04	0.45	0.00	-0.01	0.38	0.47	0.01	-0.04	0.02
% Q1 articles (Middle-authored)	0.51	0.25	0.01	-0.03	0.00	0.51	0.01	-0.02	0.04	0.52	0.02	-0.06	0.00
AIS (Single-authored)	1.23	1.36	0.01	-0.03	0.02	1.20	0.01	-0.03	0.06	1.26	0.01	-0.03	0.19
AIS (First-authored)	1.28	0.95	0.04	-0.07	0.00	1.26	0.04	-0.06	0.00	1.32	0.04	-0.12	0.00
AIS (Last-authored)	1.18	1.00	0.02	-0.05	0.00	1.15	0.03	-0.05	0.00	1.23	0.02	-0.06	0.00
AIS (Middle-authored)	1.39	0.91	0.03	-0.05	0.00	1.38	0.03	-0.04	0.00	1.40	0.03	-0.07	0.00

# Coauthors per Pub. (First-authored)	4.57	2.13	-0.02	0.04	0.00	4.65	-0.03	0.04	0.00	4.40	-0.02	0.05	0.00
# Coauthors per Pub. (Last-authored)	4.19	1.97	0.01	-0.02	0.00	4.14	0.01	-0.02	0.01	4.28	0.01	-0.02	0.15
# Coauthors per Pub. (Middle-authored)	12.45	12.81	-0.003	0.005	0.47	12.30	-0.01	0.01	0.26	12.77	0.002	-0.01	0.66
% Female Coauthors (First-authored)	0.28	0.26	-0.07	0.12	0.00	0.28	-0.07	0.11	0.00	0.27	-0.06	0.14	0.00
% Female Coauthors (Last-authored)	0.28	0.28	-0.05	0.10	0.00	0.29	-0.06	0.10	0.00	0.28	-0.04	0.11	0.00
% Female Coauthors (Middle-authored)	0.28	0.20	-0.07	0.12	0.00	0.29	-0.07	0.11	0.00	0.27	-0.05	0.14	0.00
% Articles (Single-authored)	0.44	0.30	0.05	-0.09	0.00	0.43	0.05	-0.08	0.00	0.47	0.05	-0.13	0.00
% Articles (First-authored)	0.55	0.27	0.03	-0.05	0.00	0.54	0.04	-0.05	0.00	0.57	0.02	-0.05	0.00
% Articles (Last-authored)	0.55	0.30	0.04	-0.08	0.00	0.53	0.04	-0.07	0.00	0.58	0.04	-0.11	0.00
% Articles (Middle-authored)	0.63	0.25	0.03	-0.05	0.00	0.62	0.03	-0.04	0.00	0.64	0.03	-0.09	0.00
Qualified	0.43	0.49	0.44	0.41	0.00	0.43	0.44	0.41	0.00	0.43	0.44	0.42	0.05

Notes: the table provides information on the CVs of applicants that did not withdraw from the evaluation and the p-value of a t-test of difference in means between male and female applicants, in the full sample and by position applied for. Each variable is standardised to have zero mean and unit standard deviation for the non-withdrawn applicants to each position and field. The means and the standard deviations of each applicants' pool before standardization are averaged and shown in the columns *Mean* and *SD*. *Research experience* indicates the number of years since the first publication. *First-authored Publications*, *Last-authored Publications* and *Middle-authored Publications* are all coauthored publications in which the applicant is listed as first, last or middle author, respectively. *% A articles* and *% Q1 articles* indicate the share of journal articles published in high-quality journals for humanities and scientific fields, respectively. *AIS* is the average Article Influence Score. *# Coauthors per Publication* is the average number of coauthors over all publications in the relevant group. *% Female Coauthors* is calculated over all publications in the corresponding group: total number of female coauthors over total number of coauthors. *% Articles* is the share of journal articles over all publications.

4.2. IRIS

4.2.1. The dataset

Currently, five research institutes and 60 universities use IRIS (Institutional Research Information System) for the collection and cataloguing of research. Each university has its own portal, which, in most cases, is publicly accessible on the internet. The main data were scraped from each of the 56 universities' and three research institutes' websites using ScreenScraper.[9] All authors are requested to insert into this database detailed bibliographic information on their publications, including title and year, name of coauthors, type of publication and details on the publication outlet.[10]

Identification of gender was done using the first name, since Italian names are always clearly either male or female. For foreign names, it was in some cases not possible to identify the gender with certainty and therefore these observations were dropped.

There is a problem with identifying coauthors' gender, because in most cases their first names are not included, but only the initials are mentioned. When coauthors are from the same university, identification is still done using the publication number. However, with external coauthors, this is not possible, because the publication number does not univocally identify publications in all universities' portals.[11] For this reason, the gender of coauthors is only observed for university colleagues.

Furthermore, I accessed data from the CINECA website, which contains the lists of Italian universities' academic staff by university department and year and has information on gender, position, academic recruitment field (*settore concorsuale, SC*) and academic discipline (*settore scientifico disciplinare, SSD*).[12] It includes fewer individuals than the IRIS database, as only academics holding research contracts or professorships are listed.[13] Due to the large number of

---

[9] The portals were accessed during the summer of 2016. For the list of institutes using IRIS, see https://wiki.u-gov.it/confluence/pages/releaseview.action?pageId=67639048. Institutes excluded were: Bologna, Enna, Cattolica di Milano, Museo delle Scienze and Mach.
[10] Types of publications are: journal article, book chapter, conference proceeding, monography, book as editor, patent, doctoral dissertation, etc. …
[11] Ideally, identification would be possible using publication's title, but even small differences in the way it is written by different authors would prevent it. It would be impossible also if the coauthors were not in an Italian university.
[12] Positions include: Full professor, Associate professor, Assistant Professor and Researcher.
See http://attiministeriali.miur.it/media/265763/allegato_d.pdf for the complete list of classification of fields.
[13] The IRIS data includes also PhD students and post-doctoral students, as well as researchers and professors.

individual SCs and SSDs, I create a broader classification for fields, containing sixteen disciplines. Throughout the text, I refer to them with the term "area".[14]

4.2.2. Descriptive statistics

The dataset consists of over four and a half million observations, which correspond to almost three million publications, since each publication appears as many times as the number of authors from the same university.

Slightly more than 15% of the publications are published before 1995. The average publication has 7 authors, of which 1.7 from the same university; in coauthored publications, the share of women among internal authors is 30%.

As in the National Scientific Qualification database, I observe that women are less productive than men, with 4.5 publications annually, whereas men publish on average 5.3 per year (Table 3). Women coauthor less than men and they also coauthor less with academics from different universities. Their average publication has fewer coauthors overall, especially from other universities. The share of females out of internal coauthors is 46% in women's publications and 32% in men's.

Table 3 – Publications by gender

	Mean	Standard Deviation	Male	Female	p-value
# publications	5.07	5.23	5.36	4.53	0.00
% coauthored publications	0.71	0.42	0.73	0.67	0.00
% inter-university publications	0.55	0.42	0.56	0.52	0.00
# coauthors per publication	4.84	0.05	5.37	3.82	0.00
# internal coauthors per publication	1.35	1.64	1.33	1.39	0.00
# external coauthors per publication	3.48	0.05	4.04	2.43	0.00
% females in coauthored publications	0.37	0.35	0.32	0.46	0.00

Notes: the table shows information about publications by male and female university staff in Italian universities in an average year. Gender differences are shown with a p-value of a t-test of difference in means. *% inter-university publications* refer to publications in which at least one coauthor comes from a different university (*external coauthors*). *Internal coauthors* are coauthors from the same university.

[14] The areas correspond roughly to the 14 academic recruitment fields, with the only difference that Architecture is separate from Civil Engineering and Psychology is separate from History, Philosophy and Pedagogy, due to key differences between the fields.

There are large differences across fields. For the empirical analysis, I use the subset of 1.5 million publications for which information on the academic field is available. As can be seen from Table 4, STEMM fields have the highest number of authors per publication: chemistry, biology and medicine have between 6 and 8 authors. Physics is an outlier, with on average 68 authors per publication. This is probably driven by physicists involved in projects in very large research centres (e.g. CERN). In fact, the publication with the largest number of authors lists almost 5000 names. However, the median number of authors in physics is 5. In humanities and social sciences, single-authorship is more common and the average number of authors approaches unity (law studies, history, arts and languages, sociology and architecture).

Feminisation of the field ranges from 14% in industrial engineering to 54% in psychology. The share of coauthored publications in which coauthors are of different gender is reported. Despite the relatively large presence of women, a very small proportion of publications is coauthored by men and women in arts and languages, history, law and sociology. Preference for same-sex collaborations seems to exist also in economics and business, mathematics and psychology.

Table 4 – Publications by area

Discipline	# scholars	% women	# publications	% coauthored publications	% coauthored publications (mixed gender)	# authors per publication	# authors in coauthored publications	% females in coauthored publications
Architecture	3267	0.32	75968	0.25	0.26	1.49	2.99	0.38
Arts and Languages	8718	0.55	157084	0.13	0.14	1.27	3.04	0.49
Biology	7303	0.49	103542	0.92	0.38	6.21	6.67	0.45
Chemistry	4360	0.39	71134	0.94	0.43	6.07	6.41	0.38
Civil Engineering	2298	0.19	44089	0.85	0.22	3.22	3.61	0.19
Economics and Business	7153	0.33	100320	0.59	0.18	3.06	4.49	0.34
Geosciences	1749	0.24	36746	0.91	0.23	4.84	5.24	0.28
History	5645	0.39	111478	0.13	0.15	1.34	3.59	0.37
Industrial Engineering	7136	0.14	152617	0.91	0.20	5.08	5.48	0.15
Law	7236	0.34	128856	0.09	0.15	1.18	3.09	0.28
Mathematics	4504	0.33	61660	0.81	0.16	3.24	3.76	0.28
Medicine	15477	0.28	256974	0.91	0.28	7.83	8.53	0.27
Physics	3750	0.18	68019	0.92	0.23	68.43	74.02	0.17
Psychology	1895	0.54	37074	0.77	0.23	3.20	3.85	0.55
Sociology	2712	0.35	45342	0.20	0.13	1.35	2.76	0.35
Veterinary	4248	0.32	70800	0.86	0.37	4.54	5.13	0.35

Notes: the table shows characteristics of each field and the publications in the dataset for which field is known. *# scholars* and *% women* consider only researchers and professors from the CINECA data (from researchers to full professors). *% coauthored publications (mixed gender)* is the share of coauthored publications in which there is at least one male and one female author. *# authors per publication* is an average calculated including single-authored publications.

5. Returns and penalties to coauthored publications

Using data from the first edition of the National Scientific Qualification, I test Sarsons's (2017a; 2017b) hypothesis that, in comparison with men, female researchers are attributed a minor share of the work when they coauthor.

5.1. Empirical strategy

I follow an empirical strategy of identification based on observables. I compare the gender differences in the returns to single- and co-authored publications. In order to interpret the estimates as causal effects, the conditional independence assumption needs be satisfied. That is, I have to assume that male and female candidates' publications are equal in every aspect, apart from the author's gender. To get as close as possible to being able to interpret the results as the effect of gender, I have to control for as many observable characteristics of candidates and publications as possible. Without good controls on the quality of the publications, I would not be able to exclude that the gender differences observed in the returns to publications are due to lower quality of the female applicants and their research. The information contained in the National Scientific Qualification dataset allows me to control for a large number of measures of publications' quality.

Moreover, by limiting the analysis to the candidates who proceeded to the evaluation stage, I try to avoid selection bias due to lower quality or under confident candidates, especially women, who withdrew from the evaluation.

I estimate the gender differences in the returns to all types of publications according to authorship, in terms of probability of obtaining a positive evaluation, conditional on the researchers' characteristics and publications' quality. The observable characteristics include the research experience, as measured by the number of years since the first publication, and the position held at the time of the exam in an Italian university (if any). As quality controls, I use the share of journal articles out of all the publications and the share of high-quality Cat1 articles out of all journal articles. I also control for the number of coauthors, the share of female coauthors and the average publication date. [15] All information on publications' characteristics is separate for single-, first-, last- and middle-authored publications.

---

[15] In many fields, journal articles are more valuable than other types of publications. As explained in section 4.1, the variable Cat1 combines A articles and Q1 articles, providing comparable metrics for candidates in scientific fields and in humanities and social sciences. Average publication date indicates how prolific the candidate has been recently.

I estimate the following regression using the linear probability model:

$$Y_{ie} = \beta_0 + \beta_1 Female + \beta_2 SP_i + \beta_3 FP_i + \beta_4 LP_i + \beta_5 MP_i + \mathrm{X_i}\beta_6 + \mathrm{Z_i}\beta_7 + \mu_e + \epsilon_{ie} \quad (1)$$

where Y_{ie} is a dummy variable that takes value of one if candidate i receives a positive evaluation in exam e and zero in case of a negative outcome. *Female* is a dummy variable that takes value one if the applicant is a woman, and zero if it is a man. SP_i is the number of single-authored publications. FP_i and LP_i are the numbers of coauthored publications in which the candidate is listed as first and last author, respectively. MP_i is the number of coauthored publications in which the candidate is listed as neither first nor last author. X_i is a vector of individual characteristics, including research experience (the number of years since the first publication) and current position. Z_i is a vector of the publications' quality controls listed above. In order to take into account field differences in the average research output and publication norms, I standardise each variable at the level of the applicants to each position and field (the participants to each exam). I include exam dummies (μ_e) and I cluster standard errors at the committee level.

I gradually include publications' quality controls to observe whether the previously estimated coefficients on publications' quantity remain stable, which signals that there is limited omitted variable bias, as in Oster (2016).

Conditional on the researchers' individual characteristics and publications' quality, the estimated coefficients β_2, β_3, β_4, and β_5 indicate the returns to the corresponding type of publication. Specifically, they measure the effect of an increase of one standard deviation in the number of the corresponding type of publication from the mean of the reference group, i.e. the pool of applicants to the same field and position.

I then investigate whether the returns to different publications, conditional on the researchers' individual characteristics and publications' quality, vary by gender.

$$Y_{ie} = \beta_0 + \beta_1 Female + \beta_2 SP_i + \beta_3 Female_i * SP_i + \beta_4 FP_i + \beta_5 Female_i * FP_i + \beta_6 LP_i + \beta_7 Female_i * LP_i + \beta_8 MP_i + \beta_9 Female_i * MP_i + \mathrm{X_i}\beta_{10} + \mathrm{Z_i}\beta_{11} + \mu_e + \epsilon_{ie} \quad (2)$$

The estimated coefficients β_3, β_5, β_7, and β_9 indicate the gender difference in the returns to the corresponding publications, with respect to the return for men (measured by coefficients β_2, β_4, β_6, and β_8).

I complete the analysis by considering whether the evidence is consistent with potential information asymmetries and stereotypes affecting gender differences in the attribution of merit for coauthored publications. I exploit fields' heterogeneity to analyse whether penalty for coauthored work is more common among female applicants to associate professorship, in fields where the publications' authors are listed in alphabetical order rather than in order of contribution, and in STEMM fields.

5.2. Main results

In columns 1-4 of Table 5, I estimate equation (1), starting from controlling only for candidates' individual characteristics, and then gradually adding more publication quality controls.

On average, there is a statistically insignificant difference of 1 percentage point (p.p.) in the success rate of men and women (column 1). Applicants with similar publications records who have been longer in the profession are promoted at lower rates compared to those that have been doing research for a shorter time. This may indicate that evaluators give more credit to more productive candidates. Compared to applicants not affiliated to any university at the time of evaluation, researchers and associate professors are 22 p.p. and 32.2 p.p. more likely to qualify, respectively. The number of publications is significantly associated with a positive evaluation.

The coefficients in Table 5 indicate the effect of an increase of one standard deviation in the number of publications from the mean of the reference group. For example, an increase of one standard deviation in the number of single-authored publications from the mean of the pool of applicants to the same field and position is associated with a 1.7 p.p. increase in the probability of a positive evaluation. From this the returns to each single-authored publication can be calculated as 0.09 p.p.[16] In comparison, the returns to coauthored publications are higher, both considering the effect of a standard deviation and individual publications. The returns to an extra first-, last- and middle-authored publication are, respectively, 0.21 p.p., 0.34 p.p. and 0.13 p.p.

Results in column 1 might be confounded by the fact that single- and co-authored papers provide different signals regarding authors' quality. For instance, in some fields, the most influential studies are conducted in teams. In these fields, an extra coauthored publication, especially if first- or last-authored, might for this reason be a better signal of the researcher's abilities, in comparison with a single-authored one. Even being invited to participate in research teams (as a middle author) might be an indicator of the researcher's skills.

In column 2, I control also for the quality of each type of publication, in terms of the share of articles published in high-quality journals. All quality controls, particularly of single-authored

[16] The value of 0.09 is obtained by dividing the coefficient of 1.7 from Table 5 by the standard deviation indicated in Table 2 (19.33).

publications, are positively correlated with success. The goodness-of-fit of the regression increases from 0.185 to 0.211. With the addition of controls for the publications' quality, the estimated returns to quantity do not change. Taken together, it appears that the number of single-authored publications is not particularly valued, but their quality is regarded as more important relative to the quality of coauthored publications. The number of first- and last-authored publications have the largest influence on the outcome of the evaluation, whereas middle-authored publications' quality and quantity have the smallest impact.

Table 5 – Determinants of success

	(1)	(2)	(3)	(4)	(5)
Female	-0.010	-0.007	-0.000	-0.000	0.008
	(0.007)	(0.006)	(0.008)	(0.008)	(0.008)
Research experience	-0.026***	-0.019***	0.007	0.010	0.010
	(0.005)	(0.004)	(0.008)	(0.008)	(0.008)
Researcher	0.219***	0.220***	0.179***	0.175***	0.175***
	(0.011)	(0.011)	(0.014)	(0.013)	(0.013)
Associate Professor	0.322***	0.329***	0.323***	0.318***	0.318***
	(0.021)	(0.020)	(0.023)	(0.023)	(0.023)
Single-authored	0.017***	0.019***	0.004	0.003	0.002
	(0.005)	(0.005)	(0.004)	(0.004)	(0.004)
Female*Single-authored					0.004
					(0.007)
First-authored	0.033***	0.040***	0.033***	0.032***	0.031***
	(0.004)	(0.003)	(0.004)	(0.004)	(0.004)
Female*First-authored					0.007
					(0.007)
Last-authored	0.041***	0.043***	0.040***	0.039***	0.044***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.005)
Female*Last-authored					-0.015**
					(0.006)
Middle-authored	0.029***	0.029***	0.020***	0.024***	0.031***
	(0.005)	(0.005)	(0.006)	(0.005)	(0.006)
Female*Middle-authored					-0.016**
					(0.007)
Share Cat1 Single-authored		0.054***	0.020***	0.021***	0.021***
		(0.006)	(0.006)	(0.006)	(0.006)
Share Cat1 First-authored		0.041***	0.041***	0.041***	0.040***
		(0.004)	(0.005)	(0.005)	(0.005)
Share Cat1 Last-authored		0.034***	0.032***	0.033***	0.033***

		(0.004)	(0.004)	(0.004)	(0.004)
Share Cat1 Middle-authored		0.033***	0.031***	0.033***	0.033***
		(0.005)	(0.005)	(0.005)	(0.005)
Share Articles Single-authored			0.016***	0.016***	0.016***
			(0.004)	(0.004)	(0.004)
Share Articles First-authored			0.026***	0.026***	0.026***
			(0.005)	(0.005)	(0.005)
Share Articles Last-authored			0.015***	0.016***	0.016***
			(0.004)	(0.004)	(0.004)
Share Articles Middle-authored			0.018***	0.021***	0.021***
			(0.005)	(0.005)	(0.005)
Year Single-authored			0.005	0.005	0.005
			(0.004)	(0.004)	(0.004)
Year First-authored			0.011**	0.012**	0.012**
			(0.005)	(0.005)	(0.005)
Year Last-authored			0.031***	0.034***	0.034***
			(0.005)	(0.005)	(0.005)
Year Middle-authored			0.035***	0.038***	0.038***
			(0.005)	(0.005)	(0.005)
Avg. Number of Coauthors First-authored				-0.004	-0.004
				(0.004)	(0.004)
Avg. Number of Coauthors Last-authored				-0.010**	-0.010**
				(0.004)	(0.004)
Avg. Number of Coauthors Middle-authored				-0.017***	-0.018***
				(0.005)	(0.005)
Constant	0.297***	0.294***	0.347***	0.347***	0.345***
	(0.008)	(0.008)	(0.010)	(0.010)	(0.010)
Observations	59,150	59,150	23,477	23,477	23,477
Adj. R-squared	0.185	0.211	0.209	0.211	0.212

Notes: OLS estimates. The sample includes all applicants that did not withdraw their application before the evaluation stage. The dependent variable is a dummy variable that takes value one if the candidate receives a positive evaluation. Each coefficient corresponds to an independent regression. All variables are standardised to have zero mean and unit standard deviation for the non-withdrawn applicants to each position and field. *Research experience* indicates the number of years since the first publication. *Researcher* and *Associate Professor* take value one if the applicant already holds either position in an Italian university. *First-authored*, *Last-authored* and *Middle-authored* are all coauthored publications in which the applicant is listed as first, last or middle author, respectively. *Share Cat1* is the share of articles published in high-quality journals. *Share Articles* is the share of journal articles out of all publications. *Year* is the average publication time of each type of publication. All regressions include exam dummies and standard errors are clustered at the committee level (applications to both associate and full professorship in each field). Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

In column 3, I include the share of journal articles out of all types of publications and the average publication date. The coefficient on the number of single-authored publications becomes insignificant, whereas it remains significant and relatively stable for coauthored publications. The coefficients on the two characteristics of publications are highly significant. As for the publication year, the coefficients on coauthored publications are highly significant and indicate that recent publications are valued more than recent ones. Instead, the publication date of single-authored publications is not significant. Taken together with the coefficients on quantity and quality, it is consistent with the idea that a small number of single-authored publications of high quality is important towards the evaluation to signal the researcher's quality, regardless of the publication date. Any additional single-authored publication does not particularly increase the candidate's chances of a positive evaluation.

In column 4, I also control for the average number of coauthors in coauthored publications. The coefficients on the other controls remain mainly unaltered and the R-squared increases to 0.211. For first-authored publications, the number of coauthors does not have a significant effect on the returns to the publication. However, for last- and middle-authored publications, a higher number of coauthors reduces the returns to the publication.

Finally, I estimate equation (2), allowing the impact of the quantity of publications to vary by gender. There are insignificant single-authorship and first-authorship premia for women. As for last-authored publications, there is a significant penalty. An increase of one standard deviation in the number of last-authored publications is associated with a 4.4. p.p. increase in the probability of a positive evaluation for men, but 2.9 p.p. for women.[17]

In middle-authored publications, we also observe a penalty for female applicants, which is even larger than in last-authored publications. Women have to publish twice as many middle-authored publications to increase their chances of a positive evaluation by the same amount as men.

Taken together, these results are consistent with the possibility that women are evaluated differently from men in the absence of clear information about the contribution of the applicant into a specific publication. In fact, there are no gender differences in the returns to single- and first-authored publications. On the other hand, we see a penalty in the case of middle-authored publications, where there is no information on the contribution. As for last-authored publications, they have different value according to the field. In many scientific disciplines, the last position in

[17] Dividing the estimated coefficients by the standard deviations in Table 2, the returns to one extra last-authored publication are 0.37 p.p. for men and 0.24 p.p. for women.

the list of authors in a publication is reserved for the head of the lab. In other fields where authors are listed according to contribution, being last author (mainly in publications with more than two authors) means that little input was put in the work. Finally, in fields where authors are listed alphabetically, being last author is as weak a signal of the contribution as it is in the case of middle-authored publications. Therefore, the interpretation of the estimated coefficient is not straightforward. If the effect were driven by evaluations in scientific fields, however, it would suggest that women might be valued less than their male peers for their leadership position as head of the lab.

5.3. Heterogeneity analysis

I exploit field heterogeneity to investigate whether information asymmetries or stereotypes against women might affect the differential returns to coauthored work. I divide the sample in different subsamples, in which theoretically information asymmetries regarding candidates' quality and stereotypes against women may be stronger. I estimate equation (2) in each subsample and compare the estimated returns to publications for men and women.

5.3.1. Information asymmetries

I consider separately candidates that apply for the positions of associate and full professor. There should be greater information asymmetries for applicants to associate professorship, in comparison to full professorship, because of their shorter career and smaller research output. Conversely, aspiring full professors have had more occasions to prove their quality in the past. Therefore, we would expect to see larger gender differences in the returns to coauthored publications in evaluations to associate professorship, if gender differences in the attribution of merit for coauthored publications are to be ascribed to information asymmetries.

The results are consistent with expectations. Columns 1 and 2 of Table 6 show that there is a statistically significant single-authorship premium for women at the level of full professors. However, the coefficient on the returns to single-authored publications is not statistically significant. For applicants to full professorship, the coefficients on all the interacted terms for coauthored publications are not statistically significant. On the other hand, in evaluations to associate professorship, there are significant gender differences in the returns to different types of coauthored publications. Female applicants receive a 40% last-authorship penalty and a 70% middle-authorship penalty. Faced with the uncertainty regarding who contributed the most in the work, evaluators might assign less merit to the female coauthor, when she is listed as last or middle author. On the other hand, female candidates receive a 50% first-authorship premium.[18] It may be that evaluators place relatively more importance on the work single-authored by a woman, because they consider it a clearer signal of their quality, compared to work single-authored by a man.

Additionally, it is also interesting to notice how the quality of different types of publications is valued differently at the two levels. While good quality single-authored and first-authored publications are equally important for applicants to both positions, last-authored publications are relatively more important for aspiring full professors, whereas middle-authored ones are relatively less important, compared to applicants for associate professorship.[19] In the instance of scientific fields, this is consistent with the idea that, in order to qualify as full professors, the candidate is valued more for his or her position as head of the lab.

---

[18] For example, an extra last-authored publication increases the chances of a positive evaluation by 0.48 p.p. for a man and 0.3 p.p. for a woman. The effects are calculated by dividing the estimated coefficients by the corresponding standard deviations listed in table A.1. in the appendix.

[19] The coefficients on Share Cat1 Last-authored are 0.029 for applicants to associate professorship and 0.038 for applicants to full professorship. Conversely, for Share Cat1 Middle-authored, the coefficients are 0.037 and 0.025. For Share Cat1 Single-authored and First-authored, they are 0.019 and 00.022, and 0.040 and 0.041, respectively for applicants to associate and full professorship. The corresponding standard deviations are similar for both groups.

Table 6 – Returns to publications by Position and by Norms of listing authors

	(1)	(2)	(3)	(4)	(5)
	Position		**Norms of listing authors in STEMM fields**		
	Associate professorship	Full professorship	by Contribution	Mixed	Alphabetical
Female	0.013	-0.002	-0.013	0.037**	-0.041
	(0.010)	(0.012)	(0.012)	(0.014)	(0.043)
Single-authored	0.005	-0.001	-0.003	-0.005	-0.039**
	(0.004)	(0.005)	(0.004)	(0.006)	(0.011)
Female*Single-authored	-0.005	0.026**	0.001	-0.011	0.025
	(0.008)	(0.012)	(0.010)	(0.016)	(0.015)
First-authored	0.030***	0.031***	0.029***	0.057***	0.061*
	(0.005)	(0.006)	(0.008)	(0.008)	(0.030)
Female*First-authored	0.016*	-0.019	0.021	-0.011	-0.039
	(0.009)	(0.012)	(0.014)	(0.014)	(0.038)
Last-authored	0.045***	0.040***	0.052***	0.057***	0.079**
	(0.005)	(0.007)	(0.007)	(0.009)	(0.024)
Female*Last-authored	-0.017**	-0.010	-0.005	-0.049***	-0.018
	(0.008)	(0.012)	(0.010)	(0.012)	(0.035)
Middle-authored	0.031***	0.030***	0.076***	0.063***	-0.023
	(0.006)	(0.008)	(0.010)	(0.009)	(0.022)
Female*Middle-authored	-0.021**	-0.007	-0.020*	0.000	0.040
	(0.008)	(0.012)	(0.011)	(0.014)	(0.030)
	(0.006)	(0.006)	(0.006)	(0.008)	(0.018)
Constant	0.376***	0.330***	0.419***	0.356***	0.300***
	(0.009)	(0.015)	(0.011)	(0.017)	(0.031)
Observations	13,922	9,555	9,504	6,984	1,357
R-squared	0.215	0.227	0.249	0.257	0.178

Notes: OLS estimates. The sample includes all applicants that did not withdraw their application before the evaluation stage. The dependent variable is a dummy variable that takes value one if the candidate receives a positive evaluation. Each coefficient corresponds to an independent regression. All variables are standardised to have zero mean and unit standard deviation for the non-withdrawn applicants to each position and field. *STEMM* corresponds to science, technology, engineering, mathematics and medicine. *Norms of listing authors* refer to the prevailing norm in the STEMM field: *Mixed* means that less than two-thirds of the publications followed either norm. *Alphabetical* include: Mathematics and Informatics. *By Contribution* include: Biology, Vet, Chemistry and Medicine. *First-authored*, *Last-authored* and *Middle-authored* are all coauthored publications in which the applicant is listed as first, last or middle author, respectively. All regressions include exam dummies, individual characteristics and publications' quality controls. Standard errors are clustered at the committee level (applications to both associate and full professorship in each field).
Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

A further aspect that might affect the size of information asymmetries is whether authors are listed in alphabetical order or according to contribution. In fields where the tradition is to list authors in order of contribution, we would expect no gender differences in the returns to different types of coauthored publications, particularly in first-authored publications and, to a lesser extent, in the returns to last-authored publications.[20] On the other hand, in fields where the norm is to list authors alphabetically, we would expect larger gender differences, but also similar returns to first-, last- and middle-authored publications.[21]

The analysis is complicated by the fact that norms of listing authors are flexible in most fields. The information on the norms by field was obtained by analysing a large set of publications from two universities in the IRIS dataset. All publications were coded as listing authors alphabetically or not, and the average of this "alphabetical score" was calculated for each field. Very few fields had a large majority of publications that followed either norm, whereas most fields had only around half of the publications with authors listed in alphabetical order. The implication is that splitting the sample of applications according to norms of listing authors prevalent in the field (using the median across the fields or a fifty-percent threshold) was not informative. Instead, I defined fields' norms of listing authors as alphabetical or by contribution if at least two-thirds of the publications followed either norm.

A further problem is that all social sciences and humanities follow mainly alphabetical norms, whereas scientific fields differ in their norms. Therefore, comparing fields according to norms of listing authors overlooks differences that are to be attributed to the type of disciplines, which might be linked more with stereotypes, rather than information asymmetries.

For this reason, I consider only how gender differences in the returns to publications vary in STEMM disciplines. In this way, I keep constant potential stereotypes and let only the norms of listing authors vary between the two groups.[22] In columns 3-5 of Table 6, a 25% middle-authorship penalty for women exists in fields where authors are listed according to contribution, and an

[20] As already discussed, only most lab-intensive field (one exception is chemistry) reserve the last place in the authors' list for the head of the lab. In other fields where authors are listed in order of contribution, the last position is given to the author that contributed the least.

[21] Similar returns to coauthored publications regardless of author's position would be expected. However, according to Einav and Yariv (2006), a surname starting with one of the first letters of the alphabet is associated with a number of measures of success for economics scholars. This suggests that, despite authors in publications being listed alphabetically, there might still be larger returns to first-authorship.

[22] The resulting split is the following: only Mathematics and Informatics are classified as following alphabetical norms; Vet, Biology, Chemistry and Medicine list authors in order of contribution. All other STEMM fields are classified as "mixed".

extremely large last-authorship penalty exists in fields with “mixed norms”. On the other hand, no coauthorship penalty exists in fields where authors are listed alphabetically. Another counterintuitive result is that, in fields where authors are listed alphabetically, the returns to last-authored publications are even larger than for first-authored ones (0.58 p.p. for each last-authored publication vs 0.39 p.p. for each first-authored one).[23]

It might be that controlling only by norms prevalent in the field is not enough, because often not even all publications by one author follow consistently the same norm. To explicitly test whether information asymmetries due to lack of information on the relative contribution of authors penalises women more than men, it would be necessary to identify the publications where either norm is followed.

5.3.2. Stereotypes

As already discussed, stereotypes against female researchers might be more prevalent in STEMM fields than in humanities and social sciences. If stereotypes play a role in the differential attribution of merit for coauthored work of female candidates, we would expect larger gender differences in scientific fields, and small to no gender differences in humanities and social sciences. In Table 7, it can be seen that women suffer a last-authorship penalty in scientific fields, which is consistent with expectations and with the idea that women are undervalued for their leadership role as head of labs. However, a middle-authorship penalty also exists in social sciences and humanities.

[23] The results are obtained by dividing the estimated coefficients in Table 6 by the standard deviations shown in Table A.1.

Table 7 – Returns to publications by Discipline

	(1)	(2)
	Discipline	
	SSH	*STEMM*
Female	0.010	0.004
	(0.018)	(0.009)
Single-authored	0.047***	-0.008**
	(0.010)	(0.003)
Female*Single-authored	-0.0002	0.003
	(0.013)	(0.008)
First-authored	0.012	0.040***
	(0.008)	(0.006)
Female*First-authored	0.011	0.002
	(0.011)	(0.010)
Last-authored	0.015**	0.058***
	(0.007)	(0.005)
Female*Last-authored	0.005	-0.022***
	(0.008)	(0.008)
Middle-authored	-0.004	0.057***
	(0.006)	(0.007)
Female*Middle-authored	-0.019**	-0.003
	(0.008)	(0.009)
Constant	0.253***	0.381***
	(0.023)	(0.010)
Observations	5,632	17,845
R-squared	0.255	0.227

Notes: OLS estimates. The sample includes all applicants that did not withdraw their application before the evaluation stage. The dependent variable is a dummy variable that takes value one if the candidate receives a positive evaluation. Each coefficient corresponds to an independent regression. All variables are standardised to have zero mean and unit standard deviation for the non-withdrawn applicants to each position and field. *SSH* includes humanities and social sciences, including economics. *STEMM* is science, technology, engineering, mathematics and medicine. *First-authored*, *Last-authored* and *Middle-authored* are all coauthored publications in which the applicant is listed as first, last or middle author, respectively. All regressions include exam dummies, individual characteristics and publications' quality controls.
Standard errors are clustered at the committee level (applications to both associate and full professorship in each field). Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

6. Gender differences in coauthorship patterns

As already explained, a number of different factors might influence researchers' decisions to coauthor: preferences for individual or team work, for same-sex or gender-mixed teams; the availability of (compatible) coauthors, that can improve the quality of the research output; finally, the potential returns of each publication to the researchers' own career advancement.

If coauthorship decisions were only based on the potential returns to each publication, women might engage in different behaviours depending on the likelihood of being fairly attributed merit for their coauthored work.

6.1. Empirical strategy

I analyse gender differences in authorship patterns by field, using information from the IRIS dataset. I use the adoption approach to see whether there are systematic gender differences that are consistent with women anticipating penalty for coauthorship, as found in section 5. Specifically, I explore whether women opt more than men for solo-authoring and for coauthoring with their female colleagues. Additionally, I analyse whether women coauthor more than men with their university colleagues. Engagement in interuniversity collaborations might reflect how active the researcher is in the academic community, expanding their networks also outside of the home university.[24]

At this stage, I do not control for individuals' characteristics and I do not have information neither on the quality of publications, nor on the author position in each publication. Therefore, the observed differences in coauthorship patterns are to be interpreted with caution, as they do not take into account potential quality differences.

I exploit fields' heterogeneity to investigate whether gender differences in coauthorship patterns are more marked in fields where potential information asymmetries are larger, namely in larger fields and where authors are listed in alphabetical order rather than in order of contribution.
In fact, in smaller subfields, the academic community might be more tightly connected and it may be more likely that researchers and their publications are better known within the circle, in comparison with very large subfields.
If the tradition in the field is to list publications' authors alphabetically, it is not possible to signal one's input into each publication. In these fields, women might refrain from coauthoring; on the

[24] Collaboration with colleagues from other universities might be linked with personal preferences or with other constraints, such as family, which might affect women more than men.

other hand, in fields where the lead author is signalled by being listed as the first author, women might not need to strategically engage in less coauthoring.

Moreover, I explore whether female researchers engage in different coauthorship behaviour in STEMM fields and in subfields where women are less represented, where stereotypes against women might be larger and there might be imperfect information with regards to their quality. In fact, potentially, differential attribution of merit to male and female authors in the presence of information asymmetries might depend on how women are regarded in the field.

Using OLS method, I regress four different measures of authorship on gender, controlling for academic fields:

$$Y_i = \beta_0 + \beta_1 Female_i + \beta_2 X_t + \epsilon_i \quad (3)$$

where Y_{ie} is a continuous variable that represents: a) the share of coauthored publications; b) the number of coauthors per publications; c) the share of coauthors from the same university; and d) the share of women among coauthors, of individual i. All variables are measured in annual terms to take into account different career lengths of researchers. *Female* is a dummy variable that indicates the gender of the researcher. X_t is a vector that represents area, subfield and department dummies.

I estimate equation (3) multiple times, with more narrow controls each time, because gender differences in authorship patterns at the aggregate level might overlook gender segregation within fields and subfields. In fact, academic fields differ in authorship traditions, as well as in their degree of feminisation. For example, there are more women in humanities compared to science, and coauthorship is more common in science than humanities. Therefore, by only looking at the aggregate, it might appear that women coauthor less than men.

However, there is a drawback in adding field controls. On the one hand, it allows to understand whether field differences in terms of authorship traditions explain the observed overall gender differences in authorship patterns. On the other hand, it confounds potential sorting of women into fields and departments that differ in their characteristics, for example in terms of potential information asymmetries and stereotypes.

Another factor that could affect women's coauthorship decisions is the availability of potential coauthors within the department. Despite the new possibilities of cooperation outside of one's university brought about by the internet and the increased internationalisation of academia, the department still represents an important source of potential coauthors. If there are few female colleagues, women might have a lower chance to coauthor with other women or to coauthor at all.

6.2. Main results

When no controls are included, women appear to coauthor less often than men (Table 8, Panel A) and to have 1.55 fewer coauthors per publication (Panel B). However, as already explained, these results overlook the variation across different academic fields. In Table 4, we saw that, overall, women are more present in fields where coauthoring is relatively less common. In fact, as soon as field controls are included, women seem to coauthor relatively more than men: the share of coauthored publications of women's is 1.2 p.p. higher than men's (Panel A). As for the number of coauthors, controlling for fields, women have 0.32 fewer coauthors than men, but the difference is not statistically significant (Panel B).

When I also control for narrow academic subfields (SSD), the gender difference in the share of coauthored publications is reduced further to 0.8 p.p. and women still seem to be involved in smaller teams, with 0.35 fewer coauthors.

I control for departments as well, because it is possible that women self-select into departments that have different ways of doing research, implying different coauthorship practices. I define department colleagues as the authors from the same university that pertain to the same subfield. The differences in the tendency to coauthor and the number of coauthors between male and female department colleagues are comparable to the gender differences between researchers from the same subfield.

Panel C of Table 8 shows the gender differences in the share of internal coauthors in coauthored publications. With and without area, subfield and department controls, the share of internal coauthors in women's publications is around 2.5 p.p. higher than in men's, suggesting that they are less involved in inter-university projects.

In Panel D, we see that women coauthor more with their female university colleagues (recall that only the gender of internal coauthors is observed). However, when field and subfield controls are included, the difference decreases from 13.5 p.p. to 8.5 p.p., and further to 4.4 p.p. Adding department controls, surprisingly, the share of female internal coauthors in women's publications is 3.6 p.p. lower than in their male department colleagues'. However, at this level of disaggregation, it is important to take into account the availability of female coauthors. In fact, because on average there are more men in universities, for a given number of women in a department, each has a smaller set of potential female coauthors in comparison with their male colleagues, and vice versa. Therefore, I compare departments with the same number of researchers and the same gender composition. However, although the difference gets smaller (1.6 p.p.), the share of female coauthors in women's publications is still lower than in male's publications.

Table 8 – Gender differences in coauthorship patterns

Panel A: % coauthored publications				
Female	-0.055***	0.012**	0.008***	0.009***
	(0.001)	(0.004)	(0.002)	(0.002)
Constant	0.727***	0.704***	0.705***	0.705***
	(0.001)	(0.001)	(0.001)	(0.001)
Controls:				
Field: Area (16 cat.)	-	Yes	-	-
Subfield: SSD (370 cat.)	-	-	Yes	-
Department (10241 cat.)	-	-	-	Yes
Observations	471,033	471,033	471,033	471,033
R-squared	0.004	0.660	0.688	0.729
Panel B: # coauthors per publication				
Female	-1.550***	-0.320	-0.354**	-0.325*
	(0.104)	(0.360)	(0.157)	(0.188)
Constant	5.367***	4.945***	4.957***	4.947***
	(0.061)	(0.124)	(0.054)	(0.065)
Controls:				
Field: Area (16 cat.)	-	Yes	-	-
Subfield: SSD (370 cat.)	-	-	Yes	-
Department (10241 cat.)	-	-	-	Yes
Observations	471,033	471,033	471,033	471,033
R-squared	0.000	0.044	0.082	0.220

Panel C: % internal coauthors per publication				
Female	0.028***	0.031***	0.028***	0.025***
	(0.001)	(0.003)	(0.003)	(0.002)
Constant	0.452***	0.451***	0.452***	0.453***
	(0.001)	(0.001)	(0.001)	(0.001)
Controls:				
Field: Area (16 cat.)	-	Yes	-	-
Subfield: SSD (370 cat.)	-	-	Yes	-
Department (9339 cat.)	-	-	-	Yes
Observations	334,294	334,294	334,294	334,294
R-squared	0.002	0.049	0.074	0.279

Panel D: % female coauthors					
Female	0.135***	0.085***	0.044***	-0.036***	-0.016***
	(0.001)	(0.009)	(0.005)	(0.004)	(0.004)
Constant	0.321***	0.338***	0.351***	0.378***	0.371***
	(0.001)	(0.003)	(0.001)	(0.001)	(0.002)
Controls:					
Field: Area (16 cat.)	-	Yes	-	-	-
Subfield: SSD (368 cat.)	-	-	Yes	-	-
Department (8462 cat.)	-	-	-	Yes	-
Gender composition of the department (9226 cat.)	-	-	-	-	Yes
Observations	310,354	310,354	310,354	310,354	310,354
R-squared	0.034	0.107	0.160	0.316	0.207

Notes: OLS estimates. The sample includes authors for which information on field is available (i.e. researchers, associate and full professors). Each observation corresponds to author-times-year. Each Panel corresponds to a different dependent variable. Each is a continuous variable that measure: a) the share of coauthored publications of a given year; b) the average number of coauthors out of all publications of a given year; c) the share of coauthors from the same university in coauthored publications of a given year; d) the share of female out of coauthors from the same university in coauthored publications of a given year. Each coefficient corresponds to an independent regression. Gender composition of the department groups together departments with the same number of men and women. Field, Subfield and Department (Subfield x University) dummies are included as indicated, and standard errors are clustered at the corresponding level.
Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

To understand whether the observed differences are driven by specific fields, I compare men and women's publications in each academic area with two-tailed t-tests (Table 9). Women single-author less than men in almost all areas, apart from in civil engineering, history and sociology. As for the number of coauthors, in most fields there are no differences. The exceptions are in geosciences, medicine and sociology, where women have more coauthors, and history, law and physics, where they have fewer. Physics seems to drive the differences observed overall. With fourteen more coauthors per publication than women, male physicists appear to participate in much larger projects. In fact, when the regressions shown in Panel B of Table 8 are estimated again excluding physics, women have 0.1 fewer coauthors than their male subfield colleagues, and there are no statistically significant differences at the department level (see Table A.2. in the Appendix).

Women generally coauthor more with university colleagues, except for geosciences. In arts and languages, law, sociology and civil engineering there are no gender differences.

As for the share of female internal coauthors per publication, women consistently coauthor more with other female colleagues than men do, except for in civil engineering and geosciences, where the difference is not statistically significant.

Table 9 – Gender differences in coauthorship patterns by area

	% of coauthored publications					# of coauthors				
Area	Mean	SD	men	women	p-value	Mean	SD	men	women	p-value
Architecture	0.36	0.37	0.36	0.38	0.00	0.92	1.56	0.91	0.94	0.27
Arts and Languages	0.16	0.29	0.16	0.17	0.00	0.44	1.61	0.44	0.44	1.00
Biology	0.97	0.13	0.96	0.97	0.00	5.94	10.09	5.90	5.99	0.34
Chemistry	0.98	0.11	0.97	0.98	0.00	5.26	10.72	5.27	5.25	0.90
Civil Engineering	0.90	0.23	0.90	0.91	0.19	2.54	3.22	2.54	2.53	0.91
Economics and Business	0.67	0.40	0.65	0.70	0.00	1.58	9.89	1.61	1.51	0.38
Geosciences	0.95	0.16	0.94	0.96	0.00	4.27	3.51	4.22	4.40	0.02
History	0.18	0.30	0.18	0.18	0.90	0.59	6.28	0.65	0.50	0.06
Industrial Engineering	0.95	0.16	0.95	0.96	0.00	3.69	15.84	3.74	3.40	0.12
Law	0.12	0.26	0.13	0.11	0.00	0.42	4.96	0.45	0.35	0.08
Mathematics	0.85	0.30	0.85	0.86	0.00	2.14	8.18	2.20	2.02	0.11
Medicine	0.96	0.15	0.96	0.97	0.00	7.18	10.22	7.09	7.39	0.00
Physics	0.95	0.17	0.95	0.96	0.00	36.36	154.00	38.39	26.98	0.00
Psycology	0.84	0.28	0.81	0.86	0.00	2.72	4.63	2.67	2.76	0.33
Sociology	0.25	0.35	0.25	0.25	0.40	0.58	1.71	0.56	0.62	0.04
Veterinary	0.93	0.20	0.92	0.94	0.00	4.25	13.38	4.25	4.25	0.98
	% of internal coauthors					**% of female coauthors**				
Area	Mean	SD	men	women	p-value	Mean	SD	men	women	p-value
Architecture	0.58	0.38	0.56	0.62	0.00	0.42	0.39	0.40	0.45	0.00
Arts and Languages	0.40	0.41	0.39	0.40	0.23	0.50	0.43	0.45	0.54	0.00
Biology	0.47	0.28	0.45	0.49	0.00	0.51	0.32	0.48	0.55	0.00
Chemistry	0.52	0.26	0.51	0.54	0.00	0.43	0.31	0.41	0.47	0.00
Civil Engineering	0.54	0.33	0.54	0.55	0.12	0.25	0.32	0.25	0.26	0.10
Economics and Business	0.48	0.39	0.47	0.50	0.00	0.38	0.40	0.34	0.45	0.00
Geosciences	0.39	0.28	0.40	0.38	0.01	0.30	0.32	0.29	0.30	0.14
History	0.46	0.41	0.44	0.49	0.00	0.44	0.42	0.38	0.53	0.00
Industrial Engineering	0.55	0.30	0.55	0.56	0.08	0.18	0.27	0.17	0.25	0.00
Law	0.49	0.42	0.48	0.50	0.12	0.33	0.41	0.30	0.39	0.00
Mathematics	0.41	0.37	0.39	0.45	0.00	0.32	0.39	0.28	0.40	0.00
Medicine	0.40	0.26	0.39	0.42	0.00	0.36	0.31	0.33	0.44	0.00
Physics	0.33	0.28	0.32	0.36	0.00	0.23	0.28	0.22	0.27	0.00
Psychology	0.45	0.32	0.43	0.47	0.00	0.58	0.37	0.51	0.63	0.00
Sociology	0.48	0.41	0.47	0.48	0.69	0.39	0.42	0.33	0.49	0.00
Veterinary	0.54	0.28	0.53	0.56	0.00	0.41	0.32	0.39	0.46	0.00

Notes: the table shows information on annual publications by authors in different fields, and the p-value of a t-test of difference in means between male and female authors.

6.3. Heterogeneity analysis

As already explained, if authorship decisions are made strategically, we can expect to see different patterns depending on potential information asymmetries and gender stereotypes. I compare how coauthorship patterns differ depending on the size of the subfield, the norms of listing authors, the degree of feminization of the type of discipline (STEMM or humanities and social sciences).

The median number of scholars in each subfield (SSD) is twenty and the median share of women in each subfield is 29%. I define subfields with fewer than twenty scholars small, and those with more than twenty large. Analogously, I define more and less feminised fields as having a share of women above or below 29%, respectively. For norms of listing authors, I follow the same classification explained in section 5.3.1., and I focus on STEMM fields.

Gender differences in coauthorship patterns in smaller and larger subfields are consistent with expectations (Panel A of Table 10). In smaller subfields, there are no gender differences in the tendency to coauthor and in team size, whereas in larger ones women tend to coauthor more, but select into smaller teams then men. The gender difference in the share of female coauthors is also more marked in larger fields than in smaller ones.

In Panel B, I compare STEMM fields where authors are more commonly listed in alphabetical order with STEMM fields where order of contribution is the norm. If it is not possible to signal one's input into each publication, we would expect women to coauthor less than men, or at least opt for coauthoring more with their female colleagues. As for the tendency to coauthor, if ever, women in "contribution fields" coauthor more than men by a mere 0.8 p.p., whereas in "alphabetical fields" this difference is 2.4 p.p. On the other hand, women in "alphabetical fields" have 0.09 fewer coauthors than their male colleagues, whereas "in contribution fields" there are no statistically significant differences in team size. Consistent with expectations is women's choice with regards to their coauthors' gender. In fact, in "contribution fields", the share of female coauthors in women's publications is 3.3 p.p. higher than in men's publications (8% difference), whereas this difference is as high as 9.7 p.p. in "alphabetical fields" (34%).

The results are thus consistent with the possibility that information asymmetries negatively affect female researchers' willingness to join large teams and to coauthor with their male colleagues.

In Panel C, it can be seen that, dividing subfields by their degree of feminisation, women coauthor less with their female colleagues in less feminised subfields. This, assuming that the feminisation of the field is a good proxy for the level of stereotypes against women, is not consistent with expectations. However, it is to be pointed out that fewer women also imply fewer potential females to coauthor with. There are no gender differences for what concerns the share of coauthored publications. In line with expectations, women in less feminised fields have fewer coauthors than men, whereas there are no gender differences in the number of coauthors in more feminised fields.

Women in STEMM fields have more coauthored publications than their male peers, but significantly fewer coauthors. On the other hand, there are no gender differences in the propensity to coauthor, and there is a small and slightly significant difference in team size in humanities and social sciences (Panel D). As for the share of female coauthors, the evidence goes against expectations. In both types of fields, women coauthor with their female colleagues more than men, but this difference is larger in humanities than in scientific fields. However, the issue of availability of female colleagues applies in this case as well. There are more female potential coauthors in humanities than there are in STEMM fields, and this might affect women's choices.

The results are in line with the expectation that gender stereotypes influence female researchers' decision to join larger teams. However, they are not consistent with the hypothesis that gender stereotypes affect female researchers' decisions to coauthor with men.

Table 10 – Heterogeneity analysis

Panel A: Subfield size

	% of coauthored publications		**# of coauthors**		**% of female internal coauthors**	
	Small subfields	*Large subfields*	*Small subfields*	*Large subfields*	*Small subfields*	*Large subfields*
Female	-0.001	0.010***	-0.103	-0.417**	0.023***	0.050***
	(0.003)	(0.002)	(0.094)	(0.195)	(0.009)	(0.005)
Constant	0.704***	0.706***	3.430***	5.342***	0.363***	0.348***
	(0.001)	(0.001)	(0.034)	(0.066)	(0.003)	(0.002)
R-squared	0.746	0.672	0.063	0.082	0.162	0.159

Panel B: Norms of listing authors in STEMM fields

	% of coauthored publications			**# of coauthors**			**% of female internal coauthors**		
	by Contribution	*Mixed*	*Alphabetical*	*by Contribution*	*Mixed*	*Alphabetical*	*by Contribution*	*Mixed*	*Alphabetical*
Female	0.008***	0.021***	0.024*	-0.088	-1.811*	-0.085**	0.033***	0.031***	0.097***
	(0.001)	(0.005)	(0.005)	(0.070)	(0.921)	(0.027)	(0.005)	(0.009)	(0.016)
Constant	0.958***	0.926***	0.843***	6.200***	10.540***	2.170***	0.407***	0.242***	0.285***
	(0.001)	(0.001)	(0.002)	(0.026)	(0.194)	(0.009)	(0.002)	(0.002)	(0.005)
R-squared	0.077	0.070	0.073	0.025	0.074	0.008	0.129	0.179	0.042

Panel C: Feminisation of subfield

	% of coauthored publications		**# of coauthors**		**% of female internal coauthors**	
	Less feminised	*More feminised*	*Less feminised*	*More feminised*	*Less feminised*	*More feminised*
Female	0.008**	0.008***	-0.574*	-0.178	0.033***	0.054***
	(0.003)	(0.002)	(0.322)	(0.116)	(0.006)	(0.006)
Constant	0.752***	0.654***	6.249***	3.519***	0.272***	0.448***
	(0.001)	(0.001)	(0.076)	(0.053)	(0.001)	(0.003)
R-squared	0.655	0.709	0.080	0.087	0.101	0.078

	Panel D: Discipline					
	% of coauthored publications		**# of coauthors**		**% of female internal coauthors**	
	SSH	*STEMM*	*SSH*	*STEMM*	*SSH*	*STEMM*
Female	-0.0002	0.013***	-0.108*	-0.519**	0.077***	0.037***
	(0.004)	(0.002)	(0.063)	(0.257)	(0.011)	(0.005)
Constant	0.292***	0.938***	0.806***	7.292***	0.375***	0.347***
	(0.002)	(0.001)	(0.025)	(0.081)	(0.004)	(0.002)
R-squared	0.357	0.1	0.018	0.075	0.064	0.186

Notes: OLS estimates. The sample includes authors for which information on field is available (i.e. researchers, associate and full professors). Each observation corresponds to author-times-year. Each Panel corresponds to a different split between fields. Panel A according to the subfield size in terms of number of scholars: small is below the median of 20, large is above it. Panel B according to the norms of listing authors in STEMM fields: *Mixed* means that less than two-thirds of the publications followed either norm. *Alphabetical* include: Mathematics and Informatics. *By Contribution* include: Biology, Vet, Chemistry and Medicine. Panel C according to the share of women in the subfield: less feminised is below the median of 0.29, more feminised is above it. Panel D according to the discipline: *STEMM* is science, technology, engineering, mathematics, medicine and psychology. *SSH* is humanities and social sciences, including economics.
Each pair of columns corresponds to a different continuous variable: the share of coauthored publications of a given year; the average number of coauthors out of all publications of a given year; the share of female out of coauthors from the same university in coauthored publications of a given year.
Each coefficient corresponds to an independent regression. Subfield dummies are included and standard errors are clustered at the corresponding level.
Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

7. Conclusions

A recent contribution to the literature exploring reasons for the observed lower promotion rates of women in academia was made by Sarsons (2017a; 2017b), who found evidence that female economists with coauthored papers are relatively less likely to be promoted to tenure, especially if they coauthor with men. Because in economics authors are listed in alphabetical order and not according to contribution, information asymmetry seemed to play a role in the unequal attribution of credit for coauthored research.

I test Sarsons's hypothesis using data on around 60,000 evaluations of aspiring associate and full professors in all academic disciplines in Italy. The advantage of this setup is that candidates are evaluated by a randomly selected committee and exclusively on the basis of their research output. Moreover, I add several quality measures of the publications listed in the academic CV of the applicants.

Overall, there is evidence of coauthorship penalties for women, as found by Sarsons. Specifically, I find last- and middle-authorship penalties, whereas I find no gender differences in the returns to single- and first-authored publications.

The results are consistent with the possibility that women are evaluated differently from men in the presence of information asymmetries and stereotypes. Heterogeneity analysis provides further evidence in support of this idea. In fact, whereas there are no coauthorship penalties for female applicants to full professorship, in evaluations to associate professorship there are significant gender differences in the returns to different types of coauthored publications. With regards to norms of listing authors, there are gender differences in the returns to middle-authored publications in scientific fields where authors are listed according to contribution. However, a counterintuitive result is that no gender differences exist in the returns to all types of publications in scientific fields with alphabetical norms. Moreover, stereotypes in STEMM fields seem to penalise women when they undertake leadership roles as heads of labs, as women appear to suffer a last-authorship penalty.

Additionally, following the adoption approach, I explore whether observed coauthorship patterns are consistent with the possibility that women anticipate a coauthorship disadvantage, using data on all publications in the Italian academia from the past twenty years.

I find that, overall, women coauthor less and have more female coauthors than men. However, these gender differences are largely explained by gender segregation across fields. Strikingly, when comparing tendency to coauthor with their female department colleagues, I find that women coauthor less with members of the same gender, even when controlling for the number of male and female potential coauthors.

Heterogeneity analysis provides some support for the hypothesis that women might strategically engage in coauthorship in the presence of potential information asymmetries and stereotypes. In larger subfields, they have fewer coauthors and relatively more female coauthors than in smaller ones. In STEMM fields where authors are listed alphabetically, the gender difference in the share of female coauthors is consistently larger than in STEMM fields where authors are listed according to contribution. Moreover, whereas women in humanities and social sciences do not differ from men in their tendency to coauthor, women in STEMM fields and in less feminised fields have more coauthored publications than their male peers, but significantly fewer coauthors.

My research contributes to the literature on coauthorship patterns by bringing new observational evidence on all academic disciplines that women differ from men in their coauthorship behaviour, and this difference depends on potential information asymmetries and stereotypes in the field.

With regards to evaluations, it confirms Sarsons's (2017a; 2017b) finding of penalisation of women for their coauthored research, and consolidates it by exploiting a more suitable setup of actual evaluations based solely on research output in all academic disciplines. This allowed to test hypothesis on potential reasons for the observed gender differences in the returns to coauthored research.

One important limitation is that there are virtually no fields where publications' authors are always listed in alphabetical order. Therefore, to explicitly test whether information asymmetries due to lack of information on the relative contribution of authors penalises women more than men, as suggested by Sarsons, it would be necessary to take into account the actual number of publications where this norm is followed.

I presented preliminary results on gender differences in authorship patterns. The lack of quality controls on the publications, as well as the missing information on the author's position and on the norm of listing authors followed in each publication, imply that the observed differences in coauthorship patterns are to be interpreted with caution. In future research, I will address these data limitations, as well as link fields to publications of authors not included in CINECA, to give a more thorough description of gender differences in authorship patterns and document gender distributions in fields and subfields.

8. References

Azoulay, Pierre, Christian Fons-Rosen, and Joshua S. Graff Zivin. 2015. “Does Science Advance One Funeral at a Time?” National Bureau of Economic Research (NBER) Working Paper 21788

Azoulay, Pierre, Joshua S. Graff Zivin, and Jialan Wang. 2010. “Superstar Extinction.” *The Quarterly Journal of Economics* 125(2): 549-589.

Bagues, Manuel, Mauro Sylos-Labini, and Natalia Zinovyeva. 2017. “Does the Gender Composition of Scientific Committees Matter?” *American Economic Review* 107(4): 1207-1238.

Barnett, Andy H., Richard W. Ault and David L. Kaserman. 1988. “The Rising Incidence of Co-authorship in Economics: Further Evidence.” *The Review of Economics and Statistics* 70(3): 539-543.

Boschini, Anne, and Anna Sjögren. 2007. “Is Team Formation Gender Neutral? Evidence from Coauthorship Patterns.” *Journal of Labor Economics* 25(2): 325-365.

Bosquet, Clément, Pierre-Philippe Combes, and Cecilia García-Peñalosa. 2013. “Gender and Competition: Evidence from Academic Promotions in France.” Centre for Economic Policy Research (CEPR) Discussion Paper 9711.

Cronin, Blaise, Debora Shaw, and Kathryn La Barre. 2003. "A Cast of Thousands: Coauthorship and Subauthorship Collaboration in the 20th Century as Manifested in the Scholarly Journal Literature of Psychology and Philosophy." *Journal of the American Society for Information Science and Technology* 54(9): 855-871.

Cronin, Blaise, Debora Shaw, and Kathryn La Barre. 2004. "Visible, Less Visible, and Invisible Work: Patterns of Collaboration in 20th Century Chemistry." *Journal of the American Society for Information Science and Technology* 55(2): 160-168.

De Paola, Maria, and Vincenzo Scoppa. 2015. “Gender Discrimination and Evaluator’s Gender: Evidence from the Italian Academia.” *Economica* 82(325): 162-188.

De Paola, Maria, Michela Ponzo, and Vincenzo Scoppa. 2015. “Gender Differences in Attitudes Towards Competition: Evidence from the Italian Scientific Qualification.” IZA Discussion Paper 8859.

Durante, Ruben, Giovanna Labartino, and Roberto Perrotti. 2011. “Academic Dynasties: Decentralization and Familism in the Italian Academia.” National Bureau of Economic Research (NBER) Working Paper 17572.

Durden, Garey C., and Timothy J. Perri. 1995. “Coauthorship and Publication Efficiency.” *Atlantic Economic Journal* 23(1): 69-75.

Einav, Liran, and Leeat Yariv. 2006. “What’s in a Surname? The Effects of Surname Initials on Academic Success”. *Journal of Economic Perspectives* 20(1): 175-188.

Endersby, James W. 1996. “ Collaborative Research in the Social Sciences: Multiple Authorship and Publication Credit.” *Social Science Quarterly* 77(2): 375-392.

Ginther, Donna K., and Shulamit Kahn. 2004. "Women in Economics: Moving up or Falling off the Academic Career Ladder?" *Journal of Economic Perspectives* 18 (3): 193–214.

Hamermesh, Daniel. 2013. "Six Decades of Top Economics Publishing: Who and How?" *Journal of Economic Literature* 51(1): 162-172.

Hamermesh, Daniel S., and Sharon M. Oster. 2002. "Tools or Toys? The Impact of High Technology on Scholarly Productivity." *Economic Inquiry* 40(4): 539-555.

Heck, Jean Luis, and Peter A. Zaleski. 1991. "Trends in Economic-Journal Literature: 1969-89." *Atlantic Economic Journal* 19(4): 27-32.

Hudson, John. 1996. "Trends in Multi-Authored Papers in Economics." *The Journal of Economic Perspectives* 10(3):153-158.

Jones, Benjamin F. 2005. "The Burden of Knowledge and the 'Death of the Renaissance Man': Is Innovation Getting Harder?" *The Review of Economic Studies* 76(1): 283-317.

Krapf, Matthias, Heinrich Ursprung, and Christian Zimmermann. 2014. "Parenthood and Productivity of Highly Skilled Labor: Evidence from the Groves of Academe." IZA Discussion Paper 7904.

Laband, David N., and Robert D. Tollison. 2000. "Intellectual Collaboration". *Journal of Political Economy 10*8(3): 632-662.

McDowell, John M., and Janet Kiholm Smith. 1992. "The Effect of Gender-Sorting on Propensity to Coauthor: Implications for Academic Promotions." *Economic Inquiry* 30(1): 68-82.

McDowell, John M., Larry D. Singell Jr., and Mark Stater. 2006. "Two to Tango: Gender Differences in the Decisions to Publish and Coauthor." *Economic Inquiry* 44(1): 153-168.

McDowell, John, and Michael Melvin. 1983. "The Determinants of Coauthorship: An Analysis of the Economics Literature." *Review of Economics and Statistics* 65(1): 155-160.

Oster, Emily. 2016. "Unobservable Selection and Coefficient Stability: Theory and Evidence." *Journal of Business & Economic Statistics* (forthcoming).

Perrotti, Roberto. 2002. "The Italian University System: Rules vs. Incentives." Paper presented at the First Conference on Monitoring, Italy, Rome.

Reuben, Ernesto, Paola Sapienza, and Luigi Zingales. 2014 "How Stereotypes Impair Women's Careers in Science." *Proceedings of the National Academy of Sciences* 111(12): 4403-4408.

Sarsons, Heather. 2017a. "Gender Differences in Recognition for Group Work." Working Paper. Available at: <https://scholar.harvard.edu/sarsons/publications/note-gender-differences-recognition-group-work>

Sarsons, Heather. 2017b. "Recognition for Group Work: Gender Differences in Academia." *American Economic Review: Papers and Proceedings* 107(5): 141-45.

Sauer, Raymond D. 1988. "Estimates of the Returns to Quality and Coauthorship in Economic Academia." *Journal of Political Economy* 96(4):855–66.

The Royal Society. 2016. “UK Research and the European Union. The Role of the EU in International Research Collaboration and Research Mobility.” London: The Royal Society Science Policy Centre.

Vesterlund, Lise, Linda Babcock, Maria Recalde, and Laurie Weingart. 2015. “Breaking the Glass Ceiling with “No”: Gender Differences in Accepting and Receiving Requests for Non-Promotable Tasks.” University of Pittsburgh Working Paper Series 15/005.

West, Jevin D., Jennifer Jacquet, Molly M. King, Shelley J. Correll, and Carl T. Bergstrom. 2013. “The Role of Gender in Scholarly Authorship.” *PLoS ONE* 8(7): e66212.

Wolfers, Justin. 2016. “When Teamwork Doesn’t Work for Women.” *The New York Times,* 8 January 2016. Available at: <https://www.nytimes.com/2016/01/10/upshot/when-teamwork-doesnt-work-for-women.html?_r=0> [Accessed on 22 September 2016].

Wuchty, Stefan, Benjamin F. Jones, and Brian Uzzi. 2007. “The Increasing Dominance of Teams in Production of Knowledge.” *Science (New York, N.Y.)* 316(5827): 1036-1039.

Zinovyeva, Natalia, and Manuel Bagues. 2015. “The Role of Connections in Academic Promotions.” *American Economic Journal: Applied Economics* 7(2): 264-292.

9. Appendix

Table A.1. – Within-group standard deviations

	Associate professorship	Full professorship	STEMM * Alphabetical	STEMM * by Contribution	SSH	STEMM
Single-authored publications	17.2	24.19	10.15	8.21	29.56	12.69
First-authored publications	13.11	21.74	15.70	22.05	6.96	21.45
Last-authored publications	9.39	17.8	13.43	16.85	5.13	16.39
Middle-authored publications	19.94	27.75	16.61	37.46	3.78	34.37

Note: the table shows average standard deviations of given indicators, calculated out of the pool of applicants to the same field and position in the National Scientific Qualification in the corresponding subsample. They are used to interpret the coefficients of the regressions shown in Table 6 and Table 7 as the returns to individual publications, by dividing β by the SD from this table.

Table A.2. – Gender differences in coauthorship patterns (physics excluded)

	# co-authors per publication			
Female	-0.212***	0.015	-0.092**	-0.053
	(0.030)	(0.059)	(0.041)	(0.042)
Constant	3.507***	3.427***	3.465***	3.451***
	(0.018)	(0.021)	(0.014)	(0.015)
Controls:				
Field: Area (16 cat.)	-	Yes	-	-
Subfield: SSD (370 cat.)	-	-	Yes	-
Department (10241 cat.)	-	-	-	Yes
Observations	450,967	450,967	450,967	450,967
R-squared	0.000	0.067	0.079	0.140

Notes: The table shows how the regressions estimated in Panel B of Table 8 change when publications in physics are excluded.

OLS estimates. The sample includes authors from the IRIS dataset for which information on field is available (i.e. researchers, associate and full professors), excluding publications in physics. Each observation corresponds to author-times-year. Each coefficient corresponds to an independent regression. Field, Subfield and Department (Subfield x University) dummies are included as indicated, and standard errors are clustered at the corresponding level. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.