東京大学 公共政策大学院
ワーキング・ペーパーシリーズ
GraSPP Working Paper Series
The University of Tokyo

GraSPP-DP-E-16-001

Gender Gap in Science in Japan

Sotaro Shibayama
Aldo Geuna

February 2016

GraSPP
THE UNIVERSITY OF TOKYO
GraSPP Discussion Paper E-16-001

GRADUATE SCHOOL OF PUBLIC POLICY
THE UNIVERSITY OF TOKYO
HONGO, BUNKYO-KU, JAPAN
GraSPP
THE UNIVERSITY OF TOKYO

GraSPP-DP-E-16-001

Gender Gap in Science in Japan

Sotaro Shibayama[1, 2, *]
Aldo Geuna[3, 4]

February 2016

[1] Research Center for Advanced Science and Technology, University of Tokyo, Tokyo, Japan
[2] Department of Technology Management for Innovation, University of Tokyo, Tokyo, Japan
[3] Department of Economics and Statistics Cognetti De Martiis, University of Torino, Turin, Italy
[4] BRICK, Collegio Carlo Alberto, Moncalieri, Italy

[*] Corresponding author
E-mail: shibayama@00.alumni.u-tokyo.ac.jp(SS)

GraSPP Discussion Papers can be downloaded without charge from:
http://www.pp.u-tokyo.ac.jp/research/dp/index.htm

Graduate School of Public Policy
The University of Tokyo
7-3-1, Hongo, Bunkyo-ku, Tokyo, 113-0033, Japan
Phone:+81-3-5841-1349

Old Boy's Network: Gender Gap in Science in Japan

Aldo Geuna[a,b]
Department of Economics and Statistics Cognetti De Martiis, University of Torino
BRICK, Collegio Carlo Alberto

Sotaro Shibayama[c,d]
Science, Technology and Innovation Governance Education & Research Program, University of Tokyo
Graduate School of Pharmaceutical Sciences, University of Tokyo

Preliminary incomplete draft: July 2016 – Do not quote without author permission

Acknowledgements

We are grateful to Paula Stephan, John P. Walsh, and Satoshi P. Watanabe for comments and suggestions. We acknowledge the comments received from participants of the following conferences: Italian economic association, 2015 Schumpeter, 2016. The paper benefited from comments receive by the attendees of the following seminars: University of Lugano, University of Torino, EPFL Lausanne.

[a] Department of Economics and Statistics Cognetti De Martiis, University of Torino, Lungo Dora Siena 100A 10153 Torino Italy, aldo.geuna@unito.it
[b]BRICK, Collegio Carlo Alberto,Via Real Collegio 30 10024 Moncalieri Italy
[c] Research Center for Advanced Science and Technology, University of Tokyo, 4-6-1 Komaba Meguro-ku Tokyo 153-8904 Japan, shibayama@00.alumni.u-tokyo.ac.jp
[d] Department of Technology Management for Innovation, University of Tokyo, 7-3-1 Hongo Bunkyo-ku Tokyo 113-8656 Japan

Abstract

Women are globally underrepresented in science, technology, engineering and mathematics (STEM) researcher careers. Among the major players of STEM research, Japan is marked by the largest gender gap. Drawing on cohort analyses with the population data of 97,422 STEM PhD graduates in 1985-2004 and tracing their careers up to 2012, this study shows that the overall gender gap has narrowed since the 1980s largely due to females' higher college attendance. The probability of continuing in an academic research career has slightly increased for female PhD graduates, however, it has actually decreased in the field of Science. A lower probability of surviving for females is particularly noticeable in elite imperial universities. The paper tests if institutional social network has a moderating effect on the probability of exiting an academic research career and if the network effect is gender biased. We find that male researchers tend to benefit more than female of a male social network especially when entering the research career and at the senior level. The gender effect is particularly important and significant when we consider the network of star scientists.

1. Introduction

Gender inequality in science has been of critical interest in policy and scholarly debate for long time (Long and Fox, 1995). The persistence of a gender gap in science, even in the most advanced countries, has been juxtaposed to the so-called pipeline theory according to which the lack of women in academia can be fully explained by the fact that women only recently started to enter academia. In this paper we use a cohort analysis approach to investigate the validity of the pipeline theory, as for women and men belonging to the same cohort we should observe no differences in careers. If female and male graduates from the same cohort have very different career paths, this would indicate the existence of other causes for gender imbalances. In this paper we focus specifically on institutional prestige and social network. We assess if academic prestige (top institutions and star colleagues) is gender neutral in influencing the survival in academic research career. Further, we test whether institutional social network has a moderating effect on the probability of exiting an academic research career and if such network effect is gender biased.

Among other countries with major scientific production, Japan presents a noticeable female underrepresentation. Comparable statistics in 2010 show that the proportion of female academic researchers (*%female*) in the higher education sector was 25% in Japan - lowest among the G7 countries: UK 44%, Italy 39%, USA 36%, Germany 36%, France 33%, and Canada 33%.[1] The Japanese government began to recognize the gender imbalance in general employment as a serious social issue in the 1990s (Gebco, 2014), but policy actions taken so far seem to have had a limited effect. This is particularly the case in science (Kato et al., 2012). Despite this situation, the gender gap in science has been understudied in the Japanese context compared to other countries (Kaminski and Geisler, 2012; Moss-Racusin et al., 2012). Only a handful of papers highlight this severe underrepresentation and highlight a salary gap and higher probability of exit providing only limited evidence on the motivations (Kuwahara 2001; Takahashi, Takahashi 2015). The current study aims to fill in this gap.

The present study provides the first comprehensive analysis of gender representation in science, technology, engineering, and mathematics (STEM) in Japan. It draws on the population of approximately 100,000 PhD graduates who earned PhD degrees from Japanese universities in STEM fields in 1985-2004. We obtained information on PhD graduates from the Japanese National Library database, and we followed their academic research career up to 2012 using the information archived in the database of the Japanese national research grant program, Grants-in-Aid (GiA), the primary competitive funding system in Japan. We consider exit from academic research when an academic researcher either (a) move into positions in academe which concentrate on non research activities, such as teaching or administration, or (b) she leaves an academic research career and move into industry. A researcher is considered *research active* in STEM fields when she manages to get competitive research funding from GiA. On the basis of this original dataset, first, we develop a set of econometric models for four cohorts of PhD graduates to assess the gender effect on the probability of becoming a faculty member (assistant professor, lecturer, associate, or full professor). Second, we model the exit probability of the sample of PhD graduates in the 1985-89 cohort that received at least once a GiA grant following their career till 2010 to assess the impact of social network (and its gender bias) controlling for a set of other confounding factors.

---

[1] Eurostat (European countries), NSF Science and Engineering Indicators 2014 (US), National Survey on Science and Technology Research (Japan), and Strengthening Canada's Research Capacity (Canada; 2008-2009). PhD students are included for Japan and Europe but not for the US and Canada.

We show that the overall gender gap has narrowed since the 1980s largely due to females' higher college attendance, however the probability of continuing in an academic research career after finishing the PhD has only slightly increased for female scientists, and it has actually decreased in the field of Science[2]. Furthermore, the gap is found largest in Medicine (odds ratio ≈ 2), where the greatest number of female PhDs are produced. We find that male researchers tend to benefit more than female of a male social network especially when entering the research career and at the senior level. Over all gender effect are more pronounced when we focus on the most prestigious top scientists network. Our results confirm the anecdotal view of gender biasing role in science of the old boys' network.

2. Japan: Science and gender

Japan has three types of universities - national, regional (i.e., city and prefectural), and private universities - which offer four-year degree courses and postgraduate education. In 1985 (our sample is composed of academics who obtained a PhD degree in 1985-1989), Japan had 95 national, 34 regional, and 331 private universities,[3] with national universities focused on academic research, and most private universities focused on teaching. In 1985, 73% of undergraduate students were enrolled in private universities, and 24% in national universities, while 38% of graduate students were enrolled in private or regional universities, and 62% in national universities. In terms of research funding, in 1985, national universities received 77% (decreased to 67% in 2010) of the total GiA budget, the primary national research funding system in Japan. Among national universities, the seven imperial universities (Tokyo, Kyoto, Osaka, Tohoku, Hokkaido, Kyushu, and Nagoya) are considered exceptionally prestigious for both research and education. Academic research is also conducted in PROs (e.g., RIKEN).[4] In 2004, PROs employed approximately 10% of researchers, and universities 90% (METI 2006: 264).

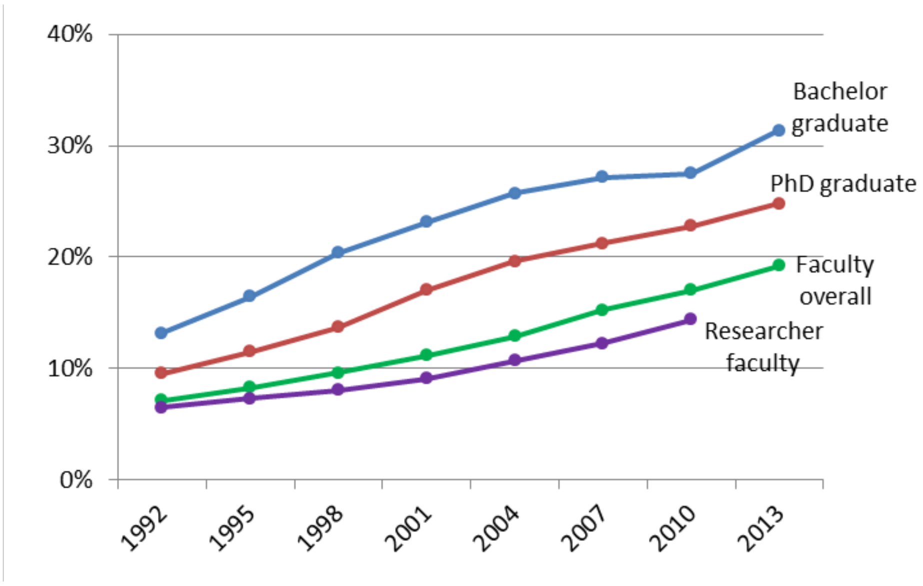
Japanese universities have a three-level promotion system from the entry position of assistant professor or lecturer, to associate professor, and finally full professor.[5] Currently, before being appointed to an entry position, academics - especially in natural sciences – must spend a few years as a postdoc. In 2005, the average postdoc period was five or six years (Yamanoi 2007: Ch.12). In the 1980s, postdocs were less common, and young academics were often appointed as assistants or lecturers directly after graduation. According to a national survey of natural scientists (NISTEP 2009b), among respondents aged 26-36 years in 1990 23.5% had held a postdoc position, 70.5% had not. Among the former, approximately 80% spent three years or less as a postdoc.

Japan's academic system has a few relevant features. First, it used to be characterized by lifetime employment (Shimbori 1981; Takahashi and Takahashi 2009). Until a series of reforms in the 2000s allowed temporary employment, entry positions were mostly permanent (Watanabe 2011). Second, many Japanese universities operate a hierarchical "chair" system (Yamanoi 2007). The

[2] The field of Science includes: Mathematics, Physics, Chemistry, Biology, etc.
[3] School Survey conducted by the Ministry of Education, Culture, Sports, Science and Technology (MEXT; http://www.e-stat.go.jp/).
[4] http://www.riken.jp/en/
[5] The position of assistant professor was officially introduced in Japanese universities in 2007. Previous to this, the position was designated "assistant" (Watanabe 2011).

system used to be, and sometimes still is, led by a full professor (the "chair"), responsible for a small team of junior researchers in entry positions and perhaps an associate professor. Thus, while junior researchers in entry positions were cleared of unemployment risk, they had to (and have to) compete to be promoted and win a position of an independent researcher. Third, Japan's employment practice is characterized by high rigidity and very low cross-sectoral mobility. According to a government statistic (METI 2006: 264) in 2004, only 1.1% of researchers (8,800 out of 790,900) moved across the three sectors of industry, government, and academia. In the same year, 97.4% of 291,100 university researchers were not mobile, 2.3% moved between two universities, 0.11% moved to industry, and 0.15% moved to government (i.e., PROs). Thus, industry is a less frequent destination for academics who leave university employment and exit is more likely due to academics giving up research and remaining in academia in a teaching or administrative position.

Figure 1. Trend of %female in STEM fields.



Source: School Basic Survey (conducted annually) for bachelors and PhD graduates; School Teachers Survey (conducted every three years) for overall faculty. The statistics do not allow a breakdown by academic rank. Both sources distinguish scientific fields, where science, engineering, agriculture, and medicine & healthcare are regarded as STEM. Researcher faculty are defined as faculty members who received Grants-in-Aid (GiA) during the three years preceding each year.

Publicly available statistics show that *%female* of bachelor graduates in Japan in 2013 was nearly 50% and that of PhD graduates was 30%.[6] New employment in entry positions (e.g., assistant professors) in the same year was 30%, but only 22% of associate and 14% of full professors in service were female. These figures suggest that PhD enrollment and promotion to senior positions are major sources of the gender gap and that entry placement seems gender-neutral. Focusing on science, technology, engineering, and mathematics (STEM) fields (or excluding social sciences and humanities), the statistics in 2013 instead indicate lower *%female*, with 31% of bachelor graduates,

[6] School Basic Survey and School Teachers Survey, administered by Ministry of Education, Culture, Sports, Science and Technology.

25% of PhD graduates and 19% of overall university faculty being female (Figure 1). Further, *%female* among research-active faculty (defined as faculty members who received national research funding) is consistently smaller than the proportion of overall faculty including teaching staff. Compared to the 1990s, the gender gap has been mitigated at all levels, which would seem attributed largely to females' higher college attendance.[7] However, Japan is lagging behind other developed countries; for example, *%female* of STEM PhD graduates was 50% in the US and 39% in the UK, and *%female* of overall faculty was 31% in the US and 40% in the UK.[8]

3. Data and descriptive analysis

We analyze the focal researcher that obtained a PhD within a specific cohort and we follow her academic research career. From the Japanese National Library database, we obtained information on PhD graduates including the names of graduates, degree fields, and year of degree award. We focus on four cohorts of five years from 1985 to 2004 (1985-1989, 1990-1994, 1995-1999, 2000-2004). We have identified 97,422 PhD graduates who were awarded PhD degrees in one of the STEM fields from a Japanese university in the period considered.[9] We excluded foreign-born graduates, who account for 7.3% of all PhD graduates, because foreign graduates are unlikely to pursue an academic career in Japan (Franzoni et al., 2012).[10] We traced their careers using the GiA database;[11] GiA is the largest source of funding for academic research in Japan and covers all scientific fields and all researcher ranks. The database provides information on the name of the Principal Investigator (PI) –one or more- and the Co-grantees and various other information including grant size, affiliations, publication output, organizational rank, grant field, etc. Since most GiA funding lasts for 2 to 5 years, and an academic can simultaneously receive multiple grants, we can identify the academic's affiliation and organizational rank in sufficient detail. Because of the central role of GiA in academic research funding (Shibayama, 2011),[12] we assume that academics who did not receive GiA funding, or stopped receiving it, are likely to be no longer research active. We started our analysis from 1985 as GiA funding for junior researchers used to be less common before then. The PhD database and GiA database are matched based primarily on full names of PhD graduates and GiA grantees.[13] Among the 97,442 PhD graduates, we found that 29,717 (30.5%) had

[7] %Female for the 4 levels increased by similar factors (i.e., annual growth rates = 4.2, 4.6, 5.0, and 4.5%, respectively).
[8] Eurostat Education Statistics (PhD), NSF Science and Engineering Indicators 2014 (faculty in the US), Higher education statistics agency (faculty in the UK).
[9] STEM fields include science, engineering, medicine, agriculture, pharmaceutical, and dentistry. The last three fields were dropped from the by-field analyses because of small sample sizes.
[10] We also excluded so-called paper-based PhDs with no course work requirement; paper-based degrees are usually awarded to senior researchers (often based on corporate research experience) and their inclusion would confound our analysis.
[11] General information on GiA is found in http://www.mext.go.jp/a_menu/shinkou/hojyo/main5_a5.htm. Kneller (2010) and Asonuma (2002) provide overviews of the GiA and the general budgetary structure in Japanese universities. The GiA database provides information on all grants awarded under the system since 1965, covering 210,000 university researchers.
[12] A survey of GiA grantees in 2006 indicates that only 3% (13% for Engineering) of academic researchers depended for the majority of their research budget on funding sources other than GiA (Iida, 2007). Among the top 7 national universities, about 84% of full and associate professors received GiA funding at least once in the period 2001-2005 (Shibayama, 2011). Since academics in private universities are less dependent on GiA, our measurements may be less reliable for them.
[13] Both databases offer full names in Chinese characters, which substantially mitigates the name ambiguity problem. We also matched on year of graduation/funding, and scientific field of degrees/funded projects.

been funded at least once as a faculty member before 2012, and 7.9% of the funded researchers were female[14].

From these data source, we constructed two datasets. The *Pre-employment exit* dataset includes cross-sectional data for 94,984 PhDs that graduated in period 1985-2004, divided in four cohorts with a researcher surviving in academic research when she has managed to be PI or Co-grantees of a GiA project at least once in the eight years following her PhD graduation.[15] Depending on the cohort, between 30% and 41% of the PhD holders got at least once a GiA grant. The *Post-employment exit* dataset includes unbalanced panel data on research careers up to 2010 for 5,264 academics who were awarded their doctoral degrees in 1985-1989 and were nationally funded at least once as a faculty member (Assistant Professor or higher rank). Although the two original databases do not provide information on age, we can assume that PhD degrees were awarded at around 26-31 years of age (NISTEP 2009a). Since the retirement age in most universities in Japan was 60 (although this has now been extended), it is unlikely that researchers that exited our sample after having started an academic research career would be retired since they should be around 57 years old in 2010.

The two datasets include the following variables (see Table 1 for the basic descriptive).[16]

Dependent Variables

For *pre-employment* exit, we prepared a dummy variable that takes the value zero if a PhD graduate was identified as PI or Co-grantee (with at least the title of Assistant Professor) in at least one GiA research project in the eight years after her graduation and 1 otherwise.

For *post-employment* exit, we assumed that an academic exited after the last year of GiA funding and coded a dummy variable 1 for the year of exit and 0 otherwise. We used the year 2012 version of the GiA database, and regard academics whose latest record in the database occurred in 2010 or later, as survivors, on the assumption that research-active academics are funded at least once in five years.[17]

Independent Variables

We code a dummy variable (*Female*) 1 for female and zero for male.

To measure *Institutional Prestige* a dummy variable was coded 1 if the focal academic is affiliated to one of the seven top imperial universities: Tokyo, Kyoto, Osaka, Tohoku, Hokkaido, Kyushu, and Nagoya.

---

[14] Female researchers were identified based on their name. The gender of the Japanese is usually fairly clear from their first names especially before the 1980s, when the PhDs currently studied were born. Nonetheless, we drew on a national researcher career database, *ReaD* (http://researchmap.jp/), to identify the gender of certain PhDs. We also used the list of popular first names for female and male newborns published by an insurance company (http://www.meijiyasuda.co.jp/enjoy/ranking/index.html). Finally, we predicted the gender of other first names as follows. The gender of the Japanese is often predictable by the last Chinese character of their first names (Typical first names consist of two Chinese characters). Thus, we made predictions based on the last characters of the names whose gender has been identified.

[15] For robustness check we also considered only 3 cohorts and checked survival in a wider window of 13 years.

[16] See Appendix A for further details on variable definition and computation.

[17] Most funding is for 3-5 year periods.

To measure the importance of the institutional academic network of the university of the focal researcher (as a proxy for peer effects and social capital), we computed the natural log of the number of GiA grantees (only principal investigators) in the period t-5 to t-1 in the same university and the same field (*Institutional Social Network*).

Control variables

We prepared several control variables for the individual, institutional, and geographical factors drawing on the funding database and other public data sources. For individual level measures we include eight variables, most of these are only available for the post-employment analysis. The funding database provides the number of publications resulting from each funded project. By dividing this publication count by the number of project members and project duration, we can compute a yearly publication count for each academic. Since publication count can differ by field and year, we standardized this measure by field/year mean and standard deviation. We then compute the accumulated count of publications prior to each year (*pub stock*). We divide funding amount for each project by the number of project members and project duration, and summed them for each year, for each academic, to compute a yearly funding input. We standardize this by the field/year mean and standard deviation to compute stock value (*fund stock*). For academic career, we compute the number of years of employment each academic had in a university (*job tenure*). For academic rank, we constructed two dummy variables: the variable *full prof* takes the value 1 for full professor, and the variable *associate prof* takes the value 1 for associate professor. For academic network, we count the cumulative number of co-grantees related to a researcher's GiA funding (*#cograntee*) and we also control for the number of universities to which a researcher was affiliated (*mobility*).

We constructed two variables for institutional factors available for both databases. To take into account organizational size effects, we computed university-level funding as follows. We first compute the GiA funds for each intersection of university, field, and year, and then total funds for each field/year for the period t-5 to t-1. We divide the former by the latter to calculate the proportion of funding distributed to each university (*%univ fund*). The share of funding received by a university in a field tries to capture the relative importance of that university in a specific research field, the more important is the university of the focal researcher in a field the higher will be her probability of being active (getting a grant) in that field relative to researcher that are working in other institutions less focused on the specific scientific field. To estimate field growth, we count the number of grantees (only principal investigators) in each year and each field, and calculate the annual growth rate (*field growth*).

Finally, for geographic factors, we constructed four variables at the level of the 47 prefectures. We collected the number of jobs in national universities located in each prefecture as a proxy for academic research jobs (*#national university employment*), and the number of jobs in private universities as a proxy for teaching-oriented job opportunities (*#private university employment*).[18] This is based on the assumption that national universities tend to be research-intensive and private universities tend to be teaching-oriented. We also collected employment numbers for each prefecture as a measure of employment opportunities in the private sector (*#industrial*

[18] Source: School Survey conducted by the MEXT (http://www.mext.go.jp/b_menu/toukei/chousa01/kihon/1267995.htm).

employment).[19] Finally, we take number of PhD graduates in universities in the same prefecture to measure the labor supply (*#PhD graduate*).

Table 1: Descriptive statistics

Variables		Pre-employment				Post-employment			
		Mean	S.D.	Min	Max	Mean	S.D.	Min	Max
Exit		0.73	0.44	0.00	1.00	0.03	0.17	0.00	1.00
Female		0.12	0.33	0.00	1.00	0.04	0.20	0.00	1.00
Institutional Social Network		5.05	1.02	0.00	7.13	4.48	1.22	0.00	6.61
	Male	4.95	1.03	0.00	7.01	4.38	1.22	0.00	6.51
	Female	2.13	0.95	0.00	4.61	1.71	0.95	0.00	4.47
	Top 5%	2.19	1.46	0.00	4.96	1.71	1.33	0.00	4.74

4. Econometric model and results

We develop two sets of econometric models. First, using the *pre-employment exit* dataset we model the probability for a PhD graduate to continue her researcher career with an academic faculty position (assistant professor, associate professor, or full professor) having received funding for research from the GiA program. Second, focusing on the oldest 1985-2004 cohort of PhD graduates we study the covariates associated to exit hazard rate.

4.1 Econometric model

Pre-employment exit

Our dependent variable wants to capture the fact that a doctoral student has managed to get a position at a Japanese university as Assistant Professor (similar to a tenure-track position; post-docs are not considered[20]) and she is active in research. We record as 1 those researchers that got a grant as PI or as a co-grantees. We do not differentiate between the two as we are not concerned with explaining capacity of fund raising of leadership in research but simple survival (remaining active in research). Both PIs and Co-grantees cannot pay their salary on the research grant. The grant can be used to pay salary of temporary personnel, equipment and other costs, it is the funding needed to keep the laboratory active. Without this type of funding it is highly unlikely that a researcher can

[19] Labor Survey conducted by the Ministry of Internal Affairs and Communications (http://www.stat.go.jp/data/roudou/index.htm). Since data are available from 1997, data for the years 1985-1996 are imputed from year 1997. Employment numbers have been stable since the late 1990s.

[20] We decided to consider a postdoc with a grant as a non survivor because the postdoc position has changed significantly during the time of the analysis with a major increase since 2000. We focus only on something like “tenure-track position”

carry on doing research in the STEM fields (clearly this assumption it is less true for Mathematics).[21]

For the pre-employment period, we estimate the likelihood of exit – i.e., leaving academic careers after PhD graduation – by logit regressions as the dependent variable is dichotomous.

Post-employment exit

We estimate the likelihood of post-employment exit by survival analysis, drawing on a duration model that allows us to analyze a point event (referred to as a failure event) which occurs after a certain period of time (spell length). The average spell length is 16 years. We draw on a discrete approach based on the complementary log-log (*cloglog*) model.[22] Based on Prentice and Gloeckler (1978), the discrete hazard time for individual *i* in time interval *t* to exit is estimated by the following function:

$$h_{it} = 1 - exp\{- exp(\beta X_i + \theta(t))\}$$

where h_{it} is the hazard rate and θ(t) is the baseline hazard function with spell duration (Jenkins 1995). A set of time dummy variables is included to capture the unobserved time-varying effect on the likelihood of exit.

In the *pre-employment exit* model we include PhD field fixed effect based on the PhD field information. The variables *Field growth* and *%univ fund* are based on a conversion of the field of funding info into PhD field (we have more detailed information for the funding fields than for the PhD). For the duration analysis we use the field of science in which funding was received.

4.2 Results: Pre-employment exit

Table 2 presents the base model results for the four cohorts. The models predicted correctly 70-80% of the actual pre-employment exit. The results show a much higher probability of exiting from an academic research career for female PhD holders than male PhD holders, slightly decreasing with each subsequent cohort. To examine the difference in the effect of gender, we ran a regression including all cohorts and found that only the coefficient of female in the 1985-1989 cohort is significantly larger than those in other cohorts. In other words, there has been a slight decrease in the probability of exit for female only moving from the first to the second cohort. Figure 2 presents *%female* among PhD graduates and research-active faculty members (i.e., those who received at least one GiA grant) and the odds ratio of females exiting before achieving a faculty position. Across STEM fields, *%female* of researcher faculty is very low ranging from 4.7% (1985-89 cohort) to 11% (2000-04 cohort), and consistently lower than the proportion of PhD graduates. Increasing *%female* in both PhD graduates and research active Assistant Professor and a decreasing odds ratio of females exits suggest that the gender imbalance has been mitigated only marginally over the 20-year period. The breakdown for the main fields presented in Figure 2 suggests that the nature of the gender imbalance differs considerably among disciplines. Medicine, the largest STEM

[21] We purposively excluded from our analysis Social and Human sciences that are not laboratory based for which this assumption would not be justified.

[22] A continuous approach can be employed. A Cox (1972) semi-parametric model yields a similar pattern of results.

field,[23] shows a higher *%female* than other fields for both PhD graduates and researcher faculty but the highest odds ratio. Female PhD graduates in medicine abandon an academic research career twice as often as male graduates. In contrast, engineering shows a significantly smaller *%female* but the lowest odds ratio, suggesting that the gender gap is present before the start of an academic career. In science, *%female* at both levels has more than doubled in 20 years but the odds ratio has increased. Thus, although employment of female researchers has increased it does not match the increase in female PhD graduates. Compared to medicine and engineering, where non-academic jobs are more common, science can be considered more representative of the academic employment market; if so, our results indicate a deterioration of the academic employment conditions for females in the last twenty years.

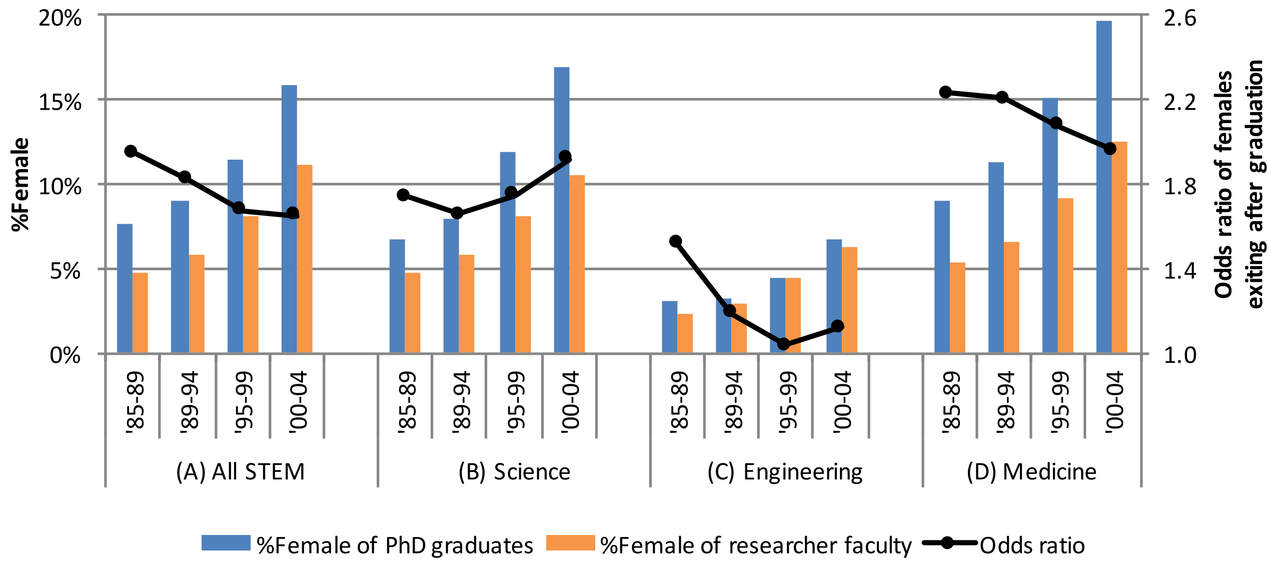
Table 2: Base model – Logit regression

	Model 1		Model 2		Model 3		Model 4	
	1985-1989		1990-1994		1995-1999		2000-2004	
Female	1.951***	(8.39)	1.821***	(9.30)	1.673***	(10.50)	1.651***	(12.55)
Institutional Prestige	0.823**	(-3.11)	0.864**	(-2.65)	0.795***	(-4.97)	0.877**	(-3.11)
Institutional Social Network	0.661***	(-8.44)	0.680***	(-9.57)	0.778***	(-8.13)	0.787***	(-8.23)
%Univ fund	1.032***	(3.68)	1.030***	(3.64)	1.011	(1.47)	1.002	(0.33)
year of graduation	0.999	(-0.05)	1.035	(1.07)	1.030*	(2.38)	1.078***	(4.82)
field growth(8-year)	0.578	(-0.33)	5.959	(0.58)	3.622	(0.73)	1.409	(0.19)
ln(#national univ employment)	0.808**	(-2.76)	0.862*	(-2.43)	0.868*	(-2.48)	0.932	(-1.27)
ln(#private univ employment)	1.070**	(3.18)	0.991	(-0.40)	0.981	(-0.91)	0.976	(-0.95)
ln(#industrial employment)	0.964	(-0.74)	1.045	(1.00)	1.073†	(1.77)	1.145***	(3.61)
ln(#PhD graduate)	1.081	(1.24)	1.096	(1.63)	1.057	(1.09)	0.983	(-0.33)
Field dummy	YES		YES		YES		YES	
N	13776		18387		27236		35585	
Log likelihood	-8488.280		-1.10e+04		-1.54e+04		-1.83e+04	
χ^2 test	528.621		610.233		673.507		818.835	

Odds rations and standard errors (in parentheses) are presented. Two-tailed test. †p<0.1; * p<0.05; ** p<0.01; *** p<0.001.

[23] For the 2000-2004 cohort, medicine, engineering, and science account for 35%, 29%, and 18% of all STEM PhD graduates.

Figure 2: Share of female and odds ratios



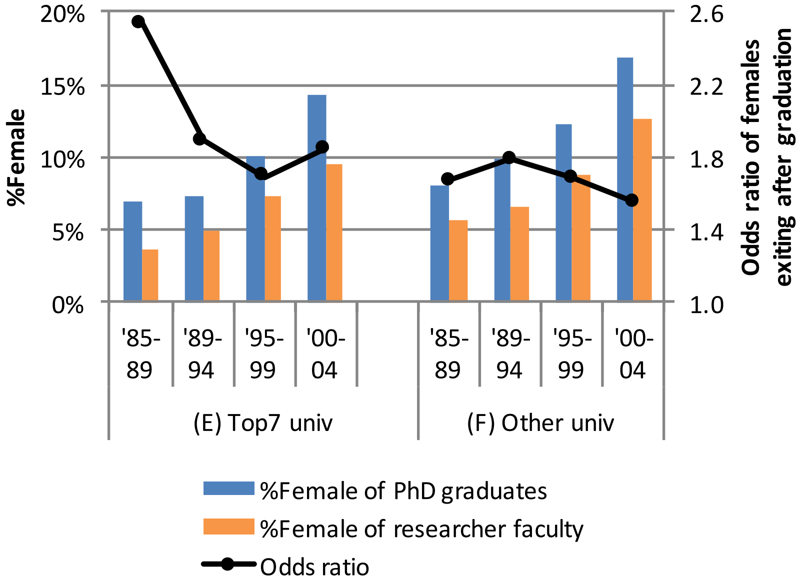
We also conducted a sensitivity analysis by repeating the procedure for the 1985-1989, 1990-1994, and 1995-1999 cohorts based on 13 years of career information. As expected, this results in lower exit but the predicted odds ratios is not significantly affected (see Table B1 in Appendix B).

Consistent with the results of previous literature from other countries (Allison and Long 1987; Long et al. 1993; Debackere and Rappa 1995; Gaughan and Robin 2004), Institutional Prestige measured by the fact of being a graduate of one to the top seven imperial universities is associated to a higher probability of continuing to be active in academic research. Institutional Social Network is also associated with a decreased probability of exiting. Having a large number of active researchers (winners of at least one GiA grant in the last five years) in the focal researcher's university and scientific field (Engineering, Science, Medicine, Dentistry, Agriculture, Pharmaceutical) is associated to higher survival. These effects are stable across cohorts, only the third cohort is statistically significantly different from the others.

Identified a first level gender effect we are now interested in examining whether institutional prestige and social network are gender biased.[24] We start by looking if we can find any moderating / intensifying effect due to the interaction between university prestige and gender. In other words, do female researchers graduating from the top seven imperial universities have a higher / lower probability of continuing in an academic research career? The top seven imperial universities produce 30-40% of all PhDs and employ 40-50% of research-active faculty. However, their *%female* is consistently smaller for both levels compared to other universities. Figure 3 presents the odds ratios for the split sample top seven imperial universities and other universities. Interestingly, the positive effect associated to being a PhD graduate of a top institution does non apply to female researchers, actually female PhDs from elite imperial universities (fewer in % terms) have a lower probability of surviving compared to female graduate from the other universities, the difference is significant at the 5% and 10% levels for the first and last cohort

[24] See Appendix C for full estimations.

Figure 3: Gender effect and institutional prestige – Odds ratios



To examine if there are gender biases in the social network effect we start by splitting local PIs by gender. The results show (Table 3) that in the first three cohorts only the male network has a direct effect while in the last cohort both male and female networks are relevant.[25]

Table 3: Base model with gender of the network - Logit regression

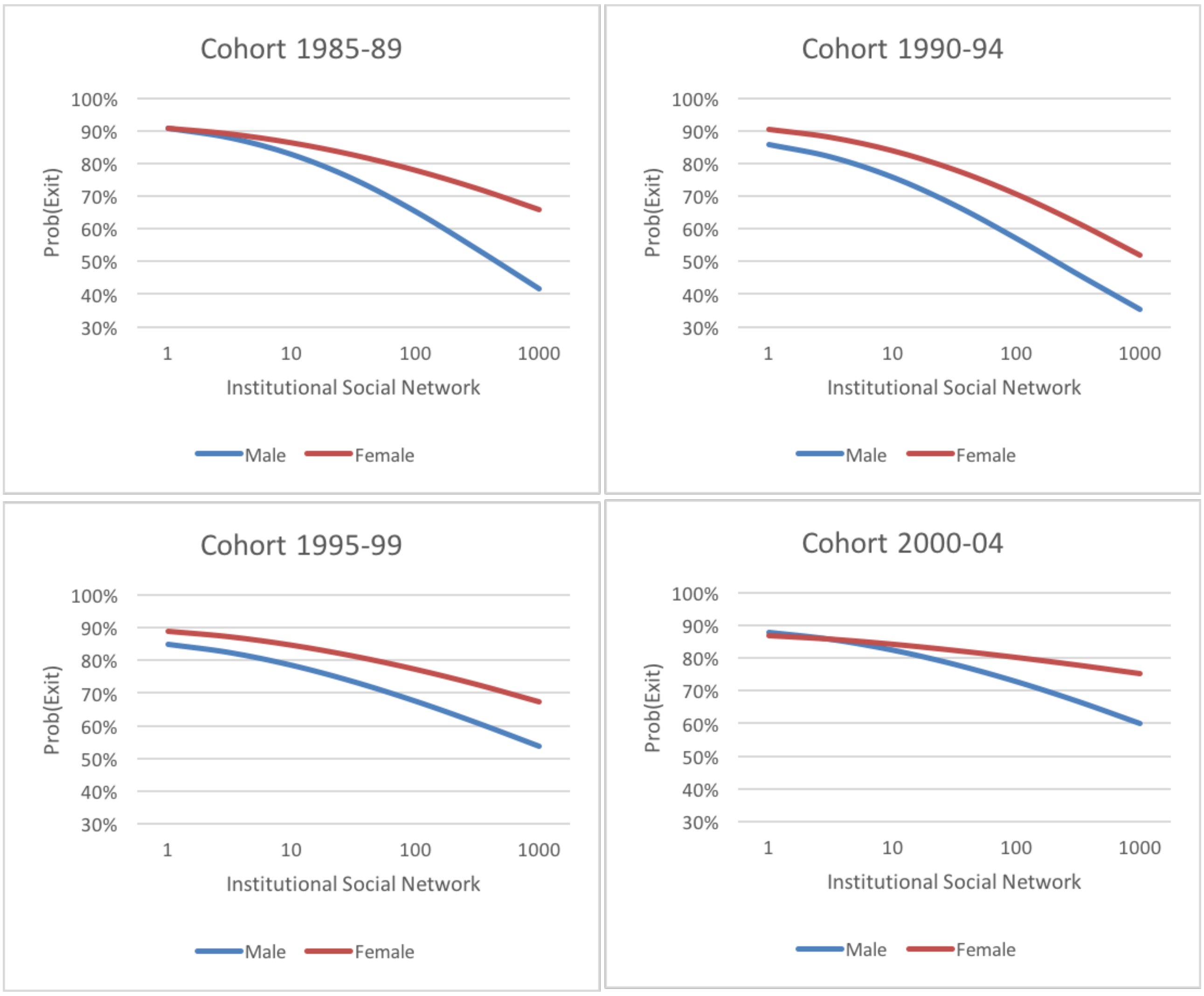
	Model 1		Model 2		Model 3		Model 4	
	1985-1989		1990-1994		1995-1999		2000-2004	
Female	1.949***	(8.37)	1.818***	(9.26)	1.675***	(10.50)	1.659***	(12.65)
Institutional Prestige	0.825**	(-3.05)	0.873*	(-2.45)	0.799***	(-4.85)	0.863***	(-3.45)
Institutional Social Network - female	0.972	(-0.63)	0.964	(-0.99)	0.939†	(-1.74)	0.886***	(-3.60)
Institutional Social Network - male	0.676***	(-6.78)	0.689***	(-8.22)	0.803***	(-5.95)	0.845***	(-4.89)
%Univ fund	1.032***	(3.66)	1.033***	(3.89)	1.014†	(1.85)	1.009	(1.16)
year of graduation	1.000	(0.00)	1.035	(1.09)	1.030*	(2.43)	1.083***	(5.09)
field growth(8-year)	0.574	(-0.33)	5.405	(0.54)	3.586	(0.72)	1.029	(0.02)
ln(#national univ employment)	0.809**	(-2.75)	0.867*	(-2.32)	0.870*	(-2.44)	0.920	(-1.51)
ln(#private univ employment)	1.070**	(3.19)	0.991	(-0.43)	0.981	(-0.94)	0.977	(-0.88)
ln(#industrial employment)	0.966	(-0.70)	1.048	(1.05)	1.073†	(1.78)	1.140***	(3.49)

[25] Statistical difference between Institutional Social Network (female) and Institutional Social Network (male) 0.1%(1985), 0.1%(1990), 5%(1995), n.s.(2000).

ln(#PhD graduate)	1.080	(1.22)	1.091	(1.55)	1.060	(1.15)	1.001	(0.01)
Field dummy	YES		YES		YES		YES	
N	13776		18387		27236		35585	
Log likelihood	-8494.095		-1.10e+04		-1.54e+04		-1.83e+04	
χ^2 test	516.990		612.981		677.150		830.240	

Odds rations and standard errors (in parentheses) are presented. Two-tailed test. †p<0.1; * p<0.05; ** p<0.01; *** p<0.001.

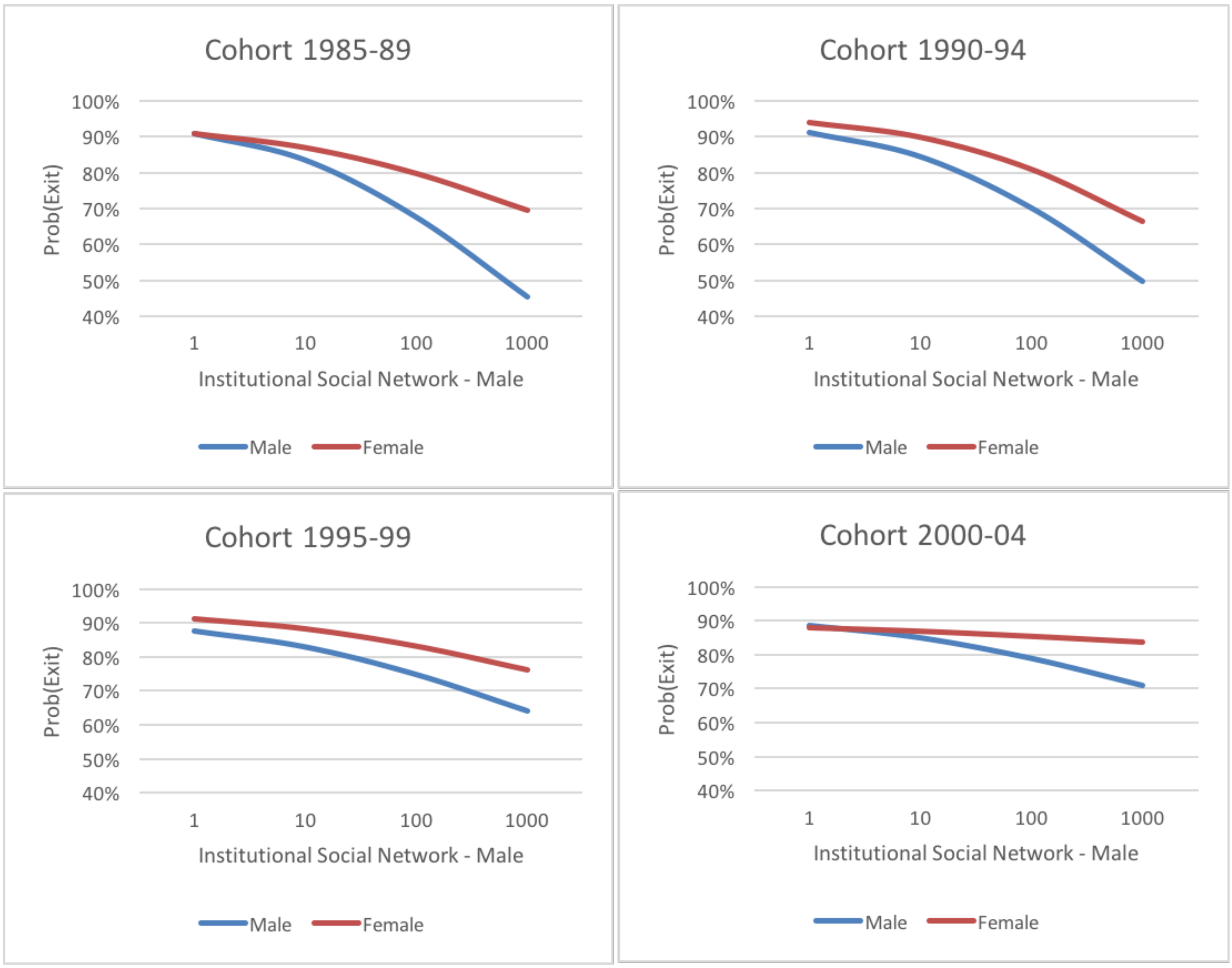
Figure 4: Predicted probability of exit – Institutional Social Network



We then turn to analyze if female researchers benefit from a moderating effect of having other active researchers (PIs of a GiA grant) in the same field and university by interacting the Institutional Social Network variable with female. The predicted probability of exit graphs in Figure 4 show that males are benefiting more than female from the moderating effect of having other PIs in the focal researcher university and scientific fields in the previous 5 years especially in the first and last cohorts.

The analysis above shows that the male network is associated to a decreased exit and that female focal scientist benefits less from institutional social network in the first and last cohorts. We combine the analysis asking whether female are benefitting equally to male of the male institutional social network looking at the gender of both the focal researcher and the network of local PIs. Figure 5 presents the predicted probability of exit showing that for both the first and last cohorts (the difference is statistically significant, 1985 cohort: male network * female (p<0.1), 2000 cohort: male network * female (p<0.01) male focal researchers are benefitting more than female researchers of the male network of PIs in their scientific field and university.

Figure 5: Combined gender effect of institutional social network



As we could expect that individual prestige might have an impact on the social network effect we repeat the gender neutrality analysis presented above including only star PIs in the local university network. We used six different measures for star academics according to them being in the top 2%, top 5%, or top 10% in terms of either publications or funding grants received. We discuss the results for the measure top 5% grants,[26] the results are very similar using the alternative measures of individual prestige. Given the small number of female top researchers we present only the analysis for the overall top network that is almost only composed by male scientists. Interestingly, when we

[26] Results for the different measures and other details results available from the authors.

consider only high prestige local PIs as a proxy for institutional social network we obtain (see Table 4) a less important moderating effect on exit. Star scientists in the same field and university of the focal researcher are correlated with a decrease in the probability of exiting but less so than in the case of all PIs.

Table 4: Base model, Star Network – Logit regression								
	Model 1		Model 2		Model 3		Model 4	
	1985-1989		1990-1994		1995-1999		2000-2004	
Female	1.946***	(8.36)	1.827***	(9.35)	1.665***	(10.39)	1.652***	(12.56)
Institutional Prestige	0.740***	(-4.90)	0.840**	(-3.14)	0.831***	(-3.94)	0.927†	(-1.74)
Institutional Social Network – top5%	0.830***	(-5.28)	0.815***	(-7.90)	0.818***	(-9.36)	0.828***	(-9.58)
%Univ fund	1.016†	(1.78)	1.019*	(2.33)	1.021**	(2.78)	1.010	(1.32)
year of graduation	1.000	(-0.00)	1.039	(1.19)	1.037**	(2.91)	1.070***	(4.29)
field growth(8-year)	0.970	(-0.02)	8.921	(0.71)	6.493	(1.06)	1.256	(0.12)
ln(#national univ employment)	0.779**	(-3.23)	0.826**	(-3.17)	0.847**	(-2.95)	0.890*	(-2.10)
ln(#private univ employment)	1.096***	(4.28)	1.001	(0.04)	0.996	(-0.20)	0.971	(-1.12)
ln(#industrial employment)	0.952	(-1.00)	1.050	(1.11)	1.070†	(1.71)	1.149***	(3.71)
ln(#PhD graduate)	1.060	(0.92)	1.105†	(1.78)	1.052	(0.99)	1.015	(0.29)
Field dummy	YES		YES		YES		YES	
N	13776		18387		27236		35585	
Log likelihood	-8511.316		-1.11e+04		-1.54e+04		- 1.83e+04	
χ^2 test	482.548		571.170		689.850		837.662	

Odds rations and standard errors (in parentheses) are presented. Two-tailed test. †p<0.1; * p<0.05; ** p<0.01; *** p<0.001.

Table 5 presents the predicted probability of exit of the model with female interaction, it shows that female scientists benefits less than their male colleagues of the moderating effect of prestigious PIs working nearby in their scientific field. Though the effect is small and only significant for the last cohort.

Table 5: Base model, Star Network with female interaction - Logit regression (coefficients presented)								
	Model 1		Model 2		Model 3		Model 4	
	1985-1989		1990-1994		1995-1999		2000-2004	
Female	1.673***	(3.65)	1.935***	(5.84)	1.667***	(5.37)	1.366***	(3.76)
Institutional prestige	0.740***	(-4.90)	0.840**	(-3.14)	0.831***	(-3.94)	0.927†	(-1.76)
Inst. Social Network (top5%)	0.826***	(-5.39)	0.817***	(-7.76)	0.818***	(-9.28)	0.821***	(-9.86)
*female	1.088	(1.27)	0.970	(-0.63)	1.000	(-0.01)	1.075*	(2.57)
%Univ fund	1.016†	(1.80)	1.019*	(2.32)	1.021**	(2.78)	1.010	(1.31)
field growth(8-year)	1.000	(0.01)	1.038	(1.19)	1.037**	(2.91)	1.069***	(4.28)
year of graduation	0.966	(-0.02)	8.891	(0.71)	6.494	(1.06)	1.223	(0.11)
ln(#national univ employ)	0.779**	(-3.23)	0.826**	(-3.16)	0.847**	(-2.95)	0.888*	(-2.15)
ln(#private univ employ)	1.097***	(4.29)	1.001	(0.04)	0.996	(-0.20)	0.970	(-1.14)
ln(#industrial employ)	0.951	(-1.02)	1.050	(1.11)	1.070†	(1.71)	1.149***	(3.70)
ln(#PhD graduate)	1.060	(0.91)	1.105†	(1.77)	1.052	(0.99)	1.018	(0.34)
Field dummy	YES		YES		YES		YES	
N	13776		18387		27236		35585	
Log likelihood	-8510.507		-1.11e+04		-1.54e+04		-1.83e+04	
χ^2 test	484.166		571.561		689.850		844.240	

Two-tailed test. †p<0.1; * p<0.05; ** p<0.01; *** p<0.001.

4.3 Results: Post-employment exit

We focus on the cohort of academics who graduated between 1985 and 1989, and follow their researcher careers for 20 years.[27] We repeat the gender analysis develop above studying exit probability splitting the sample in pre-tenure Assistant Professor (Model 1) and post-tenure Associate Professor and Full Professor (Model 2). Model 1 includes the whole 5,264 observations (Assistant Professors), and the dependent variable takes the value 1 only if an academic drops out before tenure (as an assistant professor); Model 2 includes only the 3,248 scientists that were at least promoted to Associate Professor level and 2,440 survived till 2010.

As the previous analysis we start with a base model with a first level gender effect (are female scientists more likely to exit academic career compare to their male peers?) and then we move to evaluate gender neutrality of the institutional prestige and institutional social network.

Table 6 presents the results (hazard ratios) of the base model. Female researchers at the pre-tenure level (Model 2 – Assistant professor) have 29% higher probability of exiting compare to their male

[27] We chose this cohort to achieve a sufficiently long time span to allow progression to Full Professor.

colleagues while once they are promoted to Associate professor their probability of exiting is 29% lower than their male colleagues; however, among the sample of associate and full professor there is only 3.5% of females. Institutional Prestige matters only at the junior level, with assistant professors employed in the top seven imperial universities having 28% lower probability of exiting compare to their colleagues in the other Japanese universities. As at the entry level, having PIs active in the focal researcher field at her university is associated to lower exit probability at the senior level while this effect is not significant at the pre-tenure level.

Table 6: Base model				
	Model 1		Model 2	
	(before tenure)		(after tenure)	
Female	1.293**	(2.63)	0.713†	(-1.73)
Institutional Prestige	0.720***	(-3.96)	0.886	(-0.83)
Institutional Social Network	1.013	(0.34)	0.761***	(-8.55)
full prof (v. associate)			0.668***	(-5.56)
pub stock	0.969***	(-4.08)	0.952***	(-7.20)
fund stock	0.990	(-1.42)	0.984*	(-2.51)
mobility	0.846*	(-2.19)	0.752***	(-3.96)
job tenure	1.006	(0.64)	0.996	(-0.60)
%univ fund	0.967*	(-2.33)	1.009	(0.42)
field growth	0.500*	(-2.35)	0.778	(-0.61)
ln(#national univ employment)	0.448***	(-14.40)	0.702***	(-4.38)
ln(#private univ employment)	1.083**	(3.03)	1.004	(0.08)
ln(#industrial employment)	0.601***	(-11.02)	0.725***	(-4.56)
ln(#PhD graduate)	2.024***	(13.15)	1.454***	(5.00)
Field dummies	YES		YES	
Year dummies	YES		YES	
#Observation	93474		36402	
#PhDs	5264		3248	
Log likelihood	-8155.526		-4215.055	
χ^2 test	22838.988		10920.459	

Hazard ratios and standard errors (in parentheses) are presented. Two-tailed test. †p<0.1; * p<0.05; ** p<0.01; *** p<0.001.

In the base model we identify an association between being an assistant professor at a top seven imperial universities and the survival probability. Is this effect gender neutral? We tested the interaction effect as done in the previous analysis but we did not find any longer a significant gender effect. We also checked for gender bias in the moderating effect for institutional social network, but we did not find any statistically significant. While when we look at the direct gender effect of the network (see Table 7), male social network is correlated to a lower exit probability especially at the senior level while having female colleagues in the same field and university has a negative effect at the junior level and no effect at the senior level.

Table 7: Base model with gender of the network

	Model 1		Model 2	
	(before tenure)		(after tenure)	
Female	1.244*	(2.23)	0.693†	(-1.86)
Institutional Prestige	0.725***	(-3.85)	0.894	(-0.77)
Institutional Social Network - female	1.304***	(5.90)	1.047	(0.73)
Institutional Social Network - male	0.880**	(-2.90)	0.742***	(-6.93)
full prof (v. associate)			0.669***	(-5.53)
pub stock	0.970***	(-3.93)	0.952***	(-7.20)
fund stock	0.989	(-1.62)	0.984*	(-2.52)
mobility	0.827*	(-2.47)	0.752***	(-3.97)
job tenure	1.006	(0.56)	0.996	(-0.59)
%univ fund	0.960**	(-2.80)	1.005	(0.25)
field growth	0.526*	(-2.17)	0.780	(-0.61)
ln(#national univ employment)	0.475***	(-13.22)	0.705***	(-4.31)
ln(#private univ employment)	1.092***	(3.37)	1.002	(0.03)
ln(#industrial employment)	0.611***	(-10.61)	0.725***	(-4.55)
ln(#PhD graduate)	1.855***	(11.21)	1.446***	(4.90)
Field dummies	YES		YES	
Year dummies	YES		YES	
Observation	93474		36402	
Log likelihood	-8137.691		-4214.707	
χ^2 test	22763.443		10918.758	

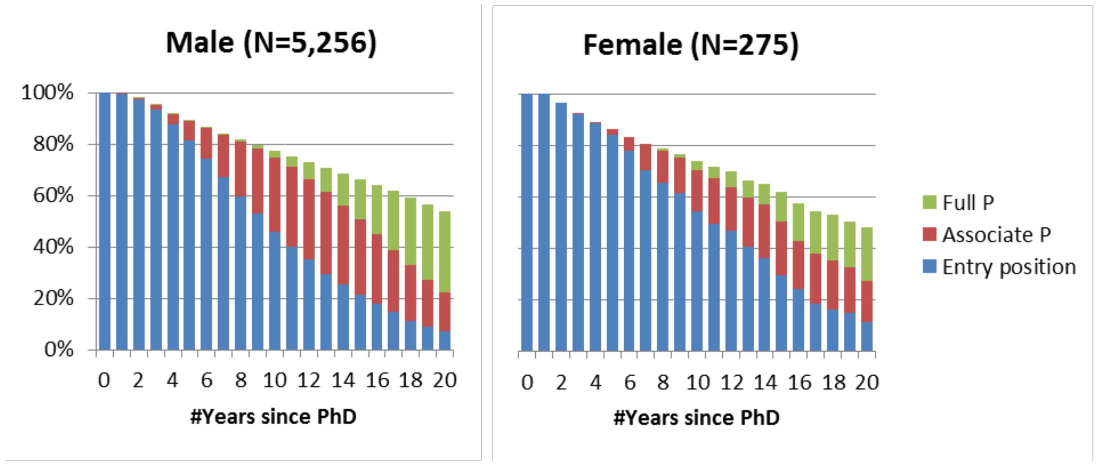
Hazard ratios and standard errors (in parentheses) are presented. Two-tailed test. †p<0.1; * p<0.05; ** p<0.01; *** p<0.001.

As we did in the pre-employment exit analysis, we repeat the gender neutrality analysis presented above including only star PIs in the local university network. Given the small number of female top researchers we present only the analysis for the overall top network that is almost only composed by male scientists. Table 8 presets the results with the interaction term between Gender and Institutional Social Network. Having star colleagues working at the focal researcher university decreases her probability of exit only at the senior lever with an important significant effect only for male researchers.

Table 8: Base model, Star Network with female interaction				
	Model 1		Model 2	
	(before tenure)		(after tenure)	
Female	1.472**	(2.66)	0.511*	(-2.32)
Institutional Prestige	0.717***	(-3.84)	0.980	(-0.13)
Institutional Social Network - top5%	1.008	(0.20)	0.784***	(-4.94)
Institutional Social Network - top5% * female	0.898	(-1.15)	1.353*	(2.14)
full prof (v. associate)			0.686***	(-5.20)
pub stock	0.970***	(-4.04)	0.951***	(-7.38)
fund stock	0.990	(-1.47)	0.987*	(-2.04)
mobility	0.845*	(-2.20)	0.752***	(-3.99)
job tenure	1.007	(0.68)	0.989	(-1.53)
%univ fund	0.970*	(-2.00)	0.998	(-0.11)
field growth	0.498*	(-2.36)	0.833	(-0.44)
ln(#national univ employment)	0.450***	(-14.61)	0.644***	(-5.56)
ln(#private univ employment)	1.082**	(2.99)	1.021	(0.45)
ln(#industrial employment)	0.602***	(-11.06)	0.698***	(-5.13)
ln(#PhD graduate)	2.021***	(13.17)	1.546***	(5.92)
Field dummies	YES		YES	
Year dummies	YES		YES	
Observation	93474		36402	
Log likelihood	-8154.903		-4233.644	
χ^2 test	22838.006		10986.182	

We further examine the career trajectory of the researchers of the cohort 1985-1989. Figure 6 indicates that promotion is generally slower for females than for males; for example, it took 12 years after graduation for half the male researchers to be appointed to associate professors and 15 years for the female counterpart. Females also tend to exit an academic career at a lower rank; among females who were active researchers for 20 years, 29% were still in an entry position, compared to 13% for males.

Figure 6: Career trajectory



5. Conclusions

This study investigated the gender gap in science by following the researcher careers of cohorts of Japanese researchers in STEM fields. Our data confirm that the gender gap is wider in STEM subjects compared to non-STEM fields, and show that a researcher career is more gender-biased than a teaching career. We analyze comparatively the four cohorts of PhD graduates (1985-1989, 1990-1994, 1995-1999, 2000-2004) highlighting an increase share of female researchers continuing in an academic career due to increased enrollment of females in PhD programs. However, the probability of surviving has only slightly decreased especially moving from the first to the second cohort. The intertemporal trend differs considerably by field; while Medicine has become less gender imbalanced, the opposite trend is found in the field of Science. The increasing gap in Science calls for policy action because gender equality is critical in this basic field, where non-academic job opportunity is limited. The increased odds ratio for female employment in Science calls for the design of future academic policies more proactive in the recruitment of female researchers. Though slightly decreasing, the gender gap is greatest in medicine (odds ratio = 2), which produces the largest number of female PhDs. The gender gap is particularly noticeable among the elite universities.

In this paper we devoted much attention to analyze the correlation between institutional social network and exit probability. We find that male researchers tend to benefit more than female of a male social network especially when entering the research career and at the senior level. Over all gender effect are more pronounced when we focus on the most prestigious top scientists network.

Finally, we studied the career path of the oldest cohort highlighting that promotion is generally slower for females and that females also tend to exit an academic career at a lower rank.

References

Cox, D. R. 1972. Regression models and life-tables. *Journal of the Royal Statistical Society Series B-Statistical Methodology*, 34: 187-220.

Estévez-Abe 2013. "An International Comparison of Gender Equality: Why is the Japanese Gender Gap So Persistent?," *Japan Labor Review* 10 (38): 82-100.

Franzoni, C., Scellato, G., Stephan, P. 2012. Foreign-born scientists: Mobility patterns for 16 countries. *Nature Biotechnology*, 30: 1250-1253.

Gebco. 2014. White paper on gender equality 2014. Tokyo: Japanese Government Cabinet Office.

Geuna, A., Shibayama, S. 2015. Moving out of academic research: Why do scientists stop doing research? In Geuna, A. (Ed.), *Global mobility of research scientists. The economics of who goes where and why*: 271-303. San Diego: Academic Press.

Iida, M. 2007. *The history of gia*. Tokyo: The Science News Ltd.

Kaminski, D., Geisler, C. 2012. Survival analysis of faculty retention in science and engineering by gender. *Science*, 335: 864-866.

Kato, M., Chayama, H., Hoshikoshi, A. 2012. Analysis on ratio of women in science in japan, *Research Material*, Vol. 209. Tokyo: NISTEP.

Kuwahara 2001. "Japanese Women in Science and Technology" Minerva Volume 39, Issue 2, pp 203-216.

Long, J. S., Fox, M. F. 1995. Scientific careers - universalism and particularism. *Annual Review of Sociology*, 21: 45-71.

Moss-Racusin, C. A., Dovidio, J. F., Brescoll, V. L., Graham, M. J., Handelsman, J. 2012. Science faculty's subtle gender biases favor male students. *Proceedings of The National Academy of Sciences of The United States of America*, 109: 16474-16479.

Prentice, R. L., Gloeckler, L. A. 1978. Regression-analysis of grouped survival data with application to breast-cancer data. *Biometrics*, 34: 57-67.

Shibayama, S. 2011. Distribution of academic research funds: A case of japanese national research grant. *Scientometrics*, 88: 43-60.

Takahashi, A. M., Takahashi S. 2015. Gender promotion differences in economics departments in Japan: A duration analysis *Journal of Asian Economics*, Volume 41, pp. 1–19.

Takahashi, A.M., Takahashi S. Maloney T. 2015. Gender salary and promotion gap in Japanese academia: Results from science and engineering. Discussion Paper N. 1522, Graduate School of Economics, Kobe Univeristy.

Appendix A: Variables definition

For dataset I, we computed the variables for the university and scientific field of affiliation of each PhD graduate at time of graduation. For dataset II, we computed variables for the university and scientific field of affiliation of each academic in each year. Our career data are incomplete because funding data are available only for the years of funding. Thus, we made imputations based on the latest funding data before the missing years. We identified scientific fields based on funding data.
With the exception of gender and year of graduation that is computed only for the Pre-employment dataset I, all the individual variables are constructed from the GiA database, and thus, available only for Post-Employment dataset II.

List of variables

Type	***Name of variable***	***Description***	***Dataset***
Dependent variable	Exit from academic research career before first academic employment	A dummy variable is coded 1 if the PhD graduate was not nationally funded (as a PI or as a Member of a research project funded by GiA with an official title of at least assistant professor – postdocs are not considered) within eight years after graduation. For the sensitivity analysis, we constructed a dummy variable that is coded 1 if the PhD graduate did not receive national funding within 13 years of graduation.	I
	Exit from academic research career after first academic employment	A dummy variable is coded 1 for the most recent year the academic received national funding and zero otherwise. If the academic received funding in 2010 or later, they are assumed to still be active researchers.	II
Independent variables	Female	We coded a dummy variable 1 for female and 0 for male.	
	Institutional Social Network	Natural log of the number of GiA PIs in the period from t-1 to t-5, in the same university and the same field (excluding duplicates – same researcher being PI more than once in the 5 years period).	I, II
	Institutional Prestige	A dummy variable coded 1 if the academic is affiliated to one of the seven imperial universities: Tokyo, Kyoto, Osaka, Tohoku, Hokkaido, Kyushu, and Nagoya. In the first dataset means being a PhD graduate, in the second being an employee.	I, II
Control factor - Institutional	%Univ fund	We first computed the GiA funds for each intersection of university/field/year, and then, total funds for each field/year. We divided the former by the latter to calculate the proportion of funding distributed to each university in each field. Calculated in the period t-5 / t-1	II
	Field growth	We counted the number of GiA grantees (principal investigators only as in different fields you might have different number of members in the project – average size of the project can be different by field) from first year	II

		after graduation to eight years after and calculate the growth rate. We did the same for total funding by fields and normalize it …….	
Control Factors - Individual	Year of graduation	Year of Graduation	I, II
	Pub stock	The GiA database provides the number of publications resulting from each funded project. We divided this publications count by the number of project members and project duration, in order to compute a yearly publication count for each academic. Since publications counts can differ by field and year, we standardized this measure by field/year mean and standard deviation and then computed the accumulated publications counts prior to each year.	II
	Fund stock	We divided the amount of funding for each project by the number of project members and project duration, and summed them for each year. We standardized this measure by the field/year mean and standard deviation, to compute a stock value.	II
	Mobility	We counted the number of universities to which an academic was affiliated prior to each year.	II
	Job tenure	We computed the number of years of employment of each academic in the university prior to each year.	II
	Full prof	A dummy variable is coded 1 for full professor and zero otherwise.	II
	Associate prof	A dummy variable is coded 1 for associate professor and zero otherwise.	II
	Pre-tenure	A dummy variable is coded 1 if an academic was neither an associate nor a full professor	II
Control Factors - Geographical[1]	ln#National university employment	We collected the number (in ln) of jobs in national universities located in each prefecture as a proxy for academic research jobs.	I, II
	ln#Private university employment	We used the number (in ln) of jobs in private universities to proxy for teaching-oriented job opportunities.[2] This is based on the assumption that national universities tend to be research-intensive and private universities tend to be teaching-oriented.	I, II

[1] We constructed the variables at the level of the 47 prefectures. For dataset I, we computed variables based on the location of the academic's PhD degree awarding university. For dataset II, we computed the variables based on the location of the academic's university affiliation in each year. The same imputation as made for the measurements of institutional factors.
[2] School Basic Survey conducted by the MEXT (http://www.mext.go.jp/b_menu/toukei/chousa01/kihon/1267995.htm).

	ln#Industrial employment	We collected employment numbers (in ln) for each prefecture as a measure of private sector employment opportunities.[3]	I, II
	ln#PhD graduate	We took the number (in ln) of PhD graduates in universities in the same prefecture to measure the labor supply.	I, II

[3] Labor Survey conducted by the Ministry of Internal Affairs and Communications (http://www.stat.go.jp/data/roudou/index.htm). Since data are available from 1997, data for the years 1985-1996 are imputed from year 1997. Employment numbers have been stable since the late 1990s.

Appendix B: Robustness checks base model

Table B1 presents the results of the logit model for only the first three cohorts with a window of 13 years.

Table B1. Base model – Three cohorts, 13 years window						
	Model 1		Model 2		Model 3	
	1985-1989		1990-1994		1995-1999	
Female	1.980***	(9.02)	1.885***	(10.26)	1.687***	(11.26)
year of graduation	1.008	(0.53)	1.021	(0.66)	1.033**	(2.74)
Institutional Prestige	0.853**	(-2.59)	0.848**	(-3.08)	0.801***	(-5.01)
%Univ fund	1.032***	(3.75)	1.018*	(2.26)	1.004	(0.53)
Institutional Social Network	0.654***	(-9.01)	0.704***	(-9.23)	0.796***	(-7.97)
field growth(8-year)	0.334	(-0.67)	4.442	(0.50)	19.280†	(1.76)
ln(#national univ employment)	0.809**	(-2.86)	0.919	(-1.45)	0.851**	(-3.00)
ln(#private univ employment)	1.045*	(2.14)	0.988	(-0.57)	0.985	(-0.76)
ln(#industrial employment)	0.987	(-0.28)	1.044	(1.02)	1.025	(0.66)
ln(#PhD graduate)	1.121†	(1.89)	1.070	(1.26)	1.105*	(2.09)
Field dummy	YES		YES		YES	
N	13776		18387		27236	
Log likelihood	-8862.106		-1.15e+04		-1.63e+04	
χ^2 test	510.315		641.909		767.225	

Odds rations and standard errors (in parentheses) are presented. Two-tailed test. †p<0.1; * p<0.05; ** p<0.01; *** p<0.001.

Appendix C: Model estimations for gender neutrality

Table C1: Base model with female interaction - Logit regression								
	Model 1		Model 2		Model 3		Model 4	
	1985-1989		1990-1994		1995-1999		2000-2004	
Female	-0.103	(-0.24)	0.405	(1.17)	0.325	(1.18)	-0.168	(-0.75)
Institutional Prestige	-0.195**	(-3.12)	-0.146**	(-2.64)	-0.230***	(-4.97)	-0.132**	(-3.11)
Institutional Social Network	-0.423***	(-8.57)	-0.388***	(-9.56)	-0.253***	(-8.15)	-0.252***	(-8.56)
Institutional Social Network * female	0.158†	(1.81)	0.039	(0.57)	0.036	(0.70)	0.126**	(3.03)
%Univ fund	0.032***	(3.70)	0.030***	(3.65)	0.010	(1.46)	0.002	(0.29)
year of graduation	-0.001	(-0.06)	0.034	(1.08)	0.029*	(2.38)	0.075***	(4.79)
field growth(8-year)	-0.537	(-0.32)	1.793	(0.58)	1.279	(0.73)	0.306	(0.17)
ln(#national univ employment)	-0.213**	(-2.76)	-0.150*	(-2.44)	-0.142*	(-2.50)	-0.075	(-1.35)
ln(#private univ employment)	0.068**	(3.19)	-0.009	(-0.40)	-0.019	(-0.91)	-0.025	(-0.97)
ln(#industrial employment)	-0.036	(-0.74)	0.044	(1.01)	0.070†	(1.77)	0.135***	(3.61)
ln(#PhD graduate)	0.077	(1.24)	0.091	(1.63)	0.055	(1.10)	-0.014	(-0.27)
Field dummy	YES		YES		YES		YES	
N	13776		18387		27236		35585	
Log likelihood	-8486.650		-1.10e+04		-1.54e+04		-1.83e+04	
χ^2 test	531.881		610.557		673.994		827.870	

Coefficients and standard errors (in parentheses) are shown. Two-tailed test. †p<0.1; * p<0.05; ** p<0.01; *** p<0.001