GRANteD

GRANT ALLOCATION DISPARITIES FROM A GENDER PERSPECTIVE

Project no.	824574
Project acronym:	GRANteD
Project title:	Grant Allocation Disparities from a Gender Perspective
Instrument:	H2020-SwafS-2018-2020/H2020-SwafS-2018-1
Start of the project:	01.01.2019
Duration:	50 months

Work Package: 3.2

THE MAKING OF A PROFESSOR: A LARGE-SCALE LONGITUDINAL ANALYSIS TO REVEAL GENDER DISPARITIES IN SCIENCE CAREERS

Due date of deliverable:	Month 36
Organisation name of lead contractor for this deliverable:	Forskningspolitik Sverige AB

Other partners involved:

Document version: VERSION 3

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 824574.

Abstract

This study examines gender disparities in grant-giving procedures and academic careers using a large data set consisting of researchers with PhD dissertations in Sweden from 1985 to 1994. The data set tracks the researchers' careers until 2020 (i.e., for all or a large part of the pre-retirement period) – a period of about 40 years. It also includes information on publications in scientific journals and applications to Swedish funding agencies. In the natural sciences area, the results indicate a consistent male advantage in grant success. We do not find such differences in the time to professorship but, considering that the results also indicate that number of grants has a statistically significant effect on time to professorship, the potential gender disparities in the grant-giving procedures can be assumed to (indirectly) affect women's careers negatively. In the medical sciences area, the results indicate that men had an advantage concerning grant success in the period before 1997, but there are no such indications concerning the periods from 1997 and after, and the results concerning time to professorship point to an advantage for women when taking merits (grants and publications performance) into account.

Name	Organisation	Contribution
ULF SANDSTRÖM	Forskningspolitik Sverige AB	Main author 1
ERIK SANDSTRÖM	Osier Legal Tech AB	Main author 2
LUIS SANZ	CSIC	Written feedback
PETER VAN DEN BESSELAAR	TMC	Written feedback

Dissemination level	
PU	Public

Consortium: The GRANteD consortium consists of six partners:

JOANNEUM RESEARCH Forschungsgesellschaft mbH (JR) (project leader, Austria),
FORSKNINGSPOLITIK SVERGIE AB (WP 3 leader) (Sweden),
OREBRO UNIVERSITY (ORU) (Sweden),
AGENCIA ESTATAL CONSEJO SUPERIOR DE INVESTIGACIONES CIENTIFICAS (CSIC) (Spain),
DEUTSCHES ZENTRUM FUR HOCHSCHUL- UND WISSENSCHAFTSFORSCHUNG GMBH (DZHW) (Germany),
TERESA MOM CONSULTANCY BV (TMC) (Netherlands)

Keywords: research councils, project registers, career, survival analysis, gender bias

To address questions and comments please contact: forskningspolitik@gmail.com

THE MAKING OF A PROFESSOR: A LARGE-SCALE LONGITUDINAL ANALYSIS TO REVEAL GENDER DISPARITIES IN SCIENCE CAREERS

Erik Sandström & Ulf Sandström

2022-05-18

Introduction

Work Package 3 (WP3) of GRANteD includes the objectives to study the careers of a large number of researchers and their research funding (or lack of funding) and how potential biases in funding agencies' procedures affects the careers. Based on the heuristic model laid out in GRANteD's D2.1 report (Fig. 1), the general hypothesis for such studies is that: (a) publication performance can impact grant allocation; (b) grant allocation and publication performance can impact careers; and (c) bias in the grant allocation can, thus, impact the careers of researchers.

Against this background, this report explores to what extent funding grants influence careers and to what extent there are gender disparities in the allocation of such grants. Here, this is done using a data set of 3,074 researchers with PhD dissertations in Sweden from 1985 to 1994, to whom we have connected publications in international scientific journals and research applications to Swedish funding bodies, from 1981 until 2019/2020.

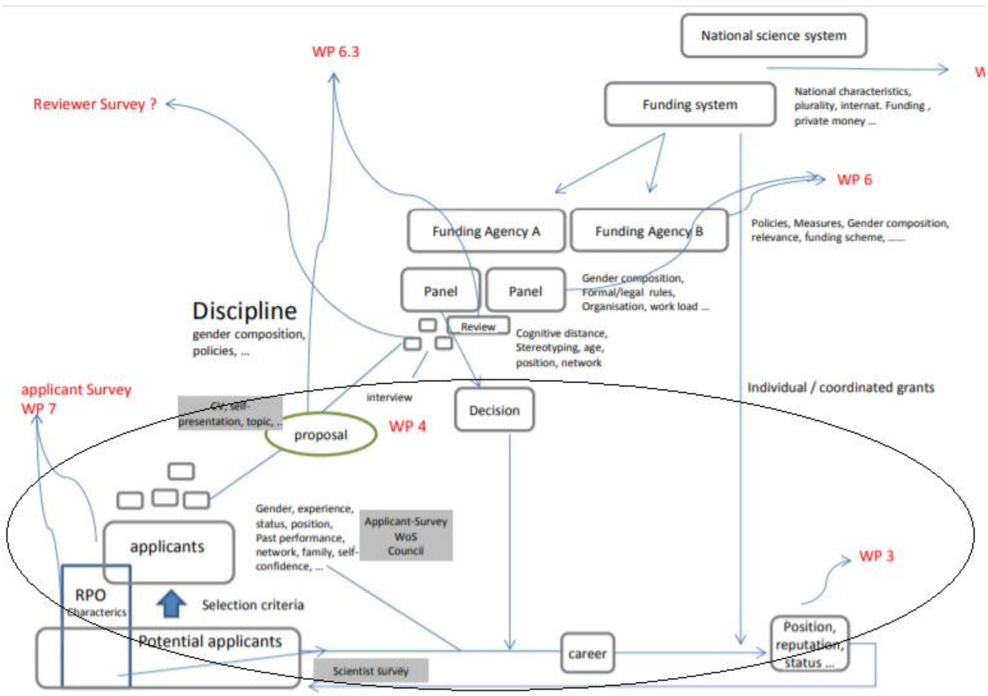


Figure 1. The GRANteD heuristic model, adapted from D2.1 report. WP3 focuses on the lower parts of the model (marked with an ellipse)

In a first analysis, we evaluate potential gender disparities in grant decisions using large-scale application data based on project registers held by Swedish funding agencies. The results of this analysis feed into the next analysis – time to professorship – where we study the indirect impact of the grant decisions on the battle for professorship. For the latter analysis, we have primarily used data from personnel registers from Swedish universities to determine if and when the researchers in our study were promoted to professor status.

In addition to career and application data, data on research publications is vital for the analyses set out in this report. As noted above, the publications are parts of the researchers' merits and how they build their careers. The merits are evaluated by the panels assigned by the funding agencies and will also lay the groundwork for the steps to professorship. We have, therefore, connected publication data to the researchers in our study and calculated bibliometric indicators to serve as proxies for the merits of the researcher at given times of their careers (e.g., when applying for grants). Partly based on Wennerås & Wold (1997), who used sum of journal impact factors, we have used a normalized journal citation score as a proxy for such merits; Wennerås & Wold's results showed that such an indicator is strongly correlated to the competence score assigned by the panels in funding agencies.

The use of bibliometric indicators, thus, plays an important role in the understanding of potential gender differences. One point of departure for the GRANteD project is to avoid naïve residualism (Cole 1987), i.e., we do not consider an observed difference between men and women as evidence of gender biased (cf. Cruz-Castro & Sans-Menendez 2019). At the same time, we do not conclude that there is equality in in grant allocation when there is equal distribution between the sexes. Observed difference as well as observed equality may hide an underlying gender bias and in our view these situations can only be revealed by inclusion of other relevant variables (ibid.).

Discussions and Policy Interventions

The study of gender disparities in research continues to be controversial. Current research activities are characterized by contradicting results and varied findings concerning the main topics (e.g., disparities in productivity, in impact, in collaboration, in careers, and in grant success). Here, we refrain from detailing these discussions but, instead, highlight some of the main issues and findings in relation to the topics of this report.

In this report, we focus on the battle for professorship and the role of the funding agencies in that battle. Becoming a professor implies a more powerful position and a better access to manpower and other resources (Dryler 2006, p. 69). In short, when in a research career, it is desirable to have the title of a professor. In comparison with other teachers and researchers, the group as a whole has a higher status, higher salary, more influence on the work environment, and better chances to raise resources from external financiers; see Nyberg (1993) for an illustration of the power of professors in gathering of resources from funding agencies.

In relation to the competition for positions at universities, several policy measures have been implemented in Sweden during the period under investigation in this report, a period in research policy discussions that has been characterized by a lively political discussion on gender equality:

- In the mid-1990s, a provision was added to the Swedish Higher Education Ordinance to specifically regulate affirmative action for the underrepresented gender in appointment to positions at Swedish universities (Chapter 4, section 16 of the Higher Education Ordinance, SFS 1998:1003), but the provision was removed in 2011.
- According to a Swedish Government Bill from 1995, each Swedish university should have goals for improving the gender distribution among newly recruited professors (Government Bill 1994/95:164, p. 37).
- In 1999, the Swedish government introduced a promotion reform that entailed a system change in such a way that promotion to professor in competition was supplemented with promotion on own merits only.[1] It was underlined that the criteria for eligibility and qualification as a professor should be kept intact, and as a whole this also seemed to be the case (Abrahamsson et al. 2003; Riis, Hartman & Levander 2011; Riis 2012). Small changes could be identified though, with some more emphasis on teaching qualifications and a little less emphasis on scientific qualifications. Danell and Hjerm (2013, p. 1001) point out that "[…] professor changed from a position to a title".

Between 2000 and 2020, the share of women among professors at Swedish universities increased from 13 to 31 percent.[2] During the same period, teaching and research staff at Swedish universities expanded from about 23,000 to over 30,000.[3]

In the research literature, gender equality problems in academia have often been illustrated by metaphors such as a narrowing pyramid, a leaky pipeline, a glass ceiling, and that women disappears in "a black hole". These metaphors could be misleading as they seem to assume that all students who start a course at the university are aiming for a career that will take them to the top positions, i.e., a professorship at a university. The pipeline metaphor with its normative view on academic careers has been challenged by Xie & Shauman in their book *Women in Science: Career Processes and Outcomes (2005).* Using large surveys, they were able to demonstrate the complexities of careers at various career stages, and that both men and women enter the pipeline at later stages, goes in and out and sometimes enter again to the university.

In the Swedish setting, the question about women's representation at university positions has been rather thoroughly investigated. In a state agency report, Dryler (2006) concluded that women were diverted and disappeared from the scholarly career; her longitudinal investigation indicated that it was twice as likely for a man as for a woman to become a professor. Chrapkowska (2006) reported the same finding. However, the opposite was found by Fridner (2004), who organized three studies based on quantitative and qualitative data with descriptive statistics regarding the academic positions of graduates from all medical departments in Sweden during the 1990s, she also included life history questionnaires. Her results indicated that there was not a "leaky pipeline" in academic medicine after graduation.

[1] It has been indicated that women seeking promotion had about the same probability as men of being promoted, or even a slightly greater chance of promotion (HsV report 2003; Dryler 2006, p. 71; Riis 2012).
[2] Swedish Higher Education Authority (UKÄ), Report 2021:22, p. 60, and Report 2010:10, s. 71.
[3] Swedish Higher Education Authority (UKÄ), Short version of annual report 2001, p. 28, and Report 2021:22, p. 81.

Instead, gender equality was reached, even if women tended to conform to "existing male norms".[4]

The assumption that women tend to leave the academy at a higher rate than men is widespread but mainly based on cross-sectional studies – only a few have studied the problem with a longer timeframe. Therefore, the Dryler report (2006) is an important contribution. It is a cohort study that goes back in time and follow people from an early career stage to later stages.

Another large cohort study Silander (2010), who conducted a survey of all Swedish doctorate graduates of 1993 – a total of 1,036 individuals, of which 30 percent were women. Using multiple regression analysis, Silander examined the relationship between, on the one hand, exit from the academy, and, on the other hand, gender, marital status, age, children, time after doctoral degree, and faculty affiliation. The results indicated that the shares of male PhDs who has left academia within one, five and ten years (respectively) after their dissertation are higher than the corresponding shares of women who has left academia within such time periods (see also Danell and Hjerm 2013).[5] Consequently, with these data, the pipeline turned out to be reversed, proportionally it throws out more men than women. A similar finding was made by Anaya-Carlsson & Melin (2007), who showed women are more likely than men to be employed at a university after completing a doctoral degree.

Childcare had some, but limited significance for the exit "decision" in the Silander study; those with younger children were more likely to exit and this tendency was more pronounced for women with children than for men with children. This corroborates findings by Fox and earlier by Long from another country (Fox 2005; Long 1990). Marital status had no demonstrable effect on exit (as "married" was also counted common law partners and cohabiting relationships with children, while cohabitants without children were counted as unmarried). Overall, exit from the academy was not significantly affected by the fact that an academic career is difficult to reconcile with family formation. With increasing age, the probability of exit increases and this tendency is more pronounced for men than for women. Time after the doctoral degree is also important; the probability of exit increases with time and covaries with gender so that women who leave the academy do so later than men who leave.

Silander (2010) takes it even further. In her view, women remain in academia, but advance to a lesser extent than men and, therefore, it is women's slower career development that should be in focus. In her findings, there is a notion of a *delayed* career for women. (Silander 2010, p 146).[6]

Silander worked with data from *Statistics Sweden* and likewise did Danell & Hjerm (2013) in their analysis of time to professorship in Sweden based on data covering 1995-2010. Their results indicate substantial gender disparities but they excluded PhDs from medical faculty

[4] Section based on Silander (2010).

[5] Silanders' study, which is based on data from Statistics Sweden, consider those who work at universities or public research institutions (according to Statistics Sweden's classification) to be within academia (regardless of position).

[6] This delayed career is illustrated in Figure 6 (below) for the natural sciences but not for the medical sciences.

due to data uncertainties.[7] There are, however, several studies that indicate gender disparity in MFR council procedures to the benefit of male applicants. For example, the Analysis Division of the Swedish Science Research Council (SRC) has published a multitude of reports showing disparity due to gender in success rates for the medical sub-council of the SRC (see SRC 2006, 2010).

Gender differences in grant application success have been studied widely over the last decades. Some studies report that women have to perform better to receive the same evaluation scores as men (Wennerås and Wold 1997) or a higher probability of receiving a research grant (e.g., Bornmann et al. 2007; Witteman et al. 2019), whereas other studies suggest that grant success differences are due to the lower publication productivity of women (e.g., Fridner et al. 2015). Again, other studies have compared men's and women's grant applications and found men to be more successful in terms of number of grants awarded but also in terms of sums awarded (Waisbren et al. 2008). However, when Waisbren et al. controlled for academic rank, they found men and women to be equally successful in acquiring grants, and they attributed this to a political pressure for equal treatment of men and women and a concomitant and increased awareness within research councils. This finding was supported by a meta-analysis of Marsh et al. (2009).

Research Questions and Model Specification

The objective of this report is to explore: (a) if there are gender disparities in the allocation of research grants by Swedish funding agencies; and (b) if such potential disparities (indirectly) create gender disparities in academic careers. This requires both a longitudinal perspective (the career dimension) and extensive data concerning grant applications, applicants, and researcher merits (to avoid naïve residualism).

To accomplish this, we have created a data set consisting of 3,074 researchers with PhD dissertations in Sweden from 1985 to 1994. For each researcher, we have added information about grant applications to Swedish funding agencies and publications in international scientific journals (from 1981 to 2019/2020). The data set also includes information concerning whether (and when) the researchers have been promoted to professor status. This allows us to evaluate the grant applications made by this group, to take publication performance into account in such evaluation, and to explore the long-term impact of the grants (or lack of grants) on the academic careers of these researchers.

Using this data set, we perform two separate analyses. The first analysis studies the effects of gender on grant decisions for applications to Swedish funding agencies, taking publications performance (and some other variables) into account (using regression analysis). In the second analysis, we use survival analysis to study gender differences in promotion to professorship and the impact of grant decisions and publication performance on such promotions.

---

[7] Danell & Hjerm (2013) report that a financed post-doc position is strongly associated with a career in research that is finalized with a professorship. The same result is reported by Nordquist et al. (2009) in a SRC report that follows a group of post-doc positions financed by the medical sub-council.

In our longitudinal approach, we are inspired by Silander's dissertation from 2010; Sabatier (2010) on the glass ceiling; Danell & Hjerm (2013) on the role of early career opportunities; Sanz-Menendez, Cruz-Castro & Alva (2013) informing about several internal university-related circumstances (social embeddedness) and the negative mobility factor[8]; Kaminski & Geisler (2012) and Box-Steffensmaier et al. (2015) contribute with data on faculty retention. Several of these papers use survival analysis, which now form the standard practice for studies of retention, time to tenure, or time to professorship.

In comparison with earlier studies, our study has several potential advantages:

- This report uses longer time periods than most studies.
- This report studies both academic careers and grant success, and takes the latter into account when analyzing the former
- This report takes bibliometric indicators into account to evaluate if publication performance can explain (or illuminate) gender differences.

Data and Methods

Data Collection

The data collection is described in detail in Appendix 1. In summary:

- We have used the Libris database at the Swedish Royal Library (KB) to find PhD dissertations published at Swedish universities from 1985 to 1994 (inclusive). We have then limited the selection to a set of 3,074 authors (researchers).
- We have collected information from personnel registers at Swedish universities (and various other sources) to add information about if and when (what calendar year) the researchers were promoted to professor status (full, promoted, or deputy).
- We have collected information from the registers of Swedish funding bodies on about 350,000 grant applications from 1981 to 2020 (inclusive) and identified which applications were submitted by any of the researchers in our study.
- We have used Web of Science (WoS) to collect information about publications in international scientific journals from 1981 to 2019(inclusive) by the researchers in our study.
- We have taken the decision to focus the study on two areas only: the medical sciences area and the natural sciences area. The decision is partly guided by the need to have a certain amount of WoS publications over the full period from 1980s until today, partly by the need to have a sufficient number of researchers in each included sciences area (the medical and the natural sciences areas have most researchers assigned to them).

[8] Same finding on the role of the mobility factor is reported in Nordquist et al. (2009), to have a post-doc abroad is not a booster to the career for Swedish assistant professors.

***Statistical analysis*[9]**

The statistical analysis is divided into two main parts. In the first part, we perform binary logistic regression to analyze potential gender disparities in the funding agencies' grant-giving procedures. The regression is performed on all grant applications[10] in the data set for which any of the researchers in the study have been main applicant, starting from the calendar year of their respective PhD dissertations.

In Table 2, we define all variables used in the regression. The nature of the dependent variable – grant success – makes binary logistic regression a relevant alternative. However, since the coefficients of a binary logistic regression can be hard to interpret, especially when including interactions (Norton, Wang & Ai 2004), we also estimate the Average Marginal Effects (AMEs) of each variable. The AME for the change of variable (e.g., changing the gender variable from female to male) represents the difference in the average prediction over all observations when the variable is fixed to the new value (e.g., male) compared to when the variable is fixed to the baseline (e.g., female). Hence, in the case of gender in our regression, the AME represent the estimated average effect of gender on the predictions of grant success.

Table 2. Definition of variables for binary logistic regression

Label	Definition	Type
Grant Success	Board decision (granted vs. rejected)	Dichotomous
Male	Gender (male vs. female)	Dichotomous
Professor	Academic status of main applicant (professor vs. non-professor) according to the information in the applicable application register	Dichotomous
Age at PhD	Age (in full years) of main applicant at the end of the calendar year in which his/her PhD dissertation was published	Continuous
Experience	Full years from the PhD dissertation of the main applicant to the end of the calendar year in which the application was registered	Continuous
NJCS (ln)	Natural logarithm of the sum of the fractionalized normalized journal citation impact of the main applicant (with addition of 1 to manage zeros), based on WoS papers published during the five[11] calendar years preceding the calendar year in which the application was registered; see further information in the next section.	Continuous
Organization	Affiliation of main applicant (full university, special university, or other)[12]	Categorical
Body	The funding body that the application was made to (BFR, EM, Formas, MFR [incl VR-MH], NFR [incl SJFR and VR-NT], TFR, or Vinnova)	Categorical

In the second part, we use survival analysis to evaluate gender differences in the time to professorship and the effects of research grants and publication performance on the potential disparities. We perform the analysis both for all the researchers in the study and for the sub-group of researchers who have been promoted to professor. In the former case, the survival

[9] The statistical analysis has been performed in R 4.05, using the "margins" package (Leeper TJ 2021) for calculations of AMEs, the "survival" package (Therneau 2021) for Kaplan-Meier and Cox PH, and the "eha" package (Broström 2020) for AFT.

[10] We have excluded applications to the small foundations (CF, HLF, and SSMF) since we only have records of granted applications from these sources.

[11] The length of the period has been selected based on tests of which length provides the lowest *Akaike information criterion* (AIC) for the regression.

[12] See appendix 1 for definitions; full universities are defined as those with several faculties, while special universities are based on one faculty/area.

analysis has some "right censorship", considering that not all researchers have been promoted to professor.

Following standard practice for evaluation of time-to-event differences, we start by graphically depicting the potential differences with nonparametric Kaplan-Meier curves and comparing the curves using log-rank tests. The Kaplan-Meier curves represent the cumulative probability that the event (here professorship) has not happened to a subject at a given time.

Further, time to professorship has been modelled using semi-parametric Cox proportional hazards regression (Cox PH, see Cox 1972). Along with Kaplan-Meier curves, Cox PH is the dominant method for the analysis of risk of promotion (Sanz-Menéndez, Cruz-Castro & Alva 2013). It allows for estimation of hazard (risk of professorship) without the need to make parametric assumptions about the form of the baseline hazard (Box-Steffensmeier et al. 2015) and is expressed by the hazard function *h(t)*, which can be interpreted as the risk of the event (here professorship) happening at time *t*:

$$h(t) = h_0(t) \times exp(X_1 \beta_1 + X_2 \beta_2 + ... + X_p \beta_p)$$

where h_0 is the baseline hazard, t is the "survival" time, X_p is covariate p, and β_p is the impact of covariate p (i.e., the parameter to estimate).

Table 3. Definition of variables for Cox PH and AFT

Label	Definition	Type
Time to Professorship	Full years from the PhD dissertation of the researcher to the end of the calendar year in which he/she was promoted to professor; the time of those who have not been promoted to professor have been censored at the end of 2020 or, if earlier, the end of the calendar year in which they deceased or turned 65.	Continuous
Male	Gender (male vs female)	Dichotomous
Age at PhD	Age (in full years) of the researcher at the end of the calendar year in which his/her PhD dissertation was published	Continuous
Grants (ln)	Natural logarithm of the number of the grants (with addition of 1 to manage zeros), based on applications registered during the nine[13] calendar years preceding the observed calendar year (time-varying)	Continuous
NJCS (ln)	Natural logarithm of the sum of the fractionalized normalized journal citation impact of the main applicant (with addition of 1 to manage zeros), based on WoS papers published during the nine (see note above) calendar years preceding the observed calendar year (time-varying); see further information in the next section.	Continuous

Cox PH relies on the assumption that that the risks of the event are proportional over the study period for the groups being compared. To avoid such assumptions, which are not necessarily true for risk of promotion, it has been suggested that parametric accelerated failure time models (AFT) could be better suited for modelling risk of promotion (Sanz-Menéndez, Cruz-Castro & Alva 2013).

Therefore, for comparison with Cox PH and for evaluation of the robustness of the results, time to professorship has also been modelled using AFT, each time choosing the model with the best fit (among the following: Exponential, Weibull, Gompertz, and Log-Logistic) according to the standard Akaike information criterion (AIC). To facilitate interpretation of the AFT, we

[13] The length of the period has been selected based on tests of which length provides the lowest AIC for the regression

have calculated "life expectancy" ratios (time-ratios), which represent the estimated factor by which a variable affects time to professorship (a value over one indicates that the variable has the effect of increasing the duration).

The variables used in the Cox PH and AFT are defined in Table 3 (above). Both Grants (ln) and NJCS (ln) are time-varying and are calculated for each calendar year after the PhD dissertation of the researcher until the calendar year the researcher was promoted to professor (or censored). Further details about the bibliometric indicator (NJCS) are set out in the next section.

Bibliometric methods

Our publication analysis is based on papers from Web of Science (WoS Core Collection; SCI-E, SSCI and AHCI). For each of the researchers in our study, information about the papers (articles, letters, proceeding papers, and reviews) published between 1981 and 2019 (inclusive) have been downloaded. The normalized journal citation score (NJCS) has been calculated for each paper as the average normalized citation score of all papers published in the same journal, during the same "publication year", and with the same document type (article, letter, proceeding papers, or review). The normalization is carried out by dividing the number of citations to a paper by the mean number of citations to a paper in the same WoS journal subject category, publication year, and document type.[14]

In order to calculate the NJCS for the applicant/researcher in this report, we aggregate the NJCS for all papers published by the applicant/researcher during the application years (see Table 2 and 3). Consequently, the indicators are size-dependent; however, we use *fractional counting,* by first multiplying the NJCS of each paper with the quotient between 1 and the number of authors of the paper.

We consider the NJCS as a reputation-oriented indicator; the more experienced and visible researchers will tend to be published in higher impact journals. For the analyses in this report, where we evaluate the behavior of panels at funding agencies and universities, NJCS is relevant since it can be regarded as a proxy of the strength of the publication lists provided by the applicant/researcher to panels.[15] This indicator is a modernized version of the Journal Impact Factor (JIF) formerly published by the WoS. As indicated above, Wennerås and Wold used the sum of JIF for their calculations in Nature (1997).

For further information and details about the applied bibliometric methods, see Sandström (2014).

---

[14] Self-citations have been deleted based on first author names

[15] We have conducted test where this indicator has been replaced by an indicator that sums a researcher's shares of highly cited papers (top 10 % in the relevant field). However, while we have found that they are largely interchangeable for the analysis in this report, NJCS generates lower AIC values for the various models.

Results

Gender differences in the funding agencies' grant-giving procedures

The analysis is performed – and the descriptive statistics and results presented – for three historical periods: 1981 - 1996, 1997 - 2005, and after 2005 (see Appendix 1 concerning the periodization). Apart from representing different historical sections (which may have different grant-giving procedures), the periods also represent different parts of the applicants' careers, since we follow the same group of potential applicants across the three periods. Tables 4a-c provide descriptive statistics for the observations (applications) and variables included in the analysis of gender differences in the funding agencies' grant-giving procedures.

The results of the binary logistic regression (coefficients and AMEs) are set out in in Tables 5a-5c, both for models with the basic variables and for models that include potential interactions between gender and other variables. [16] The AMEs of gender, NJCS, and professorship are also presented in Fig. 2-4 (based on the models with interactions).

Unsurprisingly, the results indicate that higher publication performance (NJCS) by the main applicant prior to the application has a positive – and statistically significant – effect on the chances of grant success. As can also be expected, higher academic status (professorship) generally has a positive effect as well.

With regard to gender, there is a consistent and statistically significant difference in the natural sciences area that the other variables cannot account for. For the medical sciences area, there is a difference in the first period, but it appears to diminish over period two and three. It should, however, be noted that the changes between the three historical periods to some extent could be an effect of the different stages of the applicants' careers, with the mean age and experience naturally being higher in the later periods.

It can be noted that the pseudo R^2 of the regressions are low, although they should not be compared to the R^2 of a linear regression, since the McFadden pseudo R^2 is expected to be considerably lower (McFadden 1977). This suggest that additional variables should be included in further studies.

[16] Apart from the variables reported in the Table, we have also controlled for differences between funding agencies; see Table 1.2 above.

Table 4a. Descriptive statistics for binary logistic regression (before 1997)

	Medical Sciences		Natural Sciences	
	Women	Men	Women	Men
Number of Observations (Applications)	535	1065	650	2632
Grant Success (%)	31.21	44.88	47.23	59.00
Professor (%)	1.68	3.94	0.31	3.12
Age (mean; SD in parentheses)	38.5907 (6.5233)	38.1512 (5.1389)	37.5954 (5.3319)	36.5243 (4.2402)
Experience (mean; SD in parentheses)	3.8243 (3.0848)	4.3944 (2.7297)	3.8431 (2.8925)	4.3803 (2.8699)
NJCS (ln) (mean; SD in parentheses)	1.0656 (0.5806)	1.522 (0.6741)	1.1128 (0.5833)	1.4079 (0.7008)
Full University (%)	52.34	49.01	68.46	63.53
Special University (%)	39.44	44.98	18.31	21.88
Other Organization (%)	8.22	6.01	13.23	14.59

Table 4b. Descriptive statistics for binary logistic regression (1997-2005)

	Medical Sciences		Natural Sciences	
	Women	Men	Women	Men
Number of Observations (Applications)	1172	2392	835	2574
Grant Success (%)	51.45	59.91	47.31	56.06
Professor (%)	14.68	19.94	19.28	35.51
Age (mean; SD in parentheses)	45.6007 (7.015)	43.6242 (5.5905)	43.8455 (5.9933)	43.27 (5.0574)
Experience (mean; SD in parentheses)	10.2901 (3.9525)	10.2993 (3.8079)	10.3976 (4.1039)	11.0412 (3.9298)
NJCS (ln) (mean; SD in parentheses)	1.2175 (0.6307)	1.7277 (0.6913)	1.1717 (0.6993)	1.5815 (0.7721)
Full University (%)	57.08	49.12	72.93	60.96
Special University (%)	36.09	44.65	20.00	26.61
Other Organization (%)	6.830	6.230	7.070	12.430

Table 4c. Descriptive statistics for binary logistic regression (after 2005)

	Medical Sciences		Natural Sciences	
	Women	Men	Women	Men
Number of Observations (Applications)	804	1390	567	1881
Grant Success (%)	35.95	36.62	30.34	37.80
Professor (%)	68.41	77.99	72.84	76.98
Age (mean; SD in parentheses)	56.2326	55.0597	53.8871	54.2823
	(6.3404)	(6.3384)	(5.8092)	(5.3771)
Experience (mean; SD in parentheses)	21.3918	21.6648	21.7284	22.3546
	(4.8987)	(4.9172)	(4.9869)	(5.18)
NJCS (ln) (mean; SD in parentheses)	1.3286	1.5962	1.2721	1.4522
	(0.6672)	(0.7878)	(0.767)	(0.8175)
Full University (%)	55.72	55.47	64.90	52.63
Special University (%)	37.94	32.16	20.81	30.25
Other Organization (%)	6.340	12.370	14.290	17.120

Table 5a. Binary logistic regression of grant success (before 1997)

	Medical Sciences		Natural Sciences	
	No Interactions	With Interactions	No Interactions	With Interactions
Male	0.3204*	0.2853	0.2224*	0.3473**
	(0.0656*)	(0.0498)	(0.0491*)	(0.0510*)
Professor	0.3808	1.5469	0.4681	0.5433
	(0.0800)	(0.1181)	(0.0987)	(0.0937)
Age at PhD	-0.0059	-0.0833***	-0.0566***	-0.0376
	(-0.0012)	(-0.0021)	(-0.0124***)	(-0.0131***)
Experience	0.2036***	0.3072***	0.0406**	-0.0065
	(0.0416***)	(0.0407***)	(0.0089**)	(0.0083**)
NJCS (ln)	0.5482***	0.7473***	0.5412***	0.6088***
	(0.1122***)	(0.1184***)	(0.1182***)	(0.1186***)
Special University (ref Full University)	-0.4297***	-0.6535**	-0.1786	0.2984
	(-0.0873***)	(-0.0851***)	(-0.0392)	(-0.0350)
Other Organization (ref Full University)	0.3816	0.8186*	-0.2830*	-0.3329
	(0.0810)	(0.0882)	(-0.0624*)	(-0.0652**)
Male # Professor		-1.3899		-0.1266
Male # Special University		0.3078		-0.5765*
Male # Other Organization		-0.5642		0.0449
Male # Age at PhD		0.0998***		-0.0284
Male # Experience		-0.1438**		0.0564
Male # NJCS (ln)		0.2184		-0.0809
Intercept	-0.4596***	-0.4164**	0.3816***	0.2797*
N	1600	1600	3282	3282
Pseudo R^2 (McFadden)	0.12	0.13	0.09	0.09
AIC	1929.3	1909	4134.6	4137.5

Notes: The values represent the coefficients, with AMEs in parentheses
Continuous variables have been centered
$*$ $p < 0.05$, $**$ $p < 0.01$, $***$ $p < 0.001$

Table 5b. Binary logistic regression of grant success (1997-2005)

	Medical Sciences		Natural Sciences	
	No Interactions	With Interactions	No Interactions	With Interactions
Male	0.0663 (0.0153)	0.3650** (-0.0036)	0.1336 (0.0301)	0.4534*** (0.0433*)
Professor	0.1976 (0.0449)	0.8835*** (0.0501*)	0.3067** (0.0681***)	0.9305*** (0.0724***)
Age at PhD	-0.0018 (-0.0004)	-0.0281* (-0.0006)	-0.0634*** (-0.0142***)	-0.0442* (-0.0140***)
Experience	-0.0500*** (-0.0115***)	-0.0442** (0.0118***)	-0.0874*** (-0.0196***)	-0.1388*** (-0.0200***)
NJCS (ln)	0.6093*** (0.1398***)	0.7308*** (0.1471***)	0.4452*** (0.0995***)	0.1569 (0.0971***)
Special University (ref Full University)	-0.2925*** (-0.0672***)	0.0038 (-0.0701***)	-0.0643 (-0.0145)	0.0322 (-0.0181)
Other Organization (ref Full University)	-0.1811 (-0.0413)	0.0652 (-0.0444)	-0.5207*** (-0.1180***)	-0.7702* (-0.1321***)
Male # Professor		-0.9808***		-0.7933**
Male # Special University		-0.4693**		-0.1504
Male # Other Organization		-0.3958		0.2370
Male # Age at PhD		0.0382**		-0.0250
Male # Experience		-0.0114		0.0649**
Male # NJCS (ln)		-0.1227		0.3730**
Intercept	0.3960***	0.2527**		-0.0771
N	3564	3564	3409	3409
Pseudo R^2 (McFadden)	0.05	0.06	0.08	0.08
AIC	4659.9	4629	4374.4	4365.1

Notes: The values represent the coefficients, with AMEs in parentheses

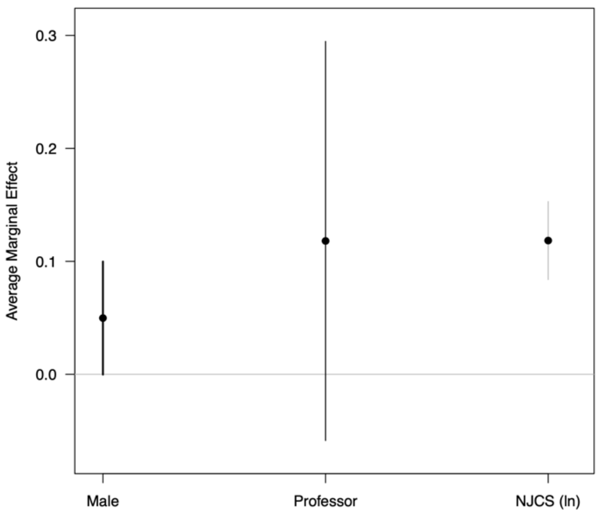
Continuous variables have been centered

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

Table 5c. Binary logistic regression of grant success (after 2005)

	Medical Sciences		Natural Sciences	
	No Interactions	With Interactions	No Interactions	With Interactions
Male	-0.1855 (-0.0412)	0.0032 (-0.0349)	0.2488* (0.0526*)	-0.2953 (0.0632**)
Professor	0.6677*** (0.1419***)	0.8508*** (0.1388***)	0.4002*** (0.0841***)	-0.0509 (0.0953***)
Age at PhD	-0.0284** (-0.0062**)	-0.0299 (-0.0065**)	-0.0290 (-0.0061)	0.0219 (-0.0082*)
Experience	-0.0418*** (-0.0092***)	-0.0571*** (-0.0092***)	-0.0149 (0.0032)	0.0122 (-0.0031)
NJCS (ln)	0.2841*** (0.0629***)	0.1327 (0.0637***)	0.3412*** (0.0733***)	-0.0124 (0.0654***)
Special University (ref Full University)	0.0639 (0.0140)	0.0621 (0.0132)	-0.0811 (-0.0176)	0.2248 (-0.0158)
Other Organization (ref Full University)	0.2400 (0.0560)	-0.3168 (0.0428)	-0.2904* (-0.0612*)	-1.2943*** (-0.0601*)
Male # Professor		-0.3095		0.6592*
Male # Special University		-0.0028		-0.3894
Male # Other Organization		0.7830		1.2149**
Male # Age at PhD		0.0061		-0.0775*
Male # Experience		0.02391		-0.0345
Male # NJCS (ln)				0.4106**
Intercept	-0.9989***	-1.116***	-0.9090***	-0.5506*
N	2194	2194	2448	2448
Pseudo R^2 (McFadden)	0.03	0.04	0.05	0.07
AIC	2802.2	2806	3050.4	3027.9

Notes: AMEs in parentheses
Continuous variables have been centered
$*$ p < 0.05, $**$ p < 0.01, $***$ p < 0.001



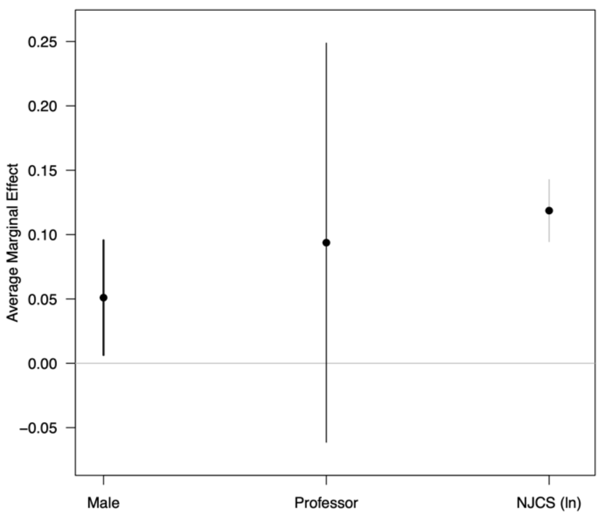


Fig 2. Average marginal effects (before 1997) in medical sciences (left) and natural sciences (right)

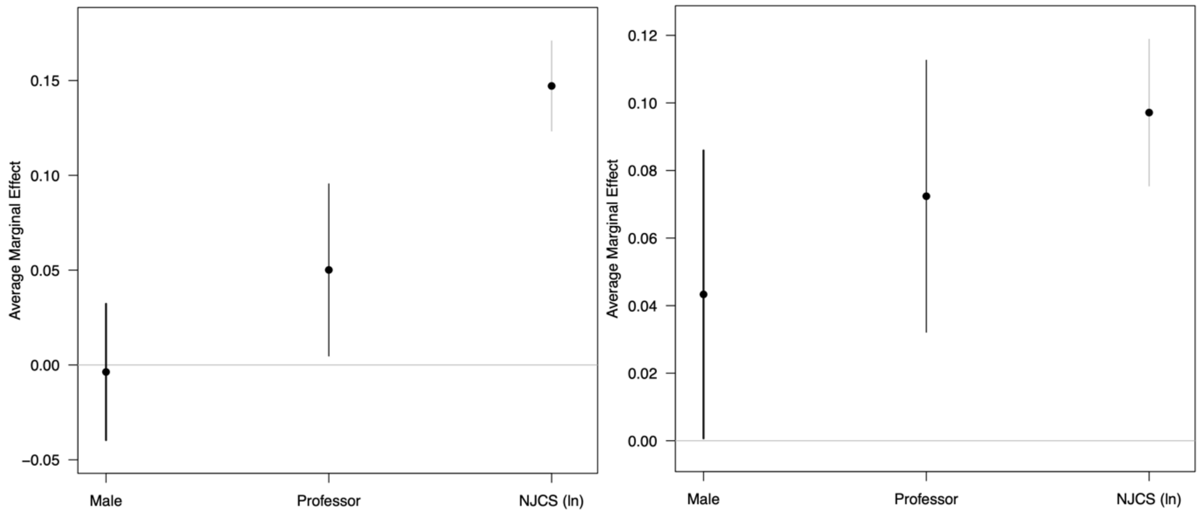


Fig 3. Average marginal effects (1997-2005) in medical sciences (left) and natural sciences (right)

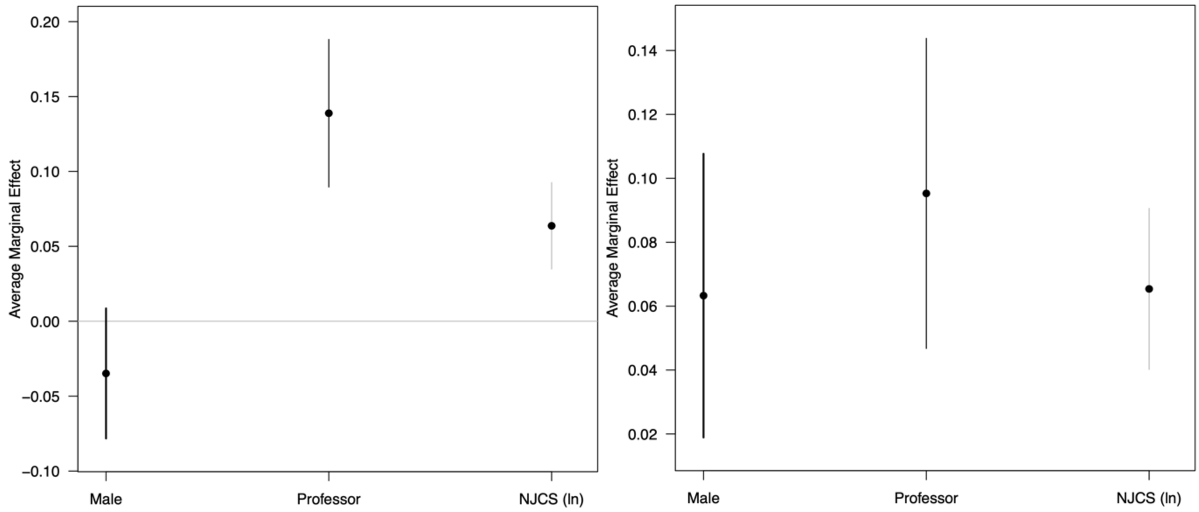


Fig 4. Average marginal effects (after 2005) in medical sciences (left) and natural sciences (right)

Gender differences in the time to professorship

Tables 6a and 6b provide descriptive statistics for the researchers and variables included in the survival analysis concerning *time to professorship*. The analysis is performed both for the full set of researchers and for the sub-group of researchers who have been promoted to professors.

Table 6a. Descriptive statistics for survival analyses (all researchers)

	Medical Sciences		Natural Sciences	
	Women	Men	Women	Men
Researcher (count)	652	1028	293	750
Professors (%)	21.93	24.51	20.48	28.13
Age at PhD (mean; SD in parentheses)	38.9325	37.982	34.1843	33.7000
	(7.1205)	(6.0765)	(5.7362)	(5.0788)
Grants (ln) (mean; SD in parentheses)	0.1312	0.1621	0.2520	0.3345
	(0.4504)	(0.5092)	(0.6051)	(0.7101)
NJCS (ln) (mean; SD in parentheses)	0.8780	1.0698	0.7322	0.9331
	(0.7114)	(0.7892)	(0.7360)	(0.8546)

Table 6b. Descriptive statistics for survival analyses (professors only)

	Medical Sciences		Science	
	Women	Men	Women	Men
Researchers (count)	143	252	60	211
Time to Professorship (mean; SD in parentheses)	16.8181	16.6301	16.3667	15.7014
	(5.3677)	(5.7749)	(4.6649)	(6.1968)
Age at PhD (mean; SD in parentheses)	37.2797	35.0992	33.1833	32.4692
	(6.3617)	(5.3464)	(4.4474)	(3.8549)
Grants (ln) (mean; SD in parentheses)	0.43433	0.5095	0.8999	1.0416
	(0.7732)	(0.8511)	(0.9520)	(1.0308)
NJCS (ln) (mean; SD in parentheses)	1.3781	1.7346	1.5893	1.7569
	(0.6372)	(0.7528)	(0.5958)	(0.7976)

Fig. 5-6 present nonparametric Kaplan-Meier survival curves by gender, for all researchers and for professors, respectively. While curves for men and women in the medical sciences area are very close, there is a distinct difference between the curves in the natural sciences area. The results of the log-rank test indicate that the difference between the curves on the right side of Fig. 5 are statistically significant ($p < 0.05$), while the difference between the curves in each of the other plots of Fig. 5 and 6 are not statistically significant.

The results of the Cox PH and AFT are set out in Table 7a and 7b, for all researchers and for professors, respectively (note that positive hazard rates in the Cox PH corresponds to negative time-ratios in the AFT).[17] Evidently, when taking differences in grant and publication performance into account, the gender difference within the natural sciences area reduces, and it is not statistically significant. This would suggest that merits (grants and publication performance), rather than gender, have resulted in shorter time to professorship in the natural sciences area. However, this should be interpreted in the light of the results from the binary logistic regression, which indicated gender differences in the funding agencies' grant-giving procedures that could not be explained by merits. Since the number of grants have a clear impact on the time to professorship (see Table 7), unjustified differences in the grant-giving procedures would indirectly affect the time to professorship. Hence, there are

[17] We have evaluated interactions between gender and the other variables in the Cox PH, but none of the interactions have generated statistically significant coefficients.

indications that the funding agencies' grant-giving procedures have contributed to gendered disparities in the academic careers within the natural sciences area.

Interestingly, while the Kaplan-Meier curves for the medical sciences area did not indicate any difference between men's and women's time to professorship, the results of the Cox PH and AFT indicate a statistically significant gender-wise difference, where men's time to professorship is longer than expected when taking grants and publication performance into account. The difference is only present when including all researchers, not when limiting to professors, which possibly suggests that there is a higher share of men that "could" or "should" have become professor (based on merits) but have not (yet) been promoted.

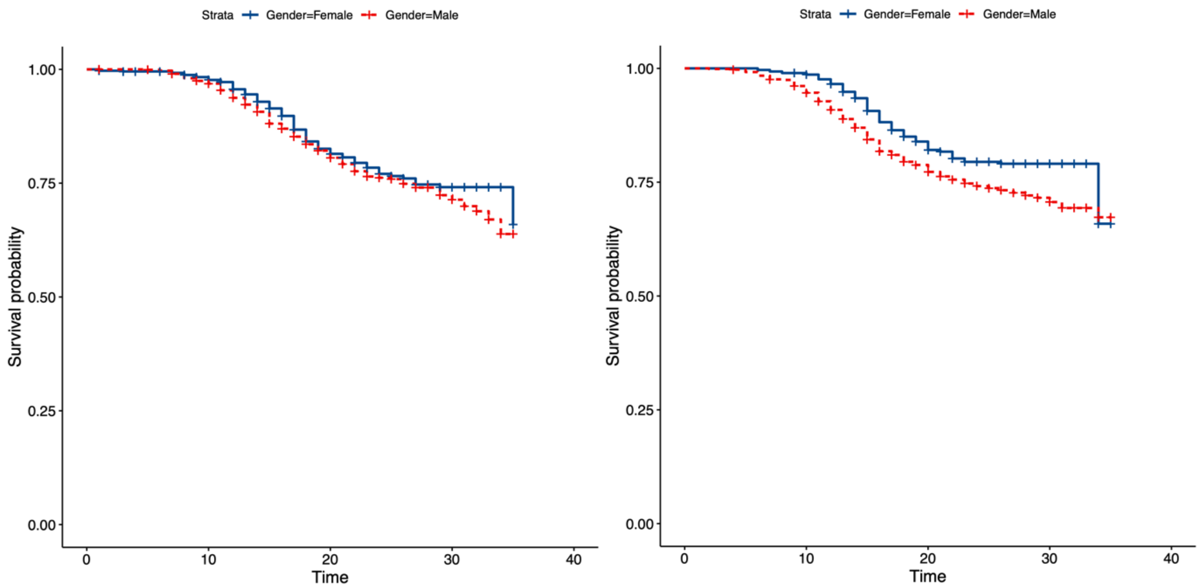


Fig 5. Kaplan-Meier professorship survival curves (all researchers) by gender for medical sciences (left) and natural sciences (right)

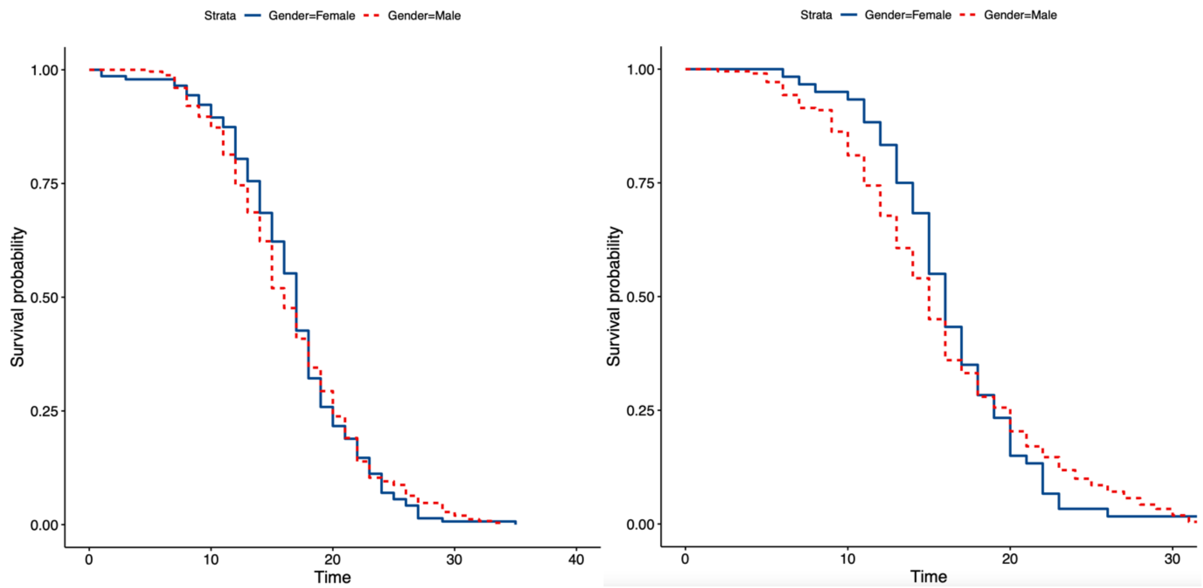


Fig 6. Kaplan-Meier professorship survival curves (professors only) by gender for medical sciences (left) and natural sciences (right)

Table 7a. Cox PH and AFT survival analysis of time to professorship (all researchers)

	Medical Sciences		Natural Sciences	
	Cox PH	AFT	Cox PH	AFT
Male	-0.3037**	0.109**	-0.0920	0.054
	(0.7381)	(1.115)	(0.9121)	(1.055)
Age at PhD	0.0263**	-0.022***	0.0111	-0.020**
	(1.0267)	(0.979)	(1.0112)	(0.980)
NJCS (ln)	1.1814***	-0.510***	1.0467***	-0.522***
	(3.2590)	(0.600)	(2.8481)	(0.593)
Grants (ln)	0.6911***	-0.486***	0.6177***	-0.394***
	(1.9958)	(0.615)	(1.8547)	(0.675)
Model		Log-Logistic		Log-Logistic
log(scale)		3.634***		3.878***
log(shape)		1.517***		1.233***
N (subjects)	1680	1680	1043	1043
N (observations)	38577	38577	25853	25853
N (events)	394	394	271	271
Global *p-value*	< 0.001	< 0.001	< 0.001	< 0.001
Pseudo R^2 (McFadden)	0.13	0.29	0.14	0.24
AIC	4877.1	2983.2	3154.7	2233.7

Notes: Hazard rates (Cox PH) and time-ratios (AFT) in parentheses
Continuous variables have been centered
$*$ p < 0.05, $**$ p < 0.01, $***$ p < 0.001

Table 7b. Cox PH and AFT survival analysis of time to professorship (professors only)

	Medical Sciences		Natural Sciences	
	Cox PH	AFT	Cox PH	AFT
Male	-0.0151	0.050	0.0408	-0.012
	(0.9850)	(1.051)	(0.9601)	(0.988)
Age at PhD	0.0530***	-0.030***	0.0231	-0.021***
	(1.0544)	(0.970)	(1.0233)	(0.979)
NJCS (ln)	0.3144***	-0.274***	0.2859**	-0.177***
	(1.3694)	(0.760)	(1.3309)	(0.838)
Grants (ln)	0.3597***	-0.369***	0.1630*	-0.197***
	(1.4328)	(0.691)	(1.1770)	(0.821)
Model		Log-Logistic		Log-Logistic
log(scale)		2.791***		2.752***
log(shape)		2.142***		1.629***
N (subjects)	395	395	271	271
N (observations)	6596	6596	4295	4295
N (events)	394	394	271	271
Global *p-value*	< 0.001	< 0.001	< 0.001	< 0.001
Pseudo R^2 (McFadden)	0.02	0.29	0.01	0.08
AIC	3856	1782.2	2508.5	1600.8

Notes: Hazard rates (Cox PH) and time-ratios (AFT) in parentheses
Continuous variables have been centered
$*$ p < 0.05, $**$ p < 0.01, $***$ p < 0.001

Conclusions and Discussion

The study set out in this report has several distinguishing features:

- It is based on general databases/registers, rather than surveys
- It uses data concerning a very large set of grant applications
- It uses data for a period that covers full academic careers
- It combines analysis of grant success with the analysis of academic careers
- It accounts for gender differences in publication performance.

This allows for a unique and more complete understanding of potential gender disparities in Swedish academic careers and grant-giving procedures.

The results for the medical sciences are, compared to the natural sciences, substantially different. While the medical sciences area (Medical and Health) in Sweden has often been reported to suffer from gender disparities, we find surprisingly little support for such claims. Our results indicate that men had an advantage concerning grant success in the period before 1997, but there are no such indications concerning the periods from 1997 and after, and the results concerning time to professorship indicate an advantage for women when taking merits (grants and publications performance) into account. This can be interpreted as an effect of the discussion that followed Wennerås & Wold's landmark study (1997) and of the political measures implemented in Sweden during the mid-90s.

In the natural sciences area, our results indicate a consistent male advantage in grant success, even when accounting for difference in publication performance (NJCS). We do not find any such differences in the time to professorship but, considering that the results also indicate that number of grants has a statistically significant effect on time to professorship, the potential gender disparities in the grant-giving procedures can be assumed to (indirectly) affect women's careers negatively.

While gender disparities are the focus of the report, it is notable that the publication performance indicator (NJCS) consistently has a statistically significant positive effect, both on the chance of grant success and on the chance for promotion to professor.

Further studies should consider additional variables to control for the observed gender difference (cf. Vetenskapsrådet 2021). It would, for example, be of interest to consider the effects of breaks in the career (e.g., due to parental leave) and how earlier application behavior/success effects the chances of later applications being granted (i.e., if success breeds success).

Acknowledgement

The authors of this report have profited from helpful and supportive comments from SAB members J Mairesse and S de Cheveigne. An external reviewer appointed by the EC has provided constructive and critical comments. The advice provided by U Riis, at Uppsala University has been highly appreciated and the kind support from our colleagues Sanz and van den Besselaar is well noted.

Furthermore, it should be mentioned that we have had generous support from the registration offices and HR departments of Swedish universities. Without their help this report would not have possible to complete. The same applies to the research councils in Sweden that have supplied us with their project registers in a very consistent manner.

Literature

Abrahamsson B, Wahlén S & Lund C (2003). Karriär genom befordran och rekrytering. Högskoleverket, Stockholm. [Career through promotion and recruitment].

Abramo G, D'Angelo CA (2016). A farewell to the MNCS and like size-independent indicators. Journal of Informetrics, 10(2), 646–651.

Abramo G, D'Angelo CA, Caprasecca A (2009). The contribution of star scientists to overall sex differences in research productivity. Scientometrics 81(1): 137-156.

Anaya-Carlsson K & Melin G (2007). Den postdoktorala perioden för doktorsexaminerade läsåret 1998/99. [The post-doc period for PhDs in Sweden 1998/99.] SISTER, Stockholm.

Bornmann L, Mutz R, Daniel H-D (2007). Gender differences in grant peer review: a meta-analysis. Journal of Informetrics 1:226–238.

Box-Steffensmeier JM, Cunha RC, Varbanov RA, Hoh YS, Knisley ML & Holmes MA (2015). Survival analysis of faculty retention and promotion in the social sciences by gender. PLoS ONE November 18, 2015.

Broström, G (2020). eha: Event History Analysis. R package version 2.8.3, https://cran.r-project.org/package=eha

Ceci SJ, Ginther DK, Kahn S, Williams WM (2014). Women in academic science: A changing landscape. Psychological Science in the Public Interest 15.3 (2014): 75-141.

Cole JR (1987). Fair Science: Women in the Scientific Community. Columbia Univ Press: New York.

Cole JR, Zuckerman H (1984). The productivity puzzle: persistence and change in patterns of publication of men and women scientist. Advances in Motivation and Achievement, Vol 2, 217-258.

Cox DR (1972). Regression Models and Life Tables. Journal of the Royal Statistical Society Series B (with Discussion) 34: 187–220.

Cruz-Castro L, Sanz-Menéndez L (2019). Literature review synthesis report. GRANteD Report D1.1.

Danell R & Hjerm M (2013). Career prospects for female university researchers have not improved. Scientometrics 94, pp, 999--1006.

Dryler H (2006). Forskarutbildning och forskarkarriär – betydelsen av kön och socialt ursprung. Högskoleverkets rapportserie 2006:2 R. Stockholm Högskoleverket. [Postgraduate education and research career - the importance of gender and social origin].

Fox, MF (2005), Gender, Family Characteristics and Publication Productivity Among Scientists, Social Studies of Science, 35, 1, 131-151.

Fridner A (2004), Karriärvägar och karriärmönster bland disputerande läkare och medicinare, Acta Universitatis Upsaliensis, Uppsala.

Fridner A, Norell A, Åkesson G, Sendén MG, Løvseth, LT, Schenck-Gustafsson K (2015). Possible reasons why female physicians publish fewer scientific articles than male physicians - a cross-sectional study. BMC Medical Education 15, 1472. doi.org/10.1186/s12909-015-0347-9

Fridner A, Norell A, Åkesson G, Sendén MG, Løvseth, LT, Schenck-Gustafsson K (2015). Possible reasons why female physicians publish fewer scientific articles than male physicians - a cross-sectional study. BMC Medical Education 15, 1472. doi.org/10.1186/s12909-015-0347-9

Government proposal 1994/95:164. Jämställdhet mellan kvinnor och män inom utbildningsområdet [Equality between women and men in Education].

GRANteD WP3.1 Investigating project registers of Swedish Research Councils and creating a subset of researchers to study career tracks.

Huang JM, Gates AJ, Sinatra R, Barabási AL (2020). Historical comparison of gender inequality in scientific careers across countries and disciplines. PNAS 117 (9) 4609-4616. DOI:10.1073/pnas.19142211177.

Högskoleverket (HsV) Rapport 2003:31 Lärosätenas arbete med jämställdhet, studentinflytande samt social och etnisk mångfald.

Kaminski D & Geisler C (2012). Survival analysis of faculty retention in science and engineering by gender. Science, 335:(17 February): 864-866.

Leeper, TJ (2021). margins: Marginal Effects for Model Objects. R package version 0.3.26, https://cran.r-project.org/package=mergins.

Long, J. S., & Fox, M. F. (1995). Scientific careers: universalism and particularism. Annual Review of Sociology, 21(45), 45–71.

Lutter M, Schröder M (2018). Who becomes a tenured professor, and why? Panel data evidence from German sociology, 1980-2013. Research Policy 45(5):999-1013.

Mairesse J, Pezzoni M (2015). Does gender affect scientific productivity? A critical review of the empirical evidence and a panel data econometric analysis for French physicists. Revue Economique 66(1):65-113.

Marsh HW, Bornmann L, Rüdiger M, Daniel HD, O'Mara A (2009). Gender effects on the peer review of grant proposals: a comprehensive meta-analysis comparing traditional and multilevel approaches. Review of Educational Research 79(3):1290 1326.

McFadden D (1977). Quantitative methods for analyzing the travel behaviour of individuals: some recent developments. Cowles Foundation for Researcb in Econimics at Yale University. Discussion Paper No. 474.

Moed, HF (2010). Measuring contextual citation impact of scientific journals. Journal of Informetrics 4(3): 265-277.

Norton, Edward C., Hua Wang, & Chunrong Ai (2004). Computing interaction effects and standard errors in logit and probit models. The Stata Journal 4(2): 154-167.

Nyberg, A (1993). Varför beviljas så få kvinnor forskningsbidrag. FRN-report. Stockholm: Forskningsrådsnämnden.

Raj A, Carr PL, Kaplan SE; Terrin N, Breeze JL, Freund KM (2016). Longitudinal analysis of gender differences in academic productivity among medical faculty across 24 Medical Schools in the United States. Academic Medicine 91:1074-1079.

Riis U (2012). Is the bar quivering? What can we learn about academic career requirements from the 1999 promotion reform? Pedagogisk forskning i Uppsala 161. Uppsala: Uppsala University.

Riis U, Hartman T & Levander S (2011). Darr på ribban: en uppföljning av 1999 års befordringsreform vid Uppsala universitet. Acta Universitatis Upsaliensis. Uppsala Studies in Education No 127.

Sabatier M (2010). Do female researchers face a glass ceiling in France? A hazard model of promotions. Applied Economics 42:2053

Sandström U (2009). Cognitive bias in peer review – a new approach. Proceedings of the 12th ISSI conferences held in Rio de Janeiro. Brazil.

Sandström U (2012). Productivity Differences between Universities: Are Small and Regional Less Productive? Paper presented to the 17th International Conference on Science and Technology Indicators, Montreal, Canada, September 5-8, 2012.

Sandström U (2014). Bibliometric Evaluation of SEPA-funded large research programs 2003-2013. Swedish SEPA Report 6636.

Sandström U, Hällsten M (2008). Persistent nepotism in peer review. Scientometrics 74 (2):175-189.

Sandström U, Wold A (2015). Centres of excellence: reward for gender or top-level research? In J Björkman & B Fjaestad (eds.) Thinking Ahead: Research, Funding and the Future. Stockholm, Makadam Publ, pp. 69 89.

Sanz-Menéndez L, Cruz-Castro L& Alva K (2013). Time to tenure in Spanish Universities: an event history analysis. PLoS ONE 2013; 8:e77028.

SFS 1979:1118. Lag om jämställdhet mellan kvinnor och män I arbetslivet [Law on equality between women and men in working life].

SFS 1998:1003. Förordning om ändring i högskolelagen [Ordinance on amendment of the higher education act].

Silander, C (2010) Pyramider och pipelines. Om högskolesystemets påverkan på jämställdhet i högskolan. Växjö: Linnaeus University Press.

SOU 2011:1 Svart på vitt – om jämställdhet i akademien. Betänkande av Delegationen för jämställdhet i högskolan. [Black and white - about gender equality in academia. Report of the Delegation for Gender Equality in Higher Education].

Swedish Higher Education Authority (UKÄ), Short version of annual report, 2001.

Swedish Higher Education Authority (UKÄ) Report 2010:10. Universitet & Högskolor. Högskoleverket.

Swedish Higher Education Authority (UKÄ) Report 2021:22. Årsredovisning 2021.

Therneau, T (2021). A Package for Survival Analysis in R. R package version 3.2-13, https://CRAN.R-project.org/package=survival.

Van den Besselaar P & Sandström U (2017). Vicious circles of gender bias, lower positions and lower impact: gender differences in scholarly productivity and impact. PLoS One 12, 8: e0183301.

Vetenskapsrådet (2006). Vetenskapsrådet och jämställdheten. Rapportserien 17:2006.

Vetenskapsrådet (2007). Jämställdheten i Vetenskapsrådets forskningsstöd 2003-2006. Rapport 2007.

Vetenskapsrådet (2010). Jämställdheten i Vetenskapsrådets forskningsstöd 2006-2008. Rapportserien 3:2010.

Vetenskapsrådet (2021). Hur jämställt är det i högskolan? Kvinnors och mäns förutsättningar att bedriva forskning. Rapport 2020:6

Waisbren SE, Bowles HR, Hasan T, Zou KH (2008). Gender differences in research grant applications and funding outcomes for medical school faculty. Journal of Women's Health 17(2):207-214.

Wang Q & Sandström U (2015). Defining the Role of Cognitive Distance in the Peer Review Process. Research Evaluation 24: 271–281.

Wennerås C, Wold A (1997). Nepotism and sexism in peer-review. Nature 387, 341-343 (22 May 1997).

Witteman H, Hendricks M, Straus S, Tannenbaum C (2019). Are gender gaps due to evaluations of the applicant or the science? A natural experiment at a national funding agency. Lancet 393:531–540.

Xie Y & Shauman KA (2003). Women in Science. Career Processes and Outcomes. Harvard Univ Press: Cambridge.

Xie Y, Shauman KA (1998). Sex differences in research productivity: New evidence about an old puzzle. American Sociological Review, 63(6), 847 870.

Xie Y, Shauman KA (2003). Women in science: career processes and outcomes. Cambridge: Harvard University Press.

Appendix 1 – Data collection

The point of departure for this report was a decision to use persons with a dissertation published from 1985 to 1994 (inclusive) – a ten-year period. That would give the possibility to cover a normal lifetime in research (assuming approximately thirty years from PhD to the end of the career). Some would end their career earlier and some a little bit later, but all of them would have a full or almost full career – inside or outside academia. This is important since earlier studies (Silander 2010; Fridner 2004; Danell & Hjerm 2013, 2014) have used shorter time periods for the academic career (often less than 20 years). To our knowledge, this is the first report that studies the full career of a large sample (for most of the participants), and it is our assumption that having the full careers might contribute to more complete results.

Libris database at the Swedish Royal Library (KB)

After initial contacts with Statistics Sweden, which were found negative from the perspective of time and access, we decided to use the Swedish Royal Library (KB) and the Libris database, which includes dissertations from Swedish universities as well as other universities in several countries. The project developed a script for the extraction of records on dissertations from the Libris database, which resulted in a compilation of over 250,000 dissertations, both Swedish and also dissertations from many other countries.

For the selected period (1985-1994), we found 11,337 Swedish dissertations (licentiates, a 2-year post-graduate exam, deleted). To facilitate better precision in later steps of the analysis (in particular, the combination of many data sources), we excluded all dissertations by authors with common Swedish surnames (Andersson, Johansson, Lundström, etc.). The "commonness" was calculated using bibliometric data covering Swedish publications from a later period (2002-2008) and defined as surname with first initial that were active at more than four university municipalities (cities) during the period of time (which resulted in a list of 725 "common" combinations). This removal affects about 10 % of the PhDs per year.

Why is it necessary to avoid common names? Formerly bibliometric indexing was performed by the use of last name and initials only. That practice made the disambiguation work tiresome, as it is very often two or more people at a department that have the same last name and first initial. This is because common names often go together with common initials like A and E. Using not very common name combinations we are able to perform the bibliometric work using high standards of quality.

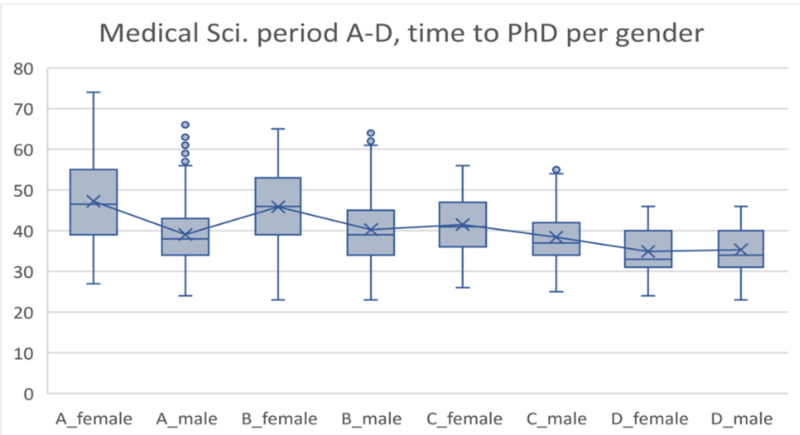
A sampling procedure was implemented that selected about 300 dissertations per year. Instead of picking specific names only groups of ten to 15 were selected and the ambition was to cover all letters in the alphabet. Already at this stage the social sciences were deselected and reasons for this are discussed in report 3.1 in WP3: the main argument is that there are no stable publication records from social science in the earlier period of the current report. Hence, the main idea of the WP3 project – combination of grant analysis and publication analysis - would not be possible to implement.

One important feature of the Libris database is that it keeps year of birth for the authors. That makes it easier to match data with other databases, e.g., the council databases. In most of the matching procedures we have used lower cased surname (without umlauts and other special characters) in combination with year of birth. Despite the removal of common names (see above), there are occurrences of researchers with the same surname and the same year of birth, but by comparing with the full name from the Libris data set we have been able to manage those homonyms.

The Libris database also provides information about title of the dissertation, faculty area (library signum), and university where the dissertation was presented. During the selected period, Sweden had ten universities with the right to grant doctorates and thus to publish dissertations: The universities of Gothenburg, Linköping, Lund, Stockholm, Umeå and Uppsala, Karolinska Institute (medicine, Stockholm), Chalmers University of Technology, Luleå University of Technology, and the Royal Institute of Technology (Stockholm). The universities with several faculties are categorized as "Universities" in the analysis, and all other (even the new universities (Malmö, Linné, Karlstad, Örebro and Östersund/Sundsvall; and, also, the university colleges) are called "Special" as they tend to be specialized in one faculty of education and research only.

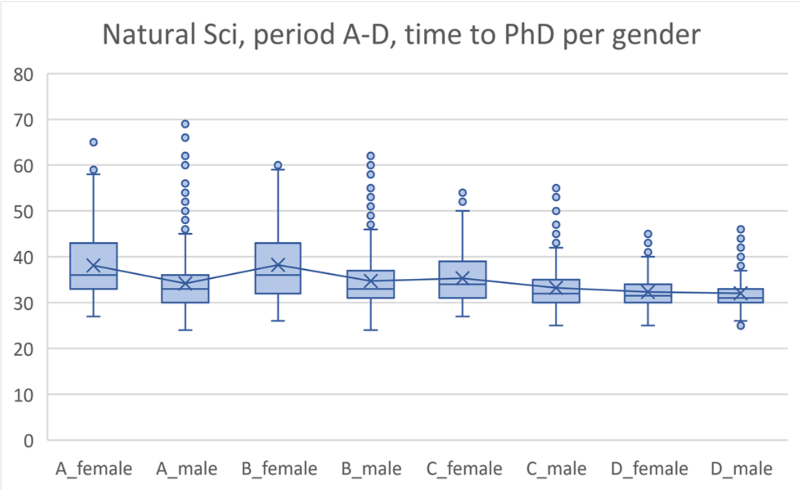
When studying the age at PhD (dissertation) for the selected researchers, we can see some interesting patterns. Finishing a PhD is not always an entry into the academic career, it can be a diploma and an idea of a life in knowledge production as a senior. Those with a dissertation 1985-1994 had their first academic experience in the late 1960s and 1970s, a period of expansion of higher education and there is quite a diversity in time to PhD. We show data in four periods: A:1943-45, B:1953-55, C:1963-65, and, D;1973-75 concerning age at PhD for the Medical and Natural Sciences (see Fig. 1.1 and Fig 1.2).

Fig 1.1. Box-plot diagram: age at PhD-dissertation in the Medical Sciences



Note: for periods, see text

Fig 1.2. Box-plot diagram: age at PhD-dissertation in the Natural Sciences Faculty



Note: for periods, see text

The figures indicate that age at PhD was considerably higher for women in the first two time periods (born in the 1940s and 1950s), but the difference diminishes during the 1960s and 1970s. This observation, that the median age at PhD was close to 50 years in the medical area, does have consequences for the career projections. Time to professor in Sweden is about 16 years for both Medical and Natural Sciences, and median time and average time is about the same. Therefore, a PhD at the age 50 would indicate that your professorship would be achieved at the age retirement (since the late 1970's the retirement age in Sweden is flexible; 65-67 years). With that said it should also be noted that with a late PhD it can also be the case that time to professorship can be much shorter.

In turn, this observation has consequences for the concept of "the science pipeline" (Berryman 1983) often called "the leaky pipeline". At the end of the pipeline, the positions after PhD, i.e., assistant professor, associate professor and full professor, were not planned for by those that published a dissertation at the age of about 50 years. They abstained from joining the battle for professorship, not everyone but probably the majority. Looking at positions only without having information on the full picture might lead to false conclusions (Xie & Shauman 2003). This information will guide us when we perform different deletions from some part of the analysis.

Web of Science publication records

To compile bibliometric data for the 3,074 PhD dissertation holders, searches in the *Web of Science* databases (SCI-Expanded; SSCI and A&HCI) were done in batches of 10-20 names and name variants. Names here are last name and initial(s). For more complex names and name changes we have used university registers, CVs, Internet resources (e.g., Ratsit.se) and phone calls. All early publication stops have been investigated and clarified to avoid name changes or alike.

All in all, over the full period from 1981 until 2019 there are almost 120,000 full count publications connected to the 3,074 PhD dissertation holders. Hence, on average, more than 40 papers were published by each of the 3,074 over the period of about 30 years. It should, however, be underlined that these figures are heavily skewed with a few highly productive researchers and many with a low and medium activity. In all, we use 125,986 article fraction shares in our analysis.

Based on addresses connected to author names we track mobility after the PhD. For those without publications we track their "career" based on Internet (LinkedIn, Ratsit) and other general sources.[18] Table 1.1 shows the total number of years from start to the end (or 2019-2020) for different types of mobility, a) within the Nordic countries (Sweden, Norway, Denmark and Finland), b) International mobility (non-Nordic Countries), c) mobility to companies (Industry) and to research institutes and d) the *inbreeds* consisting of non-mobile researchers. Here, inbreeding is treated as the natural opposite to mobility.

Table 1.1. Type of Mobility and average publishing years in WoS.

Type Mobility	Women	Men	Total
0	0	0	0
International Mobility	24.6	26.4	25.9
International Mobility (ind)	25.5	24.5	24.7
Nordic Mobility	26.0	28.1	27.5
Nordic Mobility (ind)	22.9	24.7	24.2
Nordic Mobility (inst)	20.4	26.9	24.9
No mobility	20.0	21.3	20.8
Total	**21.5**	**23.4**	**22.8**

Note:N=3.074: ind=industry; inst=research institute.
Source: Web of Science records 1981-2020.

Nordic mobility, which includes also mobility between Swedish universities seems to constitute the longest publication period. Otherwise, quite the same publication period, except for the non-mobile who seem to be apt for closing down after 20 years. Women have shorter publishing time period (from start to end) than their male colleagues. Whether that can be explained by career breaks (see Mairesse & Pezzoni 2015), will be investigated further in later versions of the report. In Table 1.1 publishing years are counted from start to end only and no actual production gaps are taken into consideration.

Grant application project registers

The choice of which research councils and foundations to investigate is an effect of the decision to focus on the medical and natural sciences areas. Those councils and foundations only that could reasonably be assumed to be relevant for such areas have been included in the investigation.

A reform of the research council system in 2001 led to a modification of the governmental organization for research. While cutting down on the number of organizations the difference between discipline-orientation and mission-oriented councils were kept as the guiding principle. One effect of that decision was that the project registers of the former research

[18] It should be underlined that publication records in the WoS database do not necessarily give reliable address data, esp. not in the years before 1996.

councils, MFR (medical science); NFR (natural sciences), TFR (engineering sciences), and the HSFR (humanities and social sciences) were archived in the Swedish National Archives.

A new umbrella organization, the Swedish Research Council (VR; Vetenskapsrådet) was started and two mission-oriented councils were organized by reshuffling several former councils. That created the council Formas (green biology, environment and societal planning) and FAS (applied social sciences). Also, in 2001, the innovation agency named Vinnova was started with a focus on innovation and on continuing the research financing of engineering research & development from STUF, NUTEK and other agencies. The Energy research agency STEM, initiated in 1998, was kept and continued its work.

Grant applications are an important input to the building of a career, especially in the Swedish case as external funding agencies stands for more than 50 % of the income to universities for research (Sandström & Besselaar 2018). Quite a large extent of that money comes from public research councils and governmental agencies. Large sums are allocated to universities from semi-public research foundations[19] and from private foundations. The prestige that comes with a grant, depending on the total sum awarded, feeds into the relative position of the researcher both within and outside of the community of researchers.

In the following investigation we have grant applications from all the major financiers although we have not all of them, further, see below.

Table 1.2 shows information drawn from the project registers. Most of the financiers' reports encompass information on granted as well as non-granted applications: exceptions to that rule are the following foundations: the Cancer foundation (CF), the Heart & Lung foundation (HLF), and the Swedish Society for Medical Research (SSMF) where we have granted applications only. It is indicated in the Table 1.2 that for the MFR information regarding grant applications is missing from 1986-1993 (except for post doc positions 1990-1993). According to the Swedish National Archive information from the project register is available on paper only. And, at the moment (December 2021) the archive has not recovered from the closing down during the pandemic. During spring 2022 we will collected all applications data but will not be able to analyze the results in this version of the paper.

The semi-public research foundations started in 1993-1994 could be important for our study: SSF, MISTRA and KK-foundation. These agencies have not been approached (so far) although their financing in some (applied and strategic areas) are significant. We propose to collect data from SSF and MISTRA in a second-round next semester (we exclude the KKS since they have limited relevance for university research). Meanwhile, we suggest that this is kept in mind but at the same time assume that the multitude of registers we have available ensures a reliable result of the investigation.

[19] In the mid-90's was formed based on funded tax funds nine foundations for research financing, among them three rather large ones; The Swedish Foundation for Strategic Research (SSF), The Swedish Foundation for Strategic Environmental Research (MISTRA) and The Knowledge Foundation (KKS), the latter with a focus on promoting information technology in society. The smaller foundations targeted areas such as health care, culture and international student exchange.

For our exercise we have close to 350,000 grant applications, see Table 1.2. An application sent in to one of councils can be considered as an indicator that the main applicant has started to develop an independent research line in his or her work and that this is also one of the aspects that are evaluated by the panels: is this research line new, and is it worthwhile?

Cleaning of the registers is necessary as there are many different types of posts in the data. In the typical case we have been able to use information about the different dossiers: there is one for research projects, another one for small travel and conference money, and in turn, renumerations to panel members is yet another dossier number. Actually, in some of the councils there are hundreds of dossiers.

Table 1.2. Funding agencies and number of grant applications

Faculty	Financier	Applications	Sum
Science	NFR 1981-2000	56 911	
Science	VR NT 2001-2021	41 941	
Science	SJFR 1990-2000 (forestry & agricult)	8 812	
Science	Formas 2001-2020	55 446	163 000
Medicine	VR-Medical 2001-2020	35 842	
Medicine	VR-Medical (rejected)	35 000	
Medicine	MFR 1993-2000	21 959	
Medicine	Cancer Foundation 1990-2020	2 178	
Medicine	Heart&Lung Foundation 1990-2020	2 573	
Medicine	Swed Soc Medical Research 1990-2020	731	98 000
Engineering	TFR 1991-2000	4 725	
Engineering	Vinnova 2001-2021	23 214	
Engineering	Vinnova (rejections)	38 000	
Engineering	STU (1980-1988) (engineering R&D)	500	
Engineering	Nutek (1989-1997) (engineering R&D)	500	
Engineering	STEM Energy Agency 1998-2020	19 114	
Engineering	BFR 1990-2000 (building & housing)	9 000	95 000
	Total	**350 000**	

Council registers consist of both new projects and continuation projects. The number of financed projects is quite high in the sample, 42 % for women and 51 % for men. The latter information tells us that the number of continuation projects is rather high, which probably is an effect of the approach to follow people in a cohort over time.

A few of the smaller foundations in the medical area do not agree to share register information on number of rejected grant applications and consequently that would increase the success rates in the sample.[20] Moreover, there are councils in the selection that create one project per year even if the funding is guaranteed for two or three years. These guaranteed posts are deleted when there is explicit information available in the register. Anyhow, this uncertainty, even if small, disturbs the important figure on the share of granted projects in relation to the

[20] We still have a firm belief to convince the foundations that they should reveal full data sets.

rejected, but at the moment we see no possible solution to the problem. Consequently, the figures in Table 1.2 might to some extent be exaggerated, but probably not too much.

Related to that, we have the migration problems that was created when the former research councils were transformed into one large organization and they had to be united into the SRCs VRAPS database. We have the same problem with the environmental councils that was headed under the agency Formas and the Fenix database. Older projects that were decided under the former councils had to be reconfigured to the new organization data model. In some cases, we expect that there might be duplicates, but these duplicates are seldom loaded with information and there is in no case information about the actual decision (grant or reject).

The 3,074 selected PhDs between 1985-1994 have created 27,258 grant applications to the above listed funding bodies, i.e., approximately nine applications per person, or sixteen if we count only those 1,748 PhDs that have applications to these bodies (and less due to the deletion of the Engineering area). That is approximately one application every second year on average. With the information held in the applications we can create an estimate of the application behavior and we can, as indicated, give a figure of success rate per person. As always, while success rates are one aspect of application behavior, the number of accepted proposals is even more a vital information.

University personnel registers and career data

Grant application dossiers hold a lot of information: about the person, about the idea, about the response from the funding agency and the panel, the responsible university and the department, the type of project etc. Another feature of the project registers is that the professional status of the applicant as well as the co-applicants, is given. We learn whether the applicant is a junior or senior researcher and the formal status of the applicant; is he or she an assistant professor, an associate professor or a full professor? In Appendix 2, we described how Swedish titles in the project registers have been translated to these three categories.

In our first analysis, where we try to explain success rates, the applicant's current status is used as one factor. In the analysis we distinguish between PhD, assistant professor, associate professor, full professor, and other. The latter category is for applicants from companies and from research institutes.

In the current report, we also have an interest in those that made it to the full professorship and one source to find out whether that is the case is the project register. However, when controlling that information – comparing to other sources, e.g., CV-information, or personnel registers from the universities – it becomes obvious that quite often there is a mismatch between different sources. And, of course, the title "Professor" can be understood in several ways:

1) Full professor, chair at the university;
2) Professor (promoted);
3) Professor (deputy);
4) Professor (acting);

5) Professor (guest)
6) Professor (adjunct).

In the current report we apply a limited definition including the three first categories. However, in order to adjust to the definition as used by Statistics Sweden not only the first three categories in the list above should be counted, but also the categories “guest” and “adjunct” as they meet the eligibility requirements for a professor. The effect of this will be available in the next version of the report (see next report D3.3 from WP3).

The project registers are a reliable source for information about the status of the applicant. But we cannot follow each person every year and there will be loopholes. Another feature is that titles are unstable. Therefore, there is a minor mismatch between information from the university’s personnel registers and the information given in the funding agency project registers.

At large, we can assume that the relevant panel holds information on the type of professorship that is connected to the actual applicant. In our analysis one we use the information given by the register (professor or non-professor) to have the status of the applicant for each application over the actual time period for each applicant.

Moreover, not seldom there is inconsistencies between official sources and self-reporting in CVs and at LinkedIn. This can partly be explained by misunderstanding of the titles: are you a professor already when you become an assistant professor or associate professor? Another possibility is that year of appointment by the vice-chancellor of the university is done months or even a year before the employment is started. Use of the project registers year of professorship also depends on whether the status was achieved before the application period started over the calendar year.

Therefore, the investigation reported here relies first and foremost on personnel registers from Swedish universities and the year for appointment. The following universities have sent their registers: Lund University, University of Gothenburg, Chalmers University of Technology (Gothenburg), the Royal Institute of Technology (Stockholm), Karolinska Institutet (medicine, Stockholm), Uppsala University[21], Linköping University[22], Swedish University of Agricultural Sciences (Uppsala), Luleå University of Technology, and Umeå University.

In our first analysis we use organizational type as a categorization of universities and university colleges. We apply the following typology developed by Sandström (2012):

- Univ (the universities with several faculties)
- Spec (the universities with one faculty only)
- New (the universities that are younger than 25 years)
- Small (the university colleges).

As a second high priority source we have the *State Calendar 2010*. That register holds information on all university professors and the year of their appointment. As a third source

[21] The Uppsala case is to some extent covered by phone registers up until 2009.
[22] The Linköping case is to some extent covered by phone registers from 1983-2003.

we have used collection of CVs from different projects during the period 2004 and later the Excellence report (Sandström & Wold 2015). Also, we have personnel registers for some of the new Swedish universities (ORU, MIUN, LNU, KAU) available up to about 2015. For the rest we have relied on project register data and Internet resources incl. LinkedIn.

To summarize, this investigation follows about 30 % of all Swedish PhDs in the period 1985-1994 during their career (about 3,000 out of >10,000) up to 2020. Instead of relying on e.g., questionnaire data the project has a multitude of registers of several types and in that respect the data do not depend on responses from surveys. It is a strength that information comes from official sources instead of self-reporting. At the same time this means that we have no direct information about family background, child care, sick leave, and other relevant circumstances that relates to the professional career.

Although we have high number of applicants (1,748) we have decided to delimit periods when people were apt for career breaking proposal work: in our interpretation that should happen about eight years after the PhD dissertation. That would include a post-doc period and a first assistant professorship to develop independence and research trails of one's own. The eight-year period after potential "independence" are the goal for our investigation and with that delimitation there will be less cases left in the grant-giving analysis.

Appendix 2: Translation of titles (status) used in the project registers to titles in English (with considerable reduction of variety)

Title (Orig Swedish)	Title (New)
Fo ass	A-Fo ass
Forskarass	A-Fo ass
Bitr prof	B-Doc
Docent	B-Doc
Högsk lekt	B-Doc
Lektor	B-Doc
Chöl överläkare	D-Doc
Univ lekt	B-Doc
Professor	C-Prof
Tf professor	C-Prof
1 forskn ing	D-Dr
1 intedent	D-Dr
1:e statsmet	D-Dr
Agr dr	D-Dr
Dr	D-Dr
Dr Med Sc	D-Dr
Dr Med Sci	D-Dr
Dr med vet	D-Dr
Dr.Med.Sc	D-Dr
Dr.Med.Sc.	D-Dr
Dr.Med.Sci	D-Dr
Dr.Med.Vet	D-Dr
Farm dr	D-Dr
Fil dr	D-Dr
M Sc	D-Dr
Med dr	D-Dr
Odont dr	D-Dr
Ph D	D-Dr
Tekn dr	D-Dr
Vet med dr	D-Dr
Forskare	D-Dr
Civ ing	E-Other
Civ jägm	E-Other
Doktorand	F-Fo stud
Fil kand	F-Fo stud
Fil lic	F-Fo stud
Fil mag	F-Fo stud
Fo stud	F-Fo stud
Forskningsass	F-Fo stud
Geol	E-Annat
Högsk adj	F-Fo stud
Leg läk	F-Fo stud
Med kand	F-Fo stud
Tekn lic	F-Fo stud
Fo stud	F-Fo stud