DISCUSSION PAPER SERIES

IZA DP No. 3878

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December 2008

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zur Zukunft der Arbeit
Institute for the Study
of Labor

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ABSTRACT

Scientific (Wo)manpower? Gender and the Composition and Earnings of PhDs in Sweden*

Although the share of female PhDs has increased explosively since the 1980s, little research has focused on the utilisation and remuneration of female versus male scientific human capital. Using rich Swedish cross-sectional register data on the stock of PhDs in 2004, this paper analyses to what extent men and women choose academic versus non-academic employment, and to what earnings differences these choices lead. Results show that women are significantly less likely than men to be academically employed in the natural sciences and medicine, whereas no significant gender differences prevail for the social sciences and the humanities. On average, women earn 15 per cent less than men, and the academically employed earn 24 per cent less than PhDs outside academia. Gender earnings differences are larger in the academic than in the non-academic labour market in the humanities and the natural sciences, whereas the opposite holds in the social sciences and medicine.

JEL Classification: J31, J70

Keywords: gender, earnings, scientific human capital

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* We would like to thank participants at the workshop on "Gender in the Academic Profession" at Aarhus School of Business, 2007, and participants at ESPE, 2008, for helpful comments and suggestions. A research grant from the Swedish Council for Working Life and Social Research is gratefully acknowledged.

1. Introduction

The share of female PhDs has increased explosively in many western countries throughout the last twenty to thirty years.[1] Making efficient use of female scientific human capital becomes more important as its share of the overall scientific capital grows, and as research and knowledge take on increasing importance in the economic growth and development of countries. Female and male PhDs are also of particular interest from a wider societal perspective, since they are likely to take on important roles not only as creators and conveyors of new knowledge but also as leaders and opinion- and policy-makers. Any gender gaps for this group are thus likely to be of importance for what will happen to gender gaps more generally in society. Yet recent research investigating academic labour markets in the UK and the US indicates that the scientific human capital of female PhDs is not used and remunerated to the same extent as that of males: women are less likely than men to remain in academia after having obtained a doctoral degree (Preston, 2004, McDowell et al., 2001 and Kahn, 1993); women in academia have lower earnings than their male colleagues (Barbezat, 1987 and 1991, Toutkoushian, 1998, Weilier, 1990, Dolton and Makepeace, 1987, McNabb and Wass, 1997 and Ward, 1999); and it is more difficult for women than for men to get promoted within academia (McDowell et al., 2001, Long et al., 1993, Kahn, 1993 and Ginther and Kahn, 2004).

However, little is known about the situation of male and female PhDs from countries other than the UK and the US. In addition, the previous literature has focused mainly on the academic labour market, not on the career development of male and female PhDs outside of academia. As the non-academic labour market has grown increasingly important for PhDs in many countries, any gender differences in this labour market will have important effects on the utilisation of female scientific human capital. This paper therefore studies the selection into (and out of) academia for men and women, and investigates the earnings outcomes and gender earnings gaps in the non-academic and academic labour markets in Sweden. Sweden constitutes an important case, not only because there is little previous research on gender differences in academia for this country but especially because Sweden is considered one of the world's most gender-equal countries (Plantenga et al., 2003). Consequently, an analysis of the situation in Sweden may serve as a benchmark to other, less gender-equal countries.

[1] See e.g. the OECD StatExtracts database on Graduates by field of education.

Despite Sweden's gender-equal reputation, its path towards gender equality has been long and remains incomplete. One area of Swedish society that still shows signs of the historical gender imbalance is science and scientific work: only in recent decades have Swedish women made significant inroads into what was long a male preserve. The first time a woman was awarded a doctorate in Sweden was at Uppsala University in 1883 – more than 400 years after the founding of the university (Blomqvist, 1996). Swedish women, however, were still not legally permitted to be appointed to public offices. The female doctorate pioneers were thus excluded from making an academic career, and the legislative hindrances were not definitely abolished until 1925.[2] But these legal obstacles to women's academic careers were not the only ones. Not until 1949 did Uppsala University (founded in 1477) appoint its first female full professor – and not until 1965 for Lund University (founded in 1666).

Although the female doctoral pioneers were increasingly followed by other women, only since the 1980s has there been a significant and rapid increase in the female share of new PhDs in Sweden. It remains an open question how well the educational and scientific capital of these female high achievers is utilised and remunerated relative to that of their male counterparts, and whether later cohorts of female PhDs are faring better than their predecessors.

This paper uses cross-sectional register data covering all individuals of working age (under 68 years) who were residing in Sweden in 2004 and who obtained a PhD during 1970-2004 (i.e. the stock of PhDs in 2004). This dataset has the advantages of being highly reliable and of including a large number of observations. We first draw a descriptive picture of the total stock of male and female PhDs and the ways in which its size, composition (in terms of degrees in the social sciences, natural sciences, humanities and medicine) and share of women vary with year of graduation. Second, we restrict our analysis to a sub-sample that excludes those who graduated in the 1970s, to investigate determinants behind the decision to leave or to remain in academia – and any gender differences in this respect. Third, we look at gender differences in earnings, for stayers and leavers and for different specialisations.

Our results show that female PhDs are significantly less likely than male PhDs to be academically employed in the natural sciences and medicine, while no significant gender differences prevail for the social sciences and the humanities. On average, academically

[2] A few women were awarded the title of professor by the Swedish government, but without a professor's chair, and a few women got positions as professors via one of the Swedish research councils. See Blomqvist (1996).

employed PhDs earn 24 per cent less than PhDs employed outside academia and for both sectors together, the average gender earnings gap is 15 per cent. The gender gap varies largely between the academic and the non-academic labour markets, as well as between subject areas, although women's earnings are always much lower than men's.

2. Previous literature

This paper is related to the literature on gender earnings and promotion differences of highly educated men and women. A more extensive review of this literature than the one presented here appears in Meyer (2005).

Although the most commonly studied career outcomes of highly educated men and women are salaries and promotion, other outcomes (e.g. the decision to remain in or leave academia, and the propensity to publish articles) have also been studied. Kahn (1995) reviews the outcomes that are likely to be affected by discrimination in the field of economics and finds that men and women differ significantly (when controlling for relevant characteristics) in choice of undergraduate major, applications to PhD programs, dropout rates from PhD programs, first jobs, salaries and promotion.

The literature on differences between highly educated men and women focuses primarily on the US and the UK academic labour markets. Most previous studies use survey data and can therefore control for factors such as number of published articles, quality of published articles and academic rank (i.e. assistant, associate or full professor). Although these factors are important determinants of the individual's decision to remain in or leave academia, and of his or her earnings outcomes, they may also in themselves be influenced by discrimination. For instance, Ferber and Teiman (1980) suggest that women encounter difficulties when dealing with editors and referees; McDowell and Smith (1992) and Boschini and Sjögren (2007) show that men and women prefer to co-author with individuals of the same sex, a choice that disadvantages women since they have more difficulty finding same-sex co-authors; and Blank (1991) compares double-blind and single-blind reviewing processes and finds that women do better under the former, both in terms of acceptance rates and referee ratings. Moreover, several studies point to women being less likely to get promoted within academia (see e.g. McDowell et al., 2001, Long et al., 1993, Kahn, 1993 and Ginther and Kahn, 2004). Thus by controlling for factors related to publications and academic rank, the researcher risks underestimating the true gender earnings difference.

In addition, by using survey data most previous studies are plagued by small sample sizes, which might lead to low levels of statistical significance due to lack of power. Yet the studies using US data find that the salary gap in academia has decreased from 21 per cent in 1968 (Barbezat, 1987) to approximately 9 per cent in the mid-1990s (Toutkoushian, 1998). In the UK, university salaries are determined within a formal institutional framework wherein salaries are closely related to tenure; therefore, the potential for variation in individual salaries – and thus discriminatory practices – should be minimal. Yet studies find a gender wage gap, of approximately 15 per cent in the early to mid-1970s (Dolton and Makepeace, 1987, McNabb and Wass, 1997), decreasing to about 8 per cent in 1995 (Ward, 1999).

The few studies that have been made for Sweden find that highly educated women are likely to fare worse than the corresponding men. Wold and Chrapkowska (1994) show that a male student is four times more likely to become a professor than a female student, and similar gender patterns are reported for economics by Persson (2002) and Jonung and Ståhlberg (2008).

Thus the previous literature points to large gender differences in employment outcomes between highly educated men and women. As these studies used survey data, they may have been biased by measurement error and small sample sizes. By using register data, this paper circumvents these problems, albeit at the cost of a less informative dataset.

3. Size and composition of the 2004 stock of PhDs in Sweden

This section examines the size and composition of the 2004 stock of PhDs in terms of gender and graduation year.[3] We look at the entire stock of PhDs, as well as specifically at those holding degrees in the social sciences, natural sciences, humanities and medicine. For 2004, we have information only on PhDs graduating the first semester (out of two). Therefore, we use data only until 2003 when displaying the actual numbers of graduates per year.

Figure 1 shows the increase in the total number of PhDs from 1970 to 2003, as revealed by the stock in 2004.[4] For the mid-1970s to the mid-1980s, the number of PhD graduates is roughly unchanged at around 600-700 per year. But from the late 1980s the number increases, and this increase takes off strongly from the mid-1990s, and continues throughout the period.

[3] We investigate all PhDs below the age of 68 who have a doctoral degree from the years 1970-2004 and who were in Swedish registers in 2004. For a comparison with the numbers graduating in these years according to the examination records, see Appendix.

[4] The attrition is largest for the earliest part of the period because many PhDs from these graduation cohorts were more than 67 years old in 2004 (see figure A1. in the appendix).

For the last ten years of the period, the number of PhDs increases by an average of nearly 150 per graduation year.

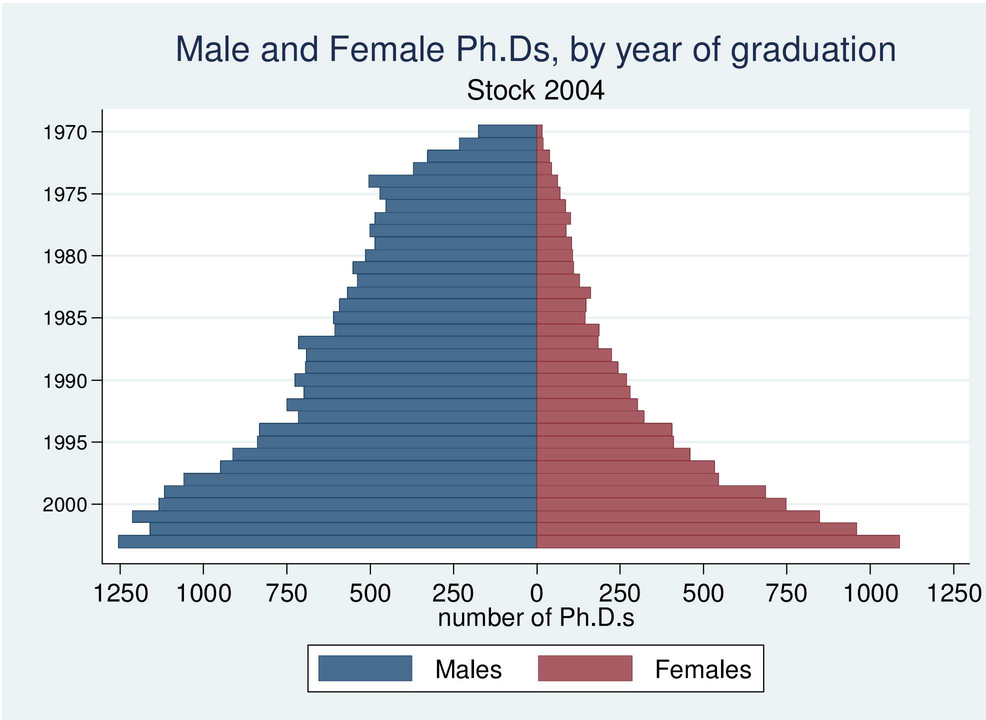

Fig. 1. Total number of PhDs, by year of graduation, 1970 - 2003.
Note: Only PhDs in the 2004 stock are included.

One reason for this rapid expansion was policy-makers' prognoses that the number of doctors would not be sufficient to supply the research-trained human resources needed for the higher education system and other sectors of the Swedish economy.[5] This apprehension led to a political decision to expand post-graduate education; the goal formulated around 1990 was that the annual number of doctoral degrees was to eventually double. Figure 1 shows that although this goal was achieved around the year 2000, the expansion has continued. The share of women with doctoral degrees has also increased substantially, with an evident correlation between the increase of women PhDs and the expansion of post-graduate education in Sweden. From a modest start the share of women increased rapidly, by 2003 amounting to almost 45 per cent of the stock of PhDs.

Although the absolute number of PhDs has increased dramatically, this increase has not been proportional across areas. Figure 2 displays the total number of PhDs (in the 2004 stock) for

[5] See SOU 2004:27, Appendix 5, which surveys the changes in Swedish post-graduate education over time.

four major areas:[6] while the most expanding area by far is medicine, the number of PhDs has also increased significantly within the natural sciences. The social sciences and the humanities developed rather similarly until the early 1990s; the number of PhDs was rather stable at around 100 per year for the social sciences and around 80 for the humanities. The number of PhDs thereafter started increasing for both areas, but much more so for the social sciences. Since the mid-1990s, the increase in the number of PhDs in the social sciences has closely mimicked that of the natural sciences, whereas the increase in the number of PhDs in the humanities has been more modest. For both the social sciences and the humanities, the increase in the number of PhDs stabilised during the first years of the 21st century, whereas the expansion within medicine and the natural sciences continued.

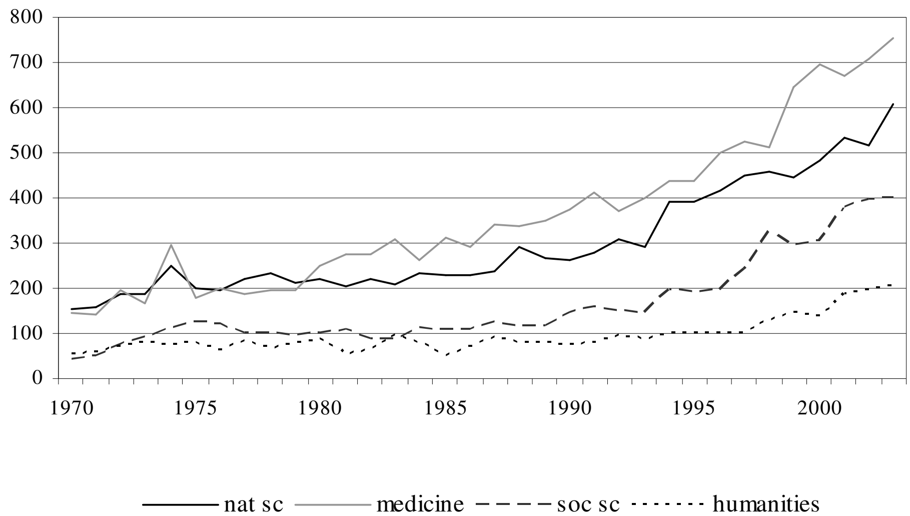

Fig. 2. Total number of PhDs by year of graduation and subject, 1970 – 2003.
Note: Only PhDs in the 2004 stock are included.

Figure 3 shows the share of female PhDs (in the 2004 stock) by year of graduation for the four subject areas. As the shares have varied substantially, we include fitted lines to make the trends more visible.

[6] The degrees that do not fit into any of these four areas have been excluded from Figure 2; the largest groups of these excluded are engineers (4,967 PhDs) and those holding PhDs in care-related disciplines other than medicine (1,276 PhDs).

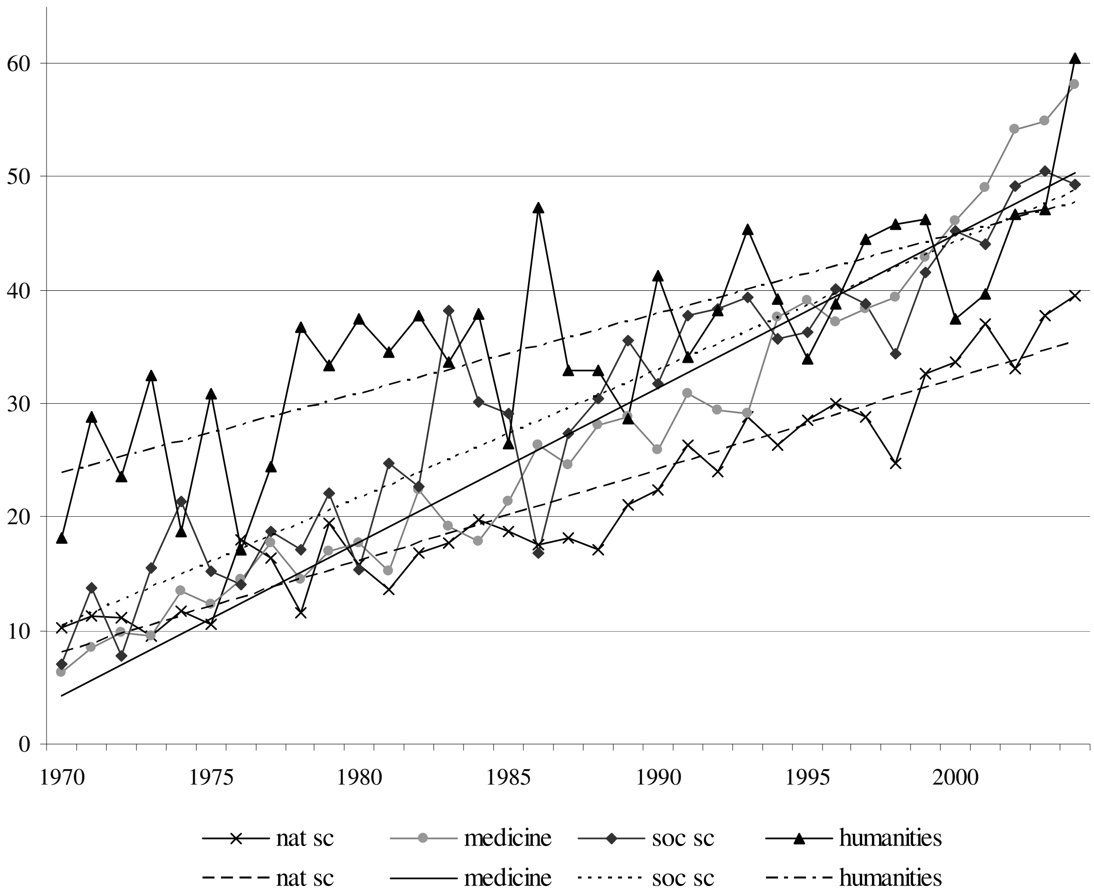

Fig. 3. The share of PhD-degrees obtained by women, by subject area and graduation year. *Note:* Only PhDs in the 2004 stock are included.

There is a positive trend towards more women graduating in all areas, although this trend is less pronounced for the humanities and the natural sciences than for medicine. During most of the period, the humanities have been, comparably speaking, attractive to women, and in particular during the 1970s and 1980s the humanities stand out as being the only area in which women account for a substantial share of the PhDs. Medicine has gone from being the area most dominated by men to being one of the most gender equal. Indeed, in medicine *more* females than males graduated in 2004, and the increase in the total number of PhDs (as shown by Figure 2) is largely attributable to the large influx of women. The natural sciences also display a marked increase in the share of female PhDs, and in 2004 almost 30 per cent of the PhDs were women. The social sciences experienced a rather dramatic increase in the share of women during the first half of the 1980s, after which the number increased rather steadily for the remainder of the period. All in all, the female share has grown most rapidly in medicine, followed by the social sciences, while the humanities and the natural sciences have seen a comparably modest growth. For the humanities, the share of women was already relatively high at the beginning of the period, whereas the natural sciences started out from a rather low level and is thus definitely lagging behind the other areas in the representation of women.

4. Sub-sample for deepened analysis

Our continued analysis is based on a sub-sample of the total stock of PhDs as previously defined. Figure A1 in the Appendix shows that the attrition caused by PhDs reaching retirement age or dying is largest for the earliest cohorts of graduates. Furthermore, as the gender imbalance for the earliest graduation years is quite extreme (see figure 1), we make a number of restrictions on the sample used in the analysis throughout the remainder of the paper. First, we restrict our sample to including only those with doctoral degrees from 1980 and onwards. Second, we exclude all PhDs born outside of Sweden, due to this group's potentially being highly heterogeneous (e.g. from individuals coming to Sweden with the sole purpose of obtaining a PhD to individuals who migrated to Sweden as children). Third, we restrict our sample to include only those who were employed in 2004 according to Statistics Sweden's employment register's definition. Thus, only those who were employed in November 2004 or had a working income of at least one base amount[7] during 2004 (or both) are in our sample. Through this last restriction, we lose less than 2 per cent of the observations, indicating that the vast majority of the PhDs in the 2004 stock were employed. Table 1 displays the number of observations lost due to each restriction, by gender.

Table 1 Restrictions to sample

	Number of women	Number of men	Total sample	Per cent women in total sample
Stock in 2004, aged <68, who graduated 1970-2004.	10,927	24,702	35,629	30,7
Remove graduates in 1970-1979	-636	-4,004	30,989	33,2
Remove foreign born individuals	-1,933	-3,519	25,537	32,7
Remove not employed	-118	-286	25,133	32,8
Total sub-sample	**8,240**	**16,893**	**25,133**	**32,8**

Slightly more than 10,000 observations are lost due to the restrictions.[8] A larger number of men than women are excluded because the sample is restricted to those graduating after 1979; again, the reason for the exclusion is the paucity of female PhDs during the early period. The shares of men and women lost because of the other two restrictions are approximately equal.

[7] The base amount was 39,300 krona in 2004 (£1=13 krona).
[8] A further 1,000 observations (approximately) are lost in the empirical models due to missing observations.

5. Staying or leaving?

After having completed the often strenuous training and research required for a PhD, an individual must decide whether to remain in academia or leave it. This decision is likely to depend on a number of factors on both the demand and the supply side of the market for scientific human resources. First, individuals are likely to differ in motivation, interests and talents, and these differences might also affect the job opportunities they receive. Second, the conditions and possibilities for combining family obligations with work may also influence the decision. Third, expected wages (and other pecuniary and non-pecuniary rewards) in the respective sectors may also influence the individual's choice. Four, on the demand side, discrimination of various kinds might come into play. These four determining factors, and their influence on the stay-or-leave decision, may very well differ between genders and among academic fields.

5.1 Do women select out of academia?

Table 2 presents descriptive statistics of the total number of PhDs, as well as the total number of PhDs academically employed. The left section shows the distribution of male and female PhDs in different areas. Approximately one third of the (restricted) stock of PhDs in Sweden in 2004 was female, although the female share varied from 38.8 per cent for the social sciences to 26.7 per cent for the natural sciences. Thus, despite the large influx of women, men still constitute the vast majority of the PhDs in Sweden, regardless of area.

The right section of Table 2 displays the absolute numbers of men and women, and the share of women, holding academic employment in 2004.[9] In 2004 there were 3,219 female PhDs employed in academia in Sweden, and 34.5 per cent of those academically employed were women. Thus, women are slightly overrepresented in academic employment. As there are more than twice as many men as women holding PhDs, the *absolute* number of women working in Swedish universities and university colleges is clearly much lower than the absolute number of men. However, Table 2 shows that the comparatively low absolute number of women in academia is *not* the result of women selecting out of academia to a larger extent than men. Except for the natural sciences, women are overrepresented in academia for the areas under consideration. The overrepresentation of women in academia is largest in

[9] Those who are coded as 'teachers and researchers at universities or university colleges' in the Swedish occupational registers have been defined as academically employed.

medicine, where 46.3 per cent of the academically employed are women, compared to 37.2 per cent of the total number of PhDs in medicine.

Table 2 Absolute number of PhDs and of PhDs academically employed, and the per cent of women. By subject.

	Total number of PhDs			PhDs with academic employment		
	Number of women	Number of men	Per cent women	Number of women	Number of men	Per cent women
All	8,240	16,893	32.8	3,219	6,112	34.5
Humanities	675	1,071	38.7	404	579	41.1
Social science	1,394	2,196	38.8	869	1,284	40.4
Natural science	1,566	4,306	26.7	593	1,734	25.5
Medicine	2,801	4,734	37.2	599	694	46.3

Notes: The category "all" includes PhDs in care related subjects other than medicine, PhDs in engineering and PhDs in other subjects.

5.2 An econometric analysis of the probability of remaining in academia

We now move on to an econometric investigation of what influences whether an individual has remained in academia or not. We investigate the situation in 2004 but have no information as to at which point an individual made his or her decision. Thus an individual might have switched between academic and non-academic employment several times, although such information is not available to us. An additional limitation of the analysis results from omitted variables that might affect the career decision (as well as the earnings), such as number of publications, talent for and interest in research and teaching, and outside career opportunities – none of which are observable in the register data. On the other hand, by using register data, we are likely to avoid measurement errors that might have been present in previous studies based on survey data, and we also have the advantage of a much larger sample size than most previous studies. Nevertheless, we cannot exclude the possibility that omitted variables bias our results.

We estimate cross-sectional binary logit models that explain the probability of being academically employed in 2004 by a set of time-related covariates (Z), a set of family-related covariates (F), and subject-of-graduation measures (G). The variable y_i equals one if individual i was employed in academia, and zero if individual i was employed outside of academia, in 2004:

$$\ln y_i = \alpha + Z_i\beta + F_i\gamma + G_i\delta + \varepsilon$$

The set of time-related covariates includes dummies indicating the year of graduation (to capture any trends in the probability of remaining in academia), the individual's age at graduation, and the age at graduation squared. The family-related covariates include marital status, children living at home or not, and children's (if any) ages (to capture any gender differences related to family formation).[10] Furthermore, we investigate whether differences exist between academic areas, as represented by dummies for the humanities, the social sciences, the natural sciences, medicine and a category combining other subject areas. In addition, some models include controls for the PhD-granting institution. Table A1 in the Appendix gives descriptive statistics and variable definitions.

We first run a simple model for the entire sample (not shown) with dummies for gender and for the four different area categories, as well as controls for the family-related variables. As the gender dummy is statistically significant, we continue our analysis by constructing interactions between all explanatory variables and the gender dummy, to capture the gender differences. In addition, we now also include graduation year dummies and institutional dummies in the model. Table A2 in the Appendix gives the results, which reveal that, first, women are less likely than men to be in academic employment. Second, the probability of having remained in academia differs among areas. Third, some of the variables connected to family status are correlated with the probability of working in academia, and several of them differ in sign or magnitude for men and women.

As the area dummies were significant, and as the descriptive statistics revealed substantial differences among the four areas, we proceed by estimating separately for each the probability of remaining in academia. Table 3 presents the results, which show no significant gender differences in the probability of being academically employed for the humanities and the social sciences, whereas females have a significantly smaller probability of being academically employed for the natural sciences and medicine. Thus, despite the large share of female doctors of medicine in academic employment (see table 2), a significant gender difference still exists when we control for other factors that influence the choice of sector (i.e. academic vs. non-academic).

Overall, few coefficients are significant for the social sciences and the humanities, and there are few significant gender differences. Thus other factors than the ones included in the model probably determine the sectoral outcome for PhDs in these areas. For the natural sciences and medicine, however, most of the estimated coefficients are statistically significant. There are possibly more attractive non-academic job opportunities for PhDs in the natural sciences and

[10] That the family variables refer to the individual's situation in 2004 is, of course, a weakness of our cross-sectional data. Longitudinal data, to which we do not have access, would better illuminate the role of family-related factors.

medicine, making the choice between an academic and a non-academic career a more viable one in these areas than for the humanities and the social sciences.

Table 3 Effects of family and age on the probability to be employed in academia in 2004.

	Humanities	Social sciences	Natural sciences	Medicine
Female	-3.209	-0.596	-10.152	-7.556
	(3.141)	(2.128)	(2.063)***	(1.662)***
Age at graduation	-0.036	0.068	-0.280	-0.487
	(0.095)	(0.061)	(0.058)***	(0.059)***
Age at grad.^2	-0.000	-0.001	0.004	0.005
	(0.001)	(0.001)	(0.001)***	(0.001)***
Married	-0.338	-0.134	0.024	-0.211
	(0.152)**	(0.104)	(0.076)	(0.110)*
No child	-0.038	-0.015	0.059	-0.125
	(0.191)	(0.131)	(0.097)	(0.124)
Youngest child 0-3	-0.105	-0.227	-0.392	-0.355
	(0.244)	(0.157)	(0.109)***	(0.160)**
Youngest child 4-6	-0.153	0.222	-0.197	-0.102
	(0.301)	(0.200)	(0.132)	(0.184)
Youngest child 7-15	*Reference*	*Reference*	*Reference*	*Reference*
Youngest child ≥ 16	0.216	-0.050	0.038	0.124
	(0.224)	(0.163)	(0.121)	(0.133)
Interactions				
Age at grad. * fem.	0.137	-0.011	0.511	0.311
	(0.143)	(0.094)	(0.104)***	(0.080)***
Age at grad.^2* fem.	-0.001	0.000	-0.006	-0.003
	(0.002)	(0.001)	(0.001)***	(0.001)***
Married * fem.	0.396	0.053	-0.029	0.321
	(0.234)*	(0.160)	(0.142)	(0.153)**
No child * fem.	0.119	-0.263	0.493	0.759
	(0.315)	(0.225)	(0.198)**	(0.191)***
Youngest child 0-3 * fem.	0.073	-0.310	1.071	0.408
	(0.414)	(0.281)	(0.215)***	(0.238)*
Youngest child 4-6 * fem.	0.254	-0.772	0.692	0.116
	(0.533)	(0.362)**	(0.260)***	(0.299)
Youngest child 7-15 * fem.	*Reference*	*Reference*	*Reference*	*Reference*
Youngest child ≥ 16 * fem.	-0.079	-0.064	0.554	0.329
	(0.380)	(0.268)	(0.265)**	(0.212)
Observations	1,760	3,506	5,822	7,410

Notes: All models include dummies for graduation year (1981-2004), and interactions between these dummies and gender. Standard errors in parentheses. *significant at 10%; **significant at 5%; ***significant at 1%.

For the natural sciences and medicine, many variables have different signs, or different magnitudes, for men and women. For instance, men with a degree in the natural sciences are less likely to be in academia in 2004 the older they were upon graduation, whereas the reverse holds for women in the natural sciences: the older the woman was at the time of graduation, the larger the probability that she is academically employed (for both genders, the effects decrease with age).

The results connected to having children are difficult to interpret, since those who do not have children living at home might either have children who have moved out or might never have had children. For male PhDs in the natural sciences and medicine, having a baby (0-3 years old) reduces the probability of working in academia. For female natural scientists, those not having children, and those having children either below or above the compulsory school age of 7-15 years are more likely to be in academic employment. For female PhDs in medicine, those who do not have children and those who have young children are more likely to be in academic employment. That female PhDs in medicine and natural science with young children are the most likely to work in academia indicates that for women in these areas an academic career might be easier to combine with family life than a non-academic one.

5.3 Time trends in the probability of working in academia?

Thus far we have restricted the analysis to the influence of socio-economic variables on the probability of being academically employed in 2004. We now extend the focus to investigating how the probability of working in academia in 2004 is influenced by the year of graduation. By doing so, we can investigate any time trends in the choice between non-academic and academic employment. We have calculated the predicted probability of working in academia in 2004 for each graduation year. Our reference individual is married, has no children living at home, and is at the subject-specific average age at the time of graduation. Figure 4 displays the results.[11] There are no clear trends in the shares choosing academic employment for the humanities and the social sciences; for these areas, men and women are about equally likely to be in academia. For the natural sciences, while there are no gender differences in the time trend, the early and the late cohorts have a higher probability of being academically employed. While those in the late cohorts might eventually select out of academia, an academic career might also have become relatively more attractive for natural scientists. Medicine is the only subject for which there are significant gender differences; the later cohorts of women in particular are much more likely than men to be academically employed. The estimates also suggest a downwards trend for men and an upwards trend for women in the probability of being academically employed. In medicine the very rapid increase in female PhDs might have resulted in the crowding out or opting out of academic employment for male PhDs.

[11] The scale on the y-axis varies between the graphs.

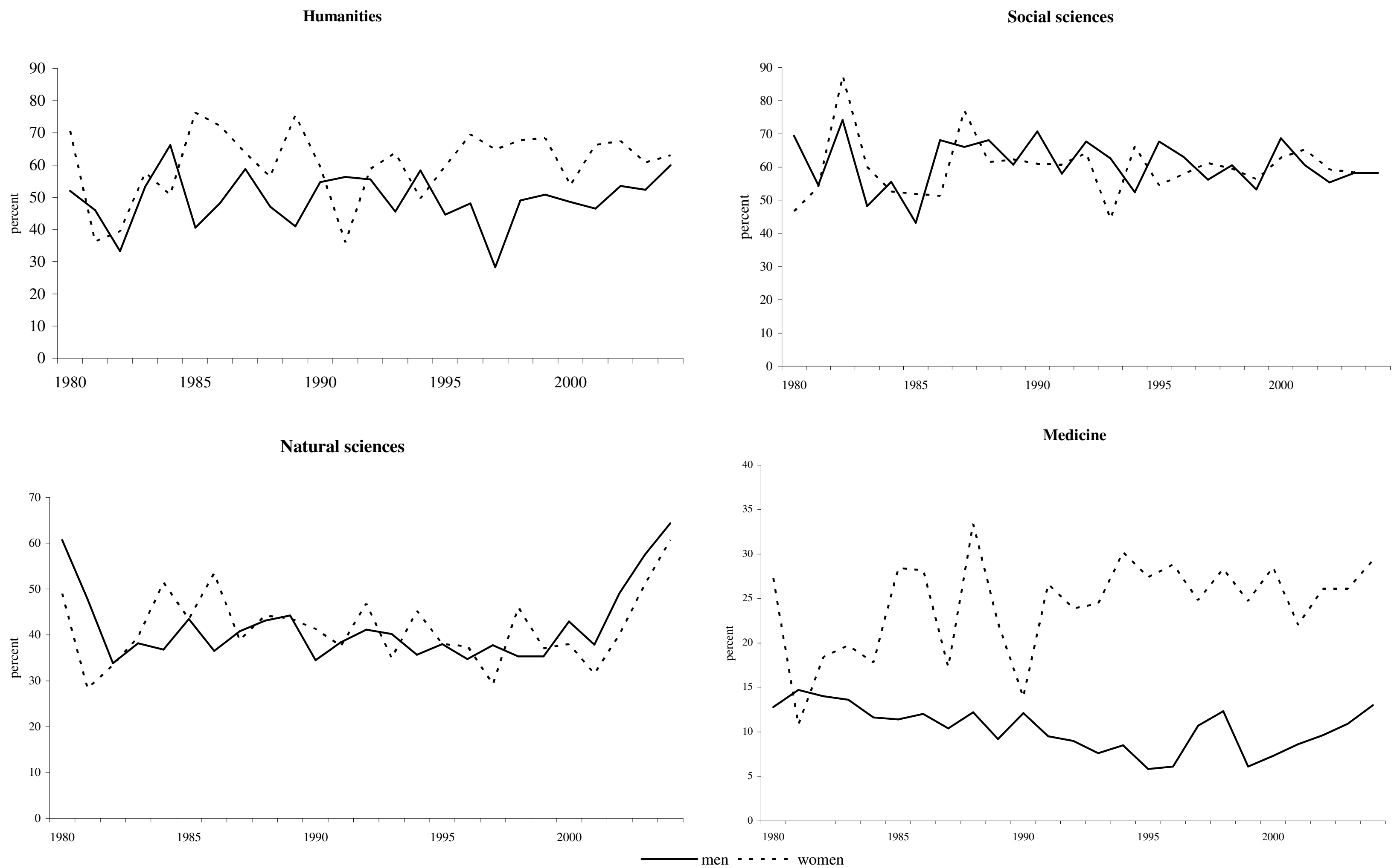

Fig. 4 The probability of being academically employed in 2004, as a function of year of graduation.
Notes: The reference individual is married, has no children living at home, and was at the subject-specific average age at the time of graduation.

6. Earnings inside and outside of academia

Having looked at where the male and female stock of scientific human capital is utilised, we now turn to the issue of remuneration. What are the earnings differences between PhDs who have remained in academia and those who have left, and how do earnings differ with gender and area, inside and outside academia? To answer these questions, this section presents results from earnings regressions on our cross-sectional data for 2004.

6.1 Are there earnings differences between sectors and genders?

We first present raw data on gender earnings differences in the academic and non-academic labour market. Our earnings measure includes earnings and positive income from self-employment in 2004. Table 4 shows that men's annual earnings are substantially higher than women's, regardless of sector or of the area of the doctoral degree. The gender differences are largest for PhDs in medicine (regardless of sector) and in social science (outside academia). On average, earnings are higher outside academia, although this pattern is not consistent for all areas: for the humanities those who work in academia earn as much as those who work outside of academia whereas in the social sciences this equal earnings pattern only applies to women.

Table 4 Mean earnings in 2004 for male and female PhDs in and outside of academia.

	Academia			**Outside academia**		
	Men	Women	Difference	Men	Women	Difference
All	416.8	344.9	17.3	562.4	429.6	23.6
Humanities	**358.7**	**302.7**	15.6	**360.5**	**302.7**	16.0
Social science	429.9	**386.3**	10.1	529.0	**379.2**	28.3
Natural science	359.6	281.5	21.7	450.1	356.7	20.8
Medicine	590.8	378.2	36.0	698.4	506.1	27.5

Notes: Earnings include income from own businesses and are displayed in thousands of Swedish krona, where £ 1≈ 13 krona. Means in bold type are *not* statistically significant on the 1 per cent level and refer to comparisons within gender across sectors. The difference is men's earnings minus women's earnings as a share of men's earnings.

6.2 An econometric analysis of earnings

Next we turn to an econometric analysis of gender earnings differences in the academic and the non-academic labour markets. The choice between an academic and a non-academic career is endogenously chosen by the individual, and the selection is likely to depend on observable and unobservable characteristics. Whether or not we should control for selection in earnings regressions depends on what caused the selection in the first place. To obtain unbiased estimates of the effects of the variables in the earnings regressions, we should take selection into consideration. However, to the extent that the selection was determined by discrimination, controlling for it might not be desirable, as by doing so we risk underestimating the degree of gender discrimination that actually exists. The preferable solution to this dilemma would be to estimate earnings regressions both where we model selection and where we do not. To model the selection, we need an instrument that affects the probability of being academically employed, but has no influence on earnings. We have explored several potential instruments that should mainly affect the choice of career, although we cannot exclude the possibility that earnings would be affected as well. These instruments all used the ratio of new students to the total number of PhDs – the idea being that the more students who enrolled in Swedish higher education, the larger the demand for teachers with a doctoral degree, a demand that would then influence the probability of academic employment for new PhDs.[12] Unfortunately, none of these attempts were successful, as the first-stage estimates proved far too imprecise to be informative. Given that none of our suggested instruments provided enough power for identification, we are restricted to analysing the earnings outcomes of men and women in the academic and in the non-academic labour markets without controlling for selection.

All earnings regressions are estimated by ordinary least squares. The dependent variable is the natural logarithm of the 2004 yearly earnings (*ln I*).[13] The models include controls for family related variables, as previously defined (*F*). In addition, we control for experience, distinguishing between (potential) 'general' experience (*E*), defined as the age in 2004 minus 27 (which is the time needed to finish a PhD if the individual goes straight through the Swedish educational system)[14] and (potential) post-doctoral experience (*PE*), defined as the time passed since obtaining the PhD. Thus we model the individual's earnings at a particular point (in 2004) as reflecting the rates-of-returns to two different types of accumulated experience, general and post-doctoral:[15]

$$ln\, I_i = \alpha + F_i\beta + E_i\gamma + PE_i\delta + \varepsilon$$

Table A1 in the Appendix provides descriptive statistics and variable definitions. To investigate whether any significant gender-related earnings differences exist, and whether any differences exist between the academic and the non-academic labour markets, we estimate a

[12] We tried several versions of instruments exploiting this idea, e.g. measuring the ratio of students to PhDs at the national level and the university level, or defining the total number of PhDs in various ways (e.g. only those that graduated in a certain year, everyone that had graduated in the past five years).

[13] As mentioned earlier we also include positive income from self-employment in our earnings measure.

[14] In Sweden, children start school at seven years of age. Then follows nine years of compulsory schooling, three years of upper-secondary schooling, three to four years of university education, and four years in a PhD program.

model in which a dummy for gender and a dummy for being academically employed are included as explanatory variables. Table 5 presents the results.

On average, female PhDs earn almost 15 per cent less than their male colleagues, and PhDs choosing academic employment earn on average 24 per cent less than PhDs working outside academia. Stern (1999) shows that scientists in the US labour market ‘pay to publish’, i.e. scientists who hold jobs where publishing is possible earn significantly less than those who hold jobs where it is not. Our results indicate that the same pattern also applies in Sweden. However, the large magnitude of the income difference between the academic and non-academic labour markets is somewhat surprising, as the ‘pay to publish’ penalty seems rather large for a country known for its compressed wage structure and small income differentials.

Table 5 Estimated effects of being academically employed on earnings

	Variable
Female	-0.148
	(0.011)***
Academia	-0.242
	(0.010)***
Constant	7.417
	(0.030)***
Observations	24,157
R2	0.17

Notes: Standard errors in parentheses: ***significant at 1%. The model includes controls for experience, experience squared, post-doctoral experience, post-doctoral experience squared, marital status and five child-age dummies. The reference individual is male, not in academia, unmarried and has a child aged 7-15.

Given large earnings differences between the academic and the non-academic labour markets, we now investigate separate earnings equations for the two sectors. To capture gender differences, we include interactions between the gender dummy and the explanatory variables. Table 6 presents the results.

Women’s earnings are much lower than men’s, regardless of area. While the magnitude of the (negative) coefficient of the gender dummy is slightly larger in academia than outside academia, we must also take the interaction dummies between female and area into consideration. When doing so, we find that the gender difference is larger in academia for humanists and natural scientists, whereas the gender difference is larger outside academia for social scientists and medical PhDs. Overall, the gender earnings difference is largest for PhDs in medicine employed outside academia, where females earn 36.7 per cent less than their male colleagues. Although we cannot control for different specialisations in medicine, this large

[15] This specification is similar to those used to reflect returns on general experience and firm-specific experience (tenure), respectively, in earnings regressions.

gender gap in earnings outside academia might be one reason that more female and fewer male PhDs in medicine choose an academic career (see figure 4).

Within the academic labour market, PhDs in the humanities and the natural sciences have the lowest incomes and those in the social sciences and medicine have the highest. Likewise, in the non-academic labour market, social scientists and PhDs in medicine have the highest incomes, but here too the natural scientists earn significantly more than those in the humanities.

Table 6 Earnings equations inside and outside of academia.

	Academia		**Outside academia**	
	Variable	Interaction (*female)	Variable	Interaction (*female)
Female	-0.289		-0.265	
	(0.116)**		(0.089)***	
Social science	0.222	0.109	0.377	-0.033
	(0.041)***	(0.064)*	(0.039)***	(0.065)
Natural science	-0.041	0.021	0.172	0.045
	(0.040)	(0.068)	(0.035)***	(0.060)
Medicine	0.257	-0.025	0.652	-0.102
	(0.046)***	(0.070)	(0.033)***	(0.056)*
Other	0.164	0.044	0.340	-0.038
	(0.039)***	(0.064)	(0.034)***	(0.059)
Experience	0.081	0.017	0.067	0.004
	(0.006)***	(0.010)*	(0.004)***	(0.007)
Experience^2	-0.002	-0.000	-0.002 **	0.000
	(0.000)***	(0.000)	(0.000)*	(0.000)
Post-doctoral exp.	0.072	-0.020	0.031	0.005
	(0.007)***	(0.011)*	(0.004)***	(0.007)
Post-doctoral exp.^2	-0.002	0.000	-0.000	-0.001
	(0.000)***	(0.000)	(0.000)***	(0.000)**
Married	0.129	-0.036	0.132	-0.042
	(0.025)***	(0.040)	(0.017)***	(0.027)
No child	-0.014	0.059	-0.059 *	0.078
	(0.032)	(0.057)	(0.021)**	(0.037)**
Youngest child 0-3	-0.005	0.008	-0.116	-0.055
	(0.038)	(0.068)	(0.023)***	(0.042)
Youngest child 4-6	0.013	-0.027	-0.069	0.011
	(0.045)	(0.083)	(0.028)**	(0.050)
Youngest child 7-15	*Reference*	*Reference*	*Reference*	*Reference*
Youngest child ≥ 16	-0.009	0.063	0.047	0.076
	(0.037)	(0.065)	(0.023)**	(0.042)*
Constant	6.891		7.350	
	(0.070)***		(0.054)***	
Observations	8,918		15,211	
R2	0.20		0.20	

Note: Standard errors in parentheses: *significant at 10%; **significant at 5%; ***significant at 1%. The reference individual is male, humanist, unmarried and has a child aged 7-15.

The return to a (first) year of general experience is fairly similar for all PhDs, amounting to about 8 per cent for men and 10 per cent for women within academia and to about 7 per cent for both men and women outside academia. But the payoff for a (first) year of post-doctoral experience shows more variation between the labour markets. Here the rate of return is markedly higher in academia, amounting to about 7 per cent for men and 5 per cent for women, whereas it is about 3 per cent outside academia for both men and women. In both labour markets married individuals have higher earnings than unmarried individuals – possibly because married individuals have unobserved characteristics that are attractive in both the labour market and the marriage market. Interestingly, having children at home (no matter what their age) has no influence on earnings in academia. In the non-academic labour market, however, men without children (at home) earn less than men with children (at home), whereas the opposite holds for women. Moreover, having young children (less than 7 years old) influences earnings negatively for both genders, whereas having a child older than 15 has a positive effect, especially for women. That having pre-school children influences earnings negatively for the non-academic (but not for the academic) labour market indicates that in Sweden work and family responsibilities might be more easily combined in the academic labour market than in the non-academic.

7. Concluding remarks

During recent decades both the absolute numbers and the shares of female PhDs has increased rapidly in many western countries. Therefore, making efficient use of female scientific human capital has become increasingly important. Nevertheless, evidence from the UK and the US shows that female PhDs are less likely than male PhDs to be academically employed, and that they have significantly lower earnings, than their male colleagues. This paper investigates these issues for Sweden, a country otherwise renowned for its gender equality. It examines the gender differences both in earnings and in the probability of being academically employed for Swedish PhDs in the humanities, the social sciences, the natural sciences and medicine.

The absolute number of PhDs in Sweden increased more than fivefold from 1970 to 2003. This increase is largely attributable to the large increase in the number of women obtaining doctorates. However, the increase in the share of women holding PhDs varies largely among different subject areas. In particular, women have increased their representation in medicine and the social sciences, whereas the share of women in natural science remains low and is growing more slowly than for the other subject areas studied. Thus when it comes to realising women's intellectual potential to the same extent as men's, as manifested by the completion of a PhD, Sweden today has achieved gender equality in the humanities, social sciences and medicine but not yet in the natural sciences.

As for the sectoral allocation of male and female scientific manpower, for historical reasons more than twice as many men as women hold PhDs in Sweden. Thus the absolute number of women working in Swedish universities and university colleges is much lower than the absolute number of men. Indeed, women constitute only about 35 per cent of the scientific workforce in academia, with the female share varying from 26 per cent in the natural sciences to 46 per cent in medicine. However, a different picture emerges from a look at the probability for female and male PhDs being academically employed, given subject area, graduation year, etc. Then natural science and medicine are the only areas for which there are significant gender differences. Particularly for the later cohorts in medicine, women are much more likely than men to be academically employed, and divergent trends for men and women could be the result of the very rapid increase in female PhDs in medicine having led to the crowding out or opting out of academic employment for male PhDs. But the overall picture is that in Sweden female PhDs are as likely as male PhDs to be in academic employment, so that no gender differences exist in the sectoral allocation of women's and men's scientific human capital.

The study nevertheless reveals large gender differences in the way that women's and men's scientific human capital is utilised and rewarded inside and outside of academia. On average (for the total stock of male and female PhDs), academically employed PhDs earn 24 per cent less than PhDs employed outside academia, and for both sectors together, the average gender earnings gap is 15 per cent. Although women's earnings are much lower than men's, regardless of sector, the size of the gap varies between the academic and the non-academic labour markets. For PhDs in the humanities and the natural sciences, the gender earnings differences are larger in academia, whereas the opposite holds for PhDs in medicine and the social sciences. The largest gender gap in earnings is found for PhDs in medicine employed outside academia, where females earn about 37 per cent less than their male colleagues. That large differences remain in Sweden in the earnings careers of male and female PhDs both inside and outside academia is evident. Nonetheless, from the present study one cannot deduce to what extent these earnings differences reflect gender differences in preferences, gender differences related to family formation or family obligations, or discrimination of various kinds. To disentangle these factors is a task for future research and is likely to require both longitudinal data and survey data.

Appendix

A comparison of the 2004 stock data with examination records

Figure A1 displays the stock of PhDs 67 years old or younger in 2004 as a share of the total number of PhDs graduating each year, according to Statistics Sweden's examination records.[16] The figure thus shows the difference between our 2004 stock data and the total number of PhDs graduating in each year. This difference is the size of attrition from our data as a result of PhDs' dying, emigrating or turning older than 67 years. The difference between the 2004 stock and the examination records is largest for the earliest graduation years, where the share of PhDs in the 2004 stock is approximately 40 per cent of the number of PhDs in the examination records. However, the difference strongly decreases throughout the 1970s, probably due to fewer PhDs being over 67 years old. The curve has a slight hump during the 1980s, showing that relatively many of those who obtained their degrees during these years still remain in the stock. Nevertheless, the share in the stock remains rather stable at around 80 per cent of the examination records from the 1980s and onwards, and therefore, we focus on this period in our econometric estimations.

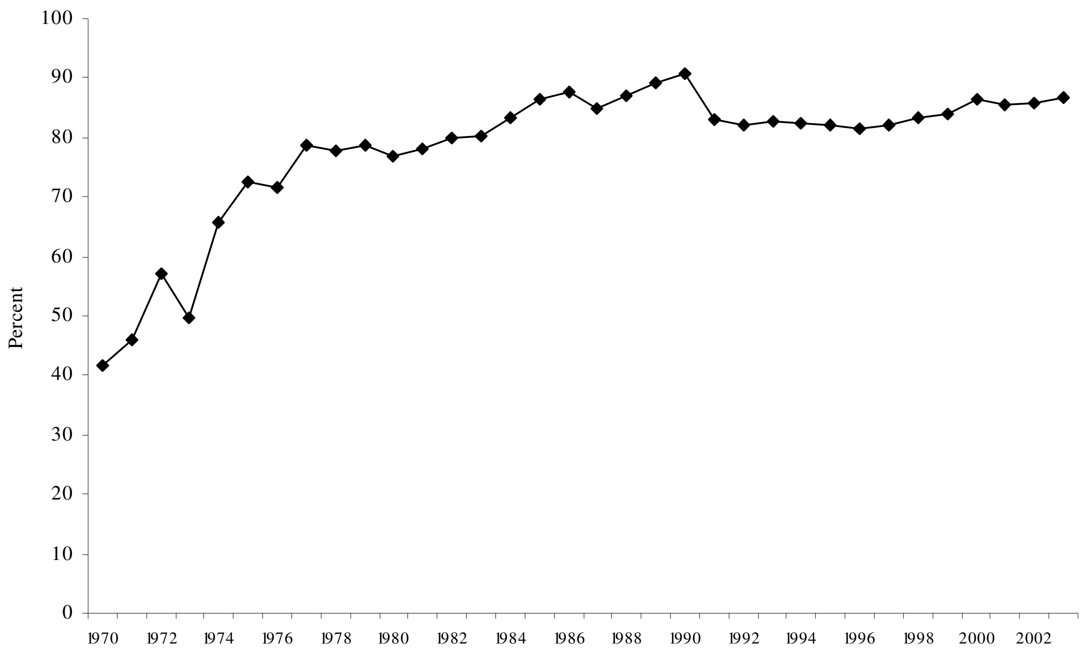

Fig. A1. Stock of PhDs less than 68 years old in 2004 as a share of Statistic Sweden's examination records.

[16] That is, we examine the ratio $\frac{stock\ \ of\ \ Ph.D.s < 68 years\ old}{ex.\, record} * 100$ by year of graduation in figure A1.

Table A1 Variable definition and means

Name	Definition	Men mean (st.d)	Women mean (st.d)
Female	*1 if female*	0 (0)	1 (0)
Academia	*1 if employed in academia*	0.37 (0.48)	0.39(0.49)
ln y	*Natural logarithm of working income*	8.34 (0.91)	8.11 (0.86)
Married	*1 if individual is married or registered partner*	0.68 (0.46)	0.59 (0.49)
No child	*1 if childless, or no child is living at home*	0.44 (0.50)	0.44 (0.50)
Youngest child 0-3	*Has at least one child aged 0-3 living at home*	0.14 (0.35)	0.16 (0.37)
Youngest child 4-6	*Has at least one child aged 4-6 living at home*	0.06 (0.25)	0.06 (0.25)
Youngest child 7-15	*Has at least one child aged 7-15 living at home*	0.19 (0.39)	0.18 (0.38)
Youngest child ≥ 16	*Has at least one child 15 or above living at home*	0.16 (0.36)	0.15 (0.36)
Age at graduation	*Age at the time of graduation.*	35.6 (6.23)	38.3 (8.17)
Age at grad.^2	*Age at graduation squared*	1304 (496)	1534 (683)
Experience	*General experience:* $age_{2004} - 27$	22.37 (10.1)	20.19 (10.4)
Experience^2	*General experience squared*	602.15	515.96
Post-doctoral exp.	*Post-doctoral experience: 2004 - year of grad.*	13.68 (9.51)	8.81 (7.84)
Post-doctoral exp.^2	*Post-doctoral experience squared.*	277.7(305.6)	139.2(214.7)
Umeå	*Umeå university*	0.06 (0.24)	0.07 (0.25)
Uppsala	*Uppsala university*	0.16 (0.37)	0.17 (0.37)
Stockholm	*Stockholm university*	0.10 (0.30)	0.12 (0.33)
Karolinska	*Karolinska institutet*	0.09 (0.29)	0.13 (0.34)
KTH	*Royal Institute of Technology*	0.08 (0.27)	0.04 (0.18)
Linköping	*Linköping university*	0.06 (0.23)	0.05 (0.22)
Göteborg	*Gothenburg university*	0.13 (0.33)	0.15 (0.36)
Chalmers	*Chalmers University of Technology*	0.07 (0.25)	0.03 (0.16)
Lund	*Lund university*	0.20 (0.40)	0.18 (0.38)
Lantbruk	*Swedish University of Agricultural Sciences*	0.04 (0.20)	0.05 (0.22)
Other	*Other*	0.02 (0.14)	0.02 (0.12)
Humanities	*PhD in the humanities*	0.06 (0.25)	0.09 (0.28)
Social science	*PhD in the social sciences*	0.13 (0.34)	0.17 (0.37)
Natural Science	*PhD in the natural sciences*	0.27 (0.44)	0.20 (0.40)
Medicine	*PhD in medicine*	0.27 (0.45)	0.33 (0.47)
Other	*PhD in other subject*	0.27 (0.44)	0.22 (0.41)

Note: The econometric models also include dummies for year of graduation. Descriptive statistics for these dummies are available from the authors on request. All variables regard the situation in 2004.

Table A2 The probability to remain in academia. All subjects, fully interacted model.

Variables	Coefficient	Interactions	Coefficient
Female	-3.880		
	(0.861)***		
Age at graduation	-0.134	Age at grad. * female	0.171
	(0.025)***		(0.039)***
Age at grad.^2	0.002	Age at grad.^2 * female	-0.002
	(0.000)***		(0.000)***
Social science	0.181	Social science * female	-0.143
	(0.078)**		(0.126)
Natural science	-0.703	Natural sc. * female	-0.091
	(0.073)***		(0.125)
Medicine	-2.072	Medicine * female	0.386
	(0.082)***		(0.131)***
Other	-0.691	Other * female	-0.060
	(0.079)***		(0.129)
Married	-0.133	Married * female	0.163
	(0.042)***		(0.068)**
No child	0.031	No child * female	0.283
	(0.051)		(0.090)***
Youngest 0-3	-0.233	Youngest 0-3 * female	0.296
	(0.060)***		(0.107)***
Youngest 4-6	-0.046	Youngest 4-6 * female	-0.024
	(0.073)		(0.134)
Youngest 7-15		Youngest 7-15 * female	
Youngest ≥ 16	0.095	Youngest ≥ 16 * female	0.179
	(0.061)		(0.108)*
Stockholm		Stockholm * female	
Umeå	0.786	Umeå * female	-0.220
	(0.086)***		(0.144)
Uppsala	0.063	Uppsala * female	-0.047
	(0.070)		(0.117)
Karolinska	0.303	Karolinska * female	-0.312
	(0.103)***		(0.158)**
KTH	-0.014	KTH * female	-0.198
	(0.087)		(0.177)
Linköping	0.424	Linköping * female	0.312
	(0.091)***		(0.156)**
Göteborg	0.257	Göteborg * female	-0.310
	(0.074)***		(0.122)**
Chalmers	0.161	Chalmers * female	0.155
	(0.091)*		(0.188)
Lund	0.265	Lund * female	0.076
	(0.067)***		(0.113)
Lantbruk	0.525	Lantbruk * female	-0.105
	(0.098)***		(0.160)
Other	0.701	Other * female	0.087
	(0.122)***		(0.235)
Constant	3.020		
	(0.518)***		
Observations	24,700		

Notes: The model includes 24 year of graduation dummies (1981-2004), plus interactions between these dummies and gender. Standard errors in parentheses: * significant at 10%; ** significant at 5%; *** significant at 1%.

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