5

Does Science Promote Women? Evidence from Academia 1973–2001

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Fewer women are present in science academe than in the workforce as a whole, and this is particularly true in the higher levels of academe, such as tenured jobs and full professorships at major research universities. This chapter begins from the point when scientists receive their Ph.D.s and investigates gender differences as they move up the academic career ladder through the stages of getting tenure-track jobs, being granted tenure, and being promoted to full professorships.

There is a large body of literature about women and science, particularly since 1982 when Congress instructed the National Science Foundation (NSF) to report biennially on the status of women and minorities in science. The NSF reports have consistently shown that since 1982 and through the most recent report (NSF 2004a), women continue to be less likely than their male colleagues to be full professors and more likely to be assistant professors. Congress established its own committee, the Congressional Committee on the Advancement of Women and Minorities in Science, Engineering, and Technological Developments (CAWMSET), to review the status of women in science. This committee (CAWMSET 2000) also found that women in SET (Science, Engineering, and Technology) ac-

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ademia are less likely to be tenured (29 percent of women versus 58 percent of men among full-time ranked academics at four year colleges) or hold full professorships (23 percent of women compared to 50 percent of men). More recently, the Government Accountability Office (GAO) reported to Congress that women scientists lag behind men in terms of salary and rank (GAO 2004). In site visits, some women report that tenure-track positions at research universities create difficulty in balancing work and family. Others report that a hostile climate makes academic employment unattractive. Another recent study by Donna Nelson and Diana Rogers (2005) found that smaller percentages of women than men who receive Ph.D.s proceed to become assistant professors in top fifty SET departments. These important sources represent only a few of the many studies on women in science.

Even though women are underrepresented in upper echelons of academic science, one cannot conclude from the NSF, CAWMSET, or Nelson reports that unfair treatment in the promotion process is the underlying cause of the gender gap in academic promotion. Two alternative possibilities include that women choose careers that do not have the rigid academic timetable or that women are less productive, particularly in terms of research, than men. Of course, research productivity itself may result from the absence of an environment and the resources that foster research, as demonstrated at MIT (Goldberg 1999).

In contrast to these negative findings, Long (2001) studies the careers of women in science from 1973 to 1995 and concludes that women have been successful in moving "from scarcity to visibility." They find that the impact of marriage and children on women's careers had largely been eliminated by 1995, although men were still 4 percent more likely to receive tenure. On the other hand, Xie and Shauman (2003) find that marriage and children exacerbate gender differences in promotion in nonacademic science. In addition, they find the gender publication gap is smaller than in previous studies and declining over time, suggesting a convergence in women's and men's academic productivity.

A recent report by the NSF (NSF 2004b) is the most comprehensive study to date of the factors contributing to promotion in academic careers of scientists and engineers. This work, carried out contemporaneously to ours and also using NSF's longitudinal Survey of Doctorate Recipients (SDR), finds that controlling for human capital, personal characteristics, and institutional factors, there remains a significant female disadvantage in the likelihood of being in a tenure-track job, of receiving tenure, and of being promoted to full professor. However, in most of their specifications, they find that these gender differences become statistically insignificant when family characteristics are allowed to affect men and women differently. Our findings are quite different qualitatively from theirs, for reasons we discuss in the conclusion. We find that in science, single women actually have an advantage over single men in obtaining tenure-track jobs and in being granted tenure after controlling for covariates, and that married men and women without children are quite similar at these two stages. Children lower the likelihood that women in science will advance up the academic job ladder beyond their early postdoctorate years. In contrast, children have a positive or zero effect on men's career success in academic science.

We also find that science is not homogeneous. There are particularly large gender differences in obtaining tenure-track jobs, getting tenure, and being promoted to full in the life sciences, the area that graduates the most women.

The remainder of the chapter is organized as follows: we first describe the data and methodology. We then discuss the entry into tenure-track jobs, describe and model the tenure decision, and then describe and model promotion to full professor. The final section concludes.

5.1 Data and Empirical Methodology

Our analysis of promotion uses data from the 1973 to 2001 waves of the Survey of Doctorate Recipients (SDR). The SDR is a biennial, longitudinal survey of doctorate recipients from U.S. institutions conducted by the National Research Council. The SDR collects detailed information on doctorate recipients including demographic characteristics, educational background, employer characteristics, academic rank, government support, primary work activity, productivity, and salary. The SDR has undergone substantial changes in the sampling frame and survey content between the 1973 and 1993 waves (Mitchell, Moonesinge, and Cox 1998). Technical reports provided by the National Science Foundation have allowed us to construct a longitudinal data set with consistent variable definitions over time.[1]

We have selected a longitudinal extract of doctorate recipients in the sciences who received their Ph.D. between the years of 1972 and 1991 and remain in the survey ten years after the Ph.D. Individuals are excluded if they are not observed more than once or if they skip more than three surveys.

We estimate three career milestones. First, we examine the probability of obtaining a tenure-track job within nine years of the Ph.D. Then we restrict the analysis to those who have ever held a tenure-track job to estimate two promotion milestones, the first award of tenure and the first award of full professorship.

1. Many longitudinal surveys are plagued by nonresponse and attrition. However, the NSF does a remarkably good job at keeping SDR response rates high. The response rate for each survey is in the range around 78 to 80 percent. Many of these nonresponders do respond to the following survey. Only about 5 percent of the sample either do not respond for three consecutive surveys or cannot be found. Note that people are dropped from the SDR when (a) they die (b) they pass seventy-five years of age (c) they are non-U.S. citizens out of the United States for two surveys in a row and (d) on a random basis in order to maintain the target sample size while incorporating new Ph.D.s.

From the 1973 through 1991 surveys, respondents provided the exact year that they received tenure, which adds some accuracy given the biennial nature of the survey. For later surveys, tenure year is imputed as the first year a person is observed with tenure in the sample. We impute the year a person receives full professorship as the first year a person is observed as a tenured full professor in the sample. Given the biennial nature of the survey, years until tenure and years until full professor may be measured with one-year error.

Our following analyses include both time-varying and nontime varying independent variables. Nontime varying variables include gender, race, whether foreign-born, field, and aspects of the person's Ph.D. institution. Time-varying independent variables include marital status, children, employer characteristics, primary and secondary work activities, government support, and limited productivity measures (discussed following). These covariates are suggested by previous studies of academic promotion (Long, Allison, and McGinnis 1993; Ginther and Kahn 2004). Table 5.1 gives descriptive statistics about both dependent and covariate variables at different stages of academic careers of scientists.

Measures of academic productivity are largely missing from the SDR data, but the SDR does ask questions about publications in the 1983, 1995, and 2001 surveys. The 1983 question refers to publications between 1980 and 1983 whereas the 1995 and 2001 questions refer to numbers of publications in the previous five years. We use these data to create rough measures of cumulative papers presented and publications per year past Ph.D. If productivity data are missing for a particular year (as they are prior to 1980), average observed productivity is used to impute total productivity—an admittedly rough correction that nevertheless seems preferable to omitting the information altogether.

Research by Ginther and Hayes (1999, 2003), Ginther (2001, 2003, 2004), and Ginther and Kahn (2004) demonstrates that employment outcomes differ by academic field. Thus, promotion is analyzed for all scientific fields together and broken down into three major scientific fields—biological and life sciences, physical sciences, and engineering. It is particularly important to differentiate between fields for gender differences in academic careers, in that the combined science statistics on women are more likely to be picking up trends in the life sciences, where most of the women are, while the statistics on men are quite likely to pick up engineering, which is heavily male. Accordingly, we point out when major facts differ across these broad areas.

We evaluate gender differences in academic careers using both probit and hazard methodologies. In our probit analyses, first we estimate whether significant gender differences exist in the probability of a tenure-track job within nine years of the Ph.D. for all individuals with valid surveys. Second, for those who hold a tenure-track job at some point in their careers, we estimate probit models of the probability of having tenure eleven years

Table 5.1 Gender differences in mean characteristics

Variables	All doctorate[a]		Tenure track[b]		Tenured[c]	
	Female	Male	Female	Male	Female	Male
Tenure-track within 9 years of Ph.D.	0.544***	0.582***	—	—	—	—
Promotion to tenure within 11 years of Ph.D.	—	—	0.516	0.532	—	—
Promotion to full within 15 years of Ph.D.	—	—	—	—	0.257***	0.316***
Age at Ph.D.	31.942***	30.674***	31.998***	30.503***	31.763***	30.152***
African American	0.051**	0.042**	0.047	0.048	0.044	0.047
Native American	0.004	0.004	0.005	0.005	0.002	0.004
Asian	0.122	0.130	0.089**	0.105**	0.076	0.084
Other race	0.002	0.002	0.003	0.002	0.001	0.001
Foreign-born	0.168	0.181	0.150	0.157	0.130	0.120
Year of Ph.D.	79.672***	80.701***	79.265***	80.254***	77.263***	78.247***
Ph.D. from Research I	0.732***	0.766***	0.739***	0.775***	0.740***	0.779***
Ph.D. from Research II	0.108	0.114	0.102	0.113	0.101	0.113
Ph.D. from Doctorate I	0.077***	0.039***	0.082***	0.039***	0.082***	0.036***
Ph.D. from Doctorate II	0.036***	0.029***	0.035	0.027	0.035	0.031
Married	0.672***	0.804***	0.648***	0.846***	0.645***	0.849***
Total children	0.756***	1.163***	0.752***	1.361***	0.767***	1.399***
Children < 6	0.320***	0.470***	0.261***	0.378***	0.169***	0.246***
Cumulative employers	—	—	1.718	1.686	2.058**	1.961**
Private university	—	—	0.274***	0.230***	0.272***	0.222***
Research I	—	—	0.267***	0.306***	0.275**	0.310**
Liberal arts I	—	—	0.200***	0.166***	0.201	0.176
Medical school	—	—	0.216	0.221	0.214	0.215
Primary work research	—	—	0.352***	0.456***	0.331***	0.427***
Primary work teach	—	—	0.456***	0.377***	0.440***	0.372***

(continued)

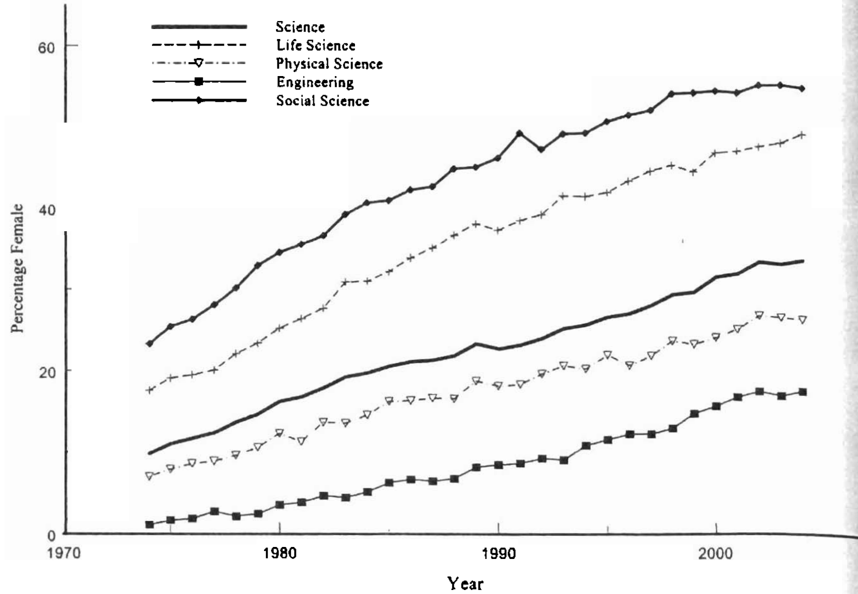

Fig. 5.1 Percentage of doctorates granted to females, 1974–2004 Survey of Earned Doctorates
Source: 1974–2004 *Survey of Earned Doctorates.*

percentage of females in each academic rank over the quarter century. The general upward trend in the percentage of females among assistant professors mirrors the trend in science Ph.D. awards from figure 5.1. Also similar to doctorates granted, life sciences have the highest percentage of females among assistant professors, with physical sciences at much lower levels and engineering at the very lowest.

Other aspects of the time trends in assistant professorships (in fig. 5.2) compared to doctoral recipients (in fig. 5.1) differ by field. In life sciences, throughout the entire quarter century, *fewer* women than men proceed from Ph.D. receipt to a tenure-track assistant professorship, with the wedge during the past four years being especially large, averaging a difference of 6 percentage points. In fact, during these four years, the proportion of females among assistant professors in life sciences has actually fallen despite the fact that given increasing time trends in doctoral receipt, we would have expected them to have risen. In contrast, in physical sciences the percent of females among assistant professors has consistently kept pace with the percentage of female doctorates. In 2001, 25 percent of doctorates awarded to women in the physical sciences and 26 percent of assistant professors

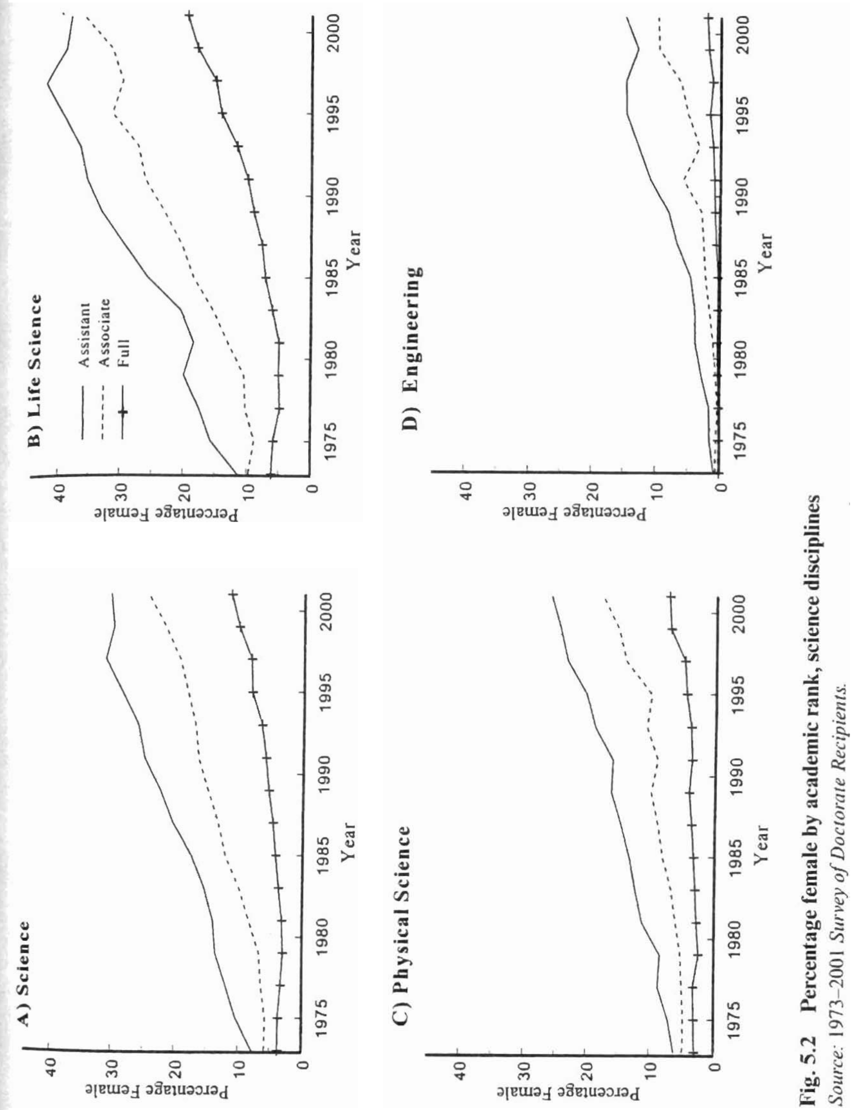

Fig. 5.2 Percentage female by academic rank, science disciplines
Source: 1973–2001 *Survey of Doctorate Recipients.*

by 5 percent on average.[5] As a result, in science as a whole a married man without children and a married woman without children are about equally likely to have a tenure-track job nine years after Ph.D. However, there are large differences between the scientific fields. At one extreme, in engineering both sexes have equally large positive impacts of marriage (21 to 22 percent). In life sciences, marriage increases women's likelihood of entering a tenure-track job by a more modest 7.1 percent (again compared to 22 percent for men). Finally, in physical science, marriage does not affect women's chances at all.

Children create a marked divergence between men and women. For science as a whole, the presence of a prekindergarten-aged child nine years post-Ph.D. lowers women's likelihood of having a tenure-track job by 8.1 percent. The presence of a grade school child has no significant effect, presumably because the demands of rearing very young children occurred before Ph.D. receipt rather than during these nine years post-Ph.D. In contrast to women, prekindergarten children have no effect on men's likelihood of having a tenure-track job while each child above six years old *increases* a man's probability of getting a tenure-track job by 2.9 percent.

Disaggregating children's impact by field, young children especially hurt the tenure-track prospects of women in life sciences (by –8.1 percent) and in physical sciences by (–5.6 percent). In engineering, while the point estimate is large (–9.8 percent), it is significant only at the 20 percent level (perhaps due to small numbers of females in engineering). Grade school children are negatively correlated with women having a tenure-track job for physical science only, where the impact is relatively small (–3.4 percent).

The positive impacts of marriage and children on men's prospects here recalls positive impacts on wages and promotion in the labor market as a whole, which has been attributed to three primary explanations. First, particularly with respect to marriage, it may be due to selection: "good catches" in the marriage market are correlated with "good catches" in the labor market. Second, it could be induced effort by men responsible for a family. Third, it could be paternalistic favoritism by employers who know that the man has a family to support. Neither the induced effort nor the paternalistic favoritism seem likely to apply to new job offers for Ph.D.s in academia. And they are unlikely to ever apply to women. We are thus left with selection as the key explanation for positive impacts of marriage in obtaining tenure-track jobs for both men and women and with the positive impacts of children for men.

5. This calculation adds the coefficient of "Married" to the coefficient of "Female*Married." Many other numbers later in this section similarly add several coefficients. For instance, the impact on men of one young child adds the coefficient on "Total Children" to the coefficient on "Children" ≤ 6, while the impact on women adds to this sum the coefficient of "Female*Total Children" and the coefficient of "Female*Children" ≤ 6. We note in the text when the sum is not significant.

Gender differences in the likelihood of receiving a tenure-track job have changed over time. In additional specifications (available upon request), the gender difference between comparable men and single women (table 5.2, model 3) was allowed to differ by year of Ph.D. In pooled science, later cohorts of women did better relative to men. For instance, single women with 1972 Ph.D.s in science had a 12.1 percent higher likelihood of entering tenure-track jobs within nine years than single men of that cohort, and this gender difference widened to 24.4 percent for those with 1991 Ph.D.s. Disaggregating, life science and physical science fields actually saw even larger changes over cohorts, while engineering had no significant cohort differences between men and women.

5.3 Empirical Analysis of Moving Up the Career Ladder: Promotion of Academic Scientists

5.3.1 Estimates of the Probability of Promotion to Tenure

Returning to figure 5.2, the dashed line shows the changing percentage of females among associate professors, while figure 5.3 shows the percentage of females among all tenured faculty. In science as a whole, the monotonically increasing trend in associate professorships mirrors trends in

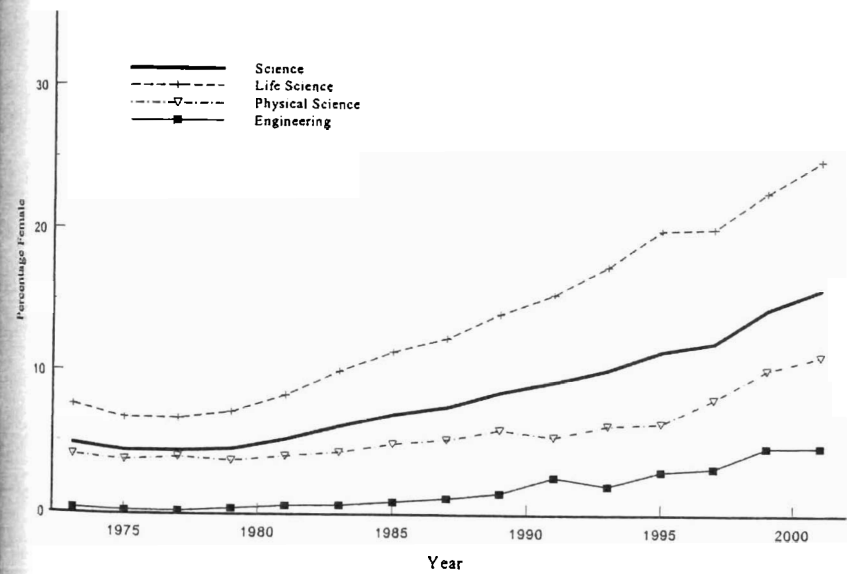

Fig. 5.3 Percentage of tenured faculty who are female, by discipline
Source: 1973–2001 *Survey of Doctorate Recipients.*

assistant professorships five to ten years earlier, and the levels are comparable. For instance, 26 percent of females among associates in 1991 is the same as the percent of females among assistant professors six years earlier. Within broad fields, however, trends in percent of females among associate professorships are not at all smooth or monotonically increasing, with substantial drops in the percentage of females in 1996 in life sciences and in 1993 in engineering, and stagnation in the percentage of females in physical sciences between 1989 and 1995.

The top panel of table 5.3 summarizes the impact of gender on tenure probabilities before we allow gender differences in the impact of family variables.[6] The first row shows the probit analysis of gender differences in the probability of tenure by eleven years from the doctorate controlling for academic field, demographic, family and employer characteristics, primary and secondary work activity, government grant support, and productivity (but without interaction terms). These results show no significant gender differences in tenure; the point estimates of the impact of being female even vary in sign across fields.

Hazard analyses are able to capture the entire year-by-year pattern of the likelihood of receiving tenure and thus in the duration until tenure. A particular strength of this analysis is that it takes into account those observed to not have received tenure by the last survey. The second row of table 5.3 presents the risk ratios from a proportional hazards model of promotion regressed on a dummy variable for gender. This risk ratio can be interpreted as the effect of being female rather than male on the probability of receiving tenure. (A number less than one indicates that on average the likelihood of tenure receipt in any given year for females is less than for males.)

In the hazard analysis with no controls, there is no significant gender difference either for science as a whole or for any of the broad fields. However, after adding in controls, the risk ratios fall, indicating less tenure for women.[7] With controls, the gender difference is only significant for life sciences, where the point estimate suggests an 8 percent lower likelihood of tenure for women ($p = .07$).[8]

Once again, adding in female-interaction terms for marriage and children changes the picture. Table 5.4 reports probit coefficients of these gender and family terms when included in addition to other covariates.[9] We have done the same estimation with hazard analyses (details available on request). Those results are qualitatively similar except where noted.

6. Appendix table 5A.2 provides detailed parameter estimates for the probit model. Hazard estimates are available by request.

7. The fact that the gender differences arise after controlling for these covariates suggests that the women who obtain tenure-track jobs have better credentials (X variables) than the men.

8. The complete hazard analysis is available upon request.

9. Note that the family variables measure the status as of eleven years after Ph.D. receipt.

Table 5.3 Gender differences in the probability and hazard of promotion

	Full sample	Life science	Physical science	Engineering
	Promotion to tenure			
Female probit coefficient	0.00	−0.03	0.01	0.02
Promoted eleven years past Ph.D.	(0.88)	(0.19)	(0.73)	(0.75)
(Including all covariates)				
	Risk ratio estimate			
Female risk ratio	0.97	1.02	1.00	1.06
(No covariates)	(0.33)	(0.60)	(0.96)	(0.56)
Model 1 female risk ratio	0.95	0.89**	0.93	1.00
(Covariates ex. productivity)	(0.14)	(0.02)	(0.22)	(0.97)
Model 2 female risk ratio	0.97	0.92*	0.94	1.03
(Including productivity covariates)	(0.29)	(0.07)	(0.28)	(0.82)
	Promotion to full			
Female probit coefficient	−0.05**	−0.09***	−0.02	0.09
Promoted fifteen years past Ph.D.	(0.02)	(0.00)	(0.51)	(0.37)
(Including all covariates)				
	Risk ratio estimate			
Female risk ratio	0.90***	0.96	0.79***	0.95
(No covariates)	(0.01)	(0.48)	(0.00)	(0.74)
Model 1 female risk ratio	0.95	0.93	0.87	1.09
(Covariates ex. productivity)	(0.34)	(0.37)	(0.11)	(0.89)
Model 2 female risk ratio	0.97	0.96	0.89	1.04
(Including productivity covariates)	(0.54)	(0.61)	(0.19)	(0.82)

Source: 1973–2001 *Survey of Doctorate Recipients.*

Notes: P-values in parentheses. Probit coefficient reports change in probability. Hazard coefficients are risk ratios—estimates the impact of female on the likelihood of promotion in each period. Promotion to tenure is estimated on those who receive a tenure-track status within this period. Promotion to full is estimated on those who have been given tenure.

***Significant at the 1 percent level.

**Significant at the 5 percent level.

*Significant at the 10 percent level.

As was true with entrance into tenure-track jobs, single women are more likely than single men to receive tenure. For science as a whole, the difference is 6.4 percent. However, disaggregating by broad field, it is only significantly true in engineering, where there is a very large difference (20.2 percent). In the life and physical sciences, differences between single men and women are essentially zero.

Marriage does not have as large an effect on men with regard to tenure receipt as it did for obtaining tenure-track jobs. Marriage only significantly increases men's likelihood of tenure in engineering (by 12.3 percent) and in science as a whole (6.2 percent). Marriage does not have a statistically significant effect on women in any field, although in physical sciences there is among full professorships continually rising to 20 percent by 2001, comparable to the level of assistant professorships in 1983. Trends and levels among tenured faculty in figure 5.3 combine the trends in associate professors with those in full professors.

The bottom panels of tables 5.3 and 5.4 summarize the impact of gender on promotion to full professorship.[10] The probits and hazards reported here use two different beginning time points. The probits estimate the likelihood that someone who has received tenure has a full professorship fifteen years after Ph.D. The hazards start with *first tenure receipt* and study the likelihood of becoming a full professor and the duration of time it takes to get there.

The first row of the bottom panel of table 5.3 gives the probit coefficient on promotion to full professor within fifteen years of Ph.D. (with covariates). For all sciences pooled, there is a significant gender difference. Breaking this down by broad fields allows us to see that this is entirely due to life sciences, where women have a 9 percent lower likelihood of being promoted to a full professorship. In the other two fields, differences are not significantly different from zero.[11]

In the hazard analysis of table 5.3, as before, the second row of the panel includes no covariates. The risk ratio from the proportional hazard analysis (without covariates) indicates highly significant gender differences in promotion to full in science as a whole. On average, the likelihood of promotion to full in any given year for females is 90 percent that of males. Disaggregating by field, we see a significantly lower promotion rate in physical science only, where the likelihood of being promoted to full professor in any given year for females is only 79 percent that of males.

Adding in a full set of controls in the last two rows of table 5.3, however, moves the risk ratio in both the full sample and in physical sciences closer to one and makes them insignificant at standard levels of significance. The gender promotion gap remains the largest in physical science after controlling for all covariates at 11 percent but has only a p-value of .19. Of course, a much larger sample than ours[12] could very well identify statistically significant gender gaps.

Details on the family interaction terms are reported in the bottom panel of table 5.4. Adding gender-family interaction terms, we see no significant differences in either the broad fields or in science overall between single

10. Appendix table 5A.3 provides detailed parameter estimates for the probit models. Hazard estimates are available on request.

11. In analysis not shown, we estimated the probability of promotion to full professor seventeen and nineteen years after Ph.D. for life scientists as well. While women are 5 percent less likely to be promoted to full professor by fifteen years after Ph.D. receipt, they were 6 percent less likely by seventeen years. There was no significant difference in the probability of being promoted to full professor by nineteen years after Ph.D. receipt.

12. There are 2,721 tenured females in science as a whole and only 990 in the physical sciences.

men and women. Marriage does not have an impact on men's promotion to full. For women, there is no impact of being married in the pooled sample, but disaggregating, a married woman in life sciences has a 7.0 percent lower chance of achieving full ($p = .11$) than a single woman. Consequently, married childless women have lower rates of promotion to full than married childless men in the life sciences. In contrast, in physical science a married woman is 12.2 percent *more* likely to have a full professorship than a single one ($p = .07$).

Having school-aged children fifteen years post-Ph.D. has no effect on men's promotion to full, except in engineering where each child makes promotion 6.4 percent more likely. Having school-aged children fifteen years post-Ph.D. has an effect on women's promotion to full only in the physical sciences, where in this case it lowers the probability of becoming full by 9.4 percent. Finally, having young children has no clear effect on full professorship for either sex in any field, with one exception: women in engineering. In engineering, young children may *raise* the probability of a woman receiving full in engineering (30.5 percent, significant at the 11 percent level).

A few other variables were shown to have different impacts on men and women. For life sciences and consequently for science as a whole, private universities significantly hurt women's chances of being promoted to full in the hazard model specifications—opposite to the gender difference found at promotion to tenure. Finally, unlike the tenure decision, both women's and men's likelihood of promotion to full worsen for later cohorts.

5.4 Conclusions: Putting Gender Differences in Promotion into Perspective

One conclusion we make from this research is that aggregate statistics on gender differences in academic science careers are often misleading. Within science as a whole, there seem to be only small (between 0 and 3 percent) and sometimes insignificant differences between men and women scientists' probability of obtaining a tenure-track job within nine years of doctorate receipt, receiving tenure, or being promoted to full professorships, after controlling for demographic and employer characteristics, academic field, primary and secondary work activity, government grants, and publications.[13] However, the broad fields of science are very dissimilar. There are particularly large gender differences in the life sciences, the area that graduates the most women. Within the life sciences, men are approximately 8 to 9 percent more likely than women to obtain a tenure-track job within nine years of their Ph.D., to receive tenure, and to be promoted to

13. The full set of controls is included in all specifications discussed in this conclusion unless otherwise noted.

full. In contrast, there are no appreciable or statistically significant differences within physical science or engineering with the exception of a large but statistically insignificant gender difference in promotion to full professorship in physical sciences.

In addition, aggregate gender differences often mask much more substantial differences between men and women with particular kinds of family structures. In fact, single women are more successful in the early years of academic careers, which in life and physical sciences covers the transition into tenure-track jobs but in engineering—with its few short postdocs—covers the tenure decision. If they make it into a tenure-track job, single women and men in the life and physical sciences are equally likely to receive tenure and to be promoted to full.

Marriage greatly increases the likelihood that men get tenure-track jobs (by 22 percent), but has smaller and generally less significant effects on men's promotion at either level. Marriage tends *not* to hurt women's likelihood of getting tenure-track jobs, being granted tenure, or becoming full.[14] Indeed, marriage increases the likelihood of obtaining tenure-track jobs, although not as much as it helps men. The positive effects of marriage on obtaining tenure-track jobs for both men and women seems most likely to be due to selection, insofar as it is unlikely to be either induced effort or paternalistic favoritism. Combining gender differences of singles and gender differences in the impact of marriage, a married man without children and a married woman without children are typically similar in their academic progress, with some exceptions.

It is striking that marriage does not *hurt* women in science. Dual career problems do not seem to deter women from getting a tenure-track job, from getting tenure, or from becoming a full professor, despite the fact that more than 60 percent of women scientists are married to scientists (Rosser 2004).

The presence of children, however, does disadvantage women during the early post-Ph.D. years that coincide with the child-bearing window. In life sciences and physical sciences, young children make it less likely for women to make it through the postdoc hurdle and get a tenure-track job. In engineering, people tend to go directly from the doctorate receipt to jobs, bypassing the postdoc stage. Here, too, however, having had children for much of their early career (as indicated by the school-aged children at eleven years post-Ph.D.) lowers women's likelihood of succeeding in academia (in this case, of receiving tenure), while the absence of children makes women in engineering more successful in getting tenure than similar men. These results indicate that to some extent, women in science must make an early choice between a family and an academic career. Opting out of academic career jobs because of children dovetails with some of

14. The single exception is a 7 percent lower chance of achieving full in life sciences.

Preston's (2004) results, which show a major reason that women leave science is because of childcare responsibilities.

In contrast, for men the presence of grade-school children (but not young children) is positively correlated with their likelihood of receiving tenure-track jobs and receiving tenure. A gender difference is not surprising, given that men spend much less time than women in childcare, even in professional couples. Preston (2004) finds that those male scientists who do spend time in childcare have similar impacts on their academic careers.

It is possible that the negative impact of children on women early in their academic careers is also partly selection. We cannot know whether the women who have children during the formative years of their careers would be less devoted to their careers even in the absence of children than those who do not (i.e., a selection story), or are being hampered by the children's presence.

However, to the extent that children do indeed hamper women's early career progression, science departments and associations should not therefore conclude that gender differences in early academic careers are nothing to be concerned about. Our results indicate that women must face a choice between having children or succeeding in their scientific careers, while men do not face these same choices. While science departments are clearly not responsible for the cultural expectation that mothers are the primary parental caregivers, the findings here should encourage conversations on whether the present system within academic science of long postdocs requiring long hours, particularly in life sciences, are necessary or even desirable to good science.[15]

The estimated gender differences that we have found among women scientists entering academic jobs post-Ph.D. are different from the recent NSF report (NSF 2004a) using the same data set. Where we find that single women have greater rates entering tenure-track jobs and being promoted to tenure and full (ceteris paribus), the NSF found no gender differences for entering tenure-track jobs and lower rates of women promoted to full. Where the NSF found that marriage hurt women's careers at various stages, we find that marriage in the absence of children does not hurt. While NSF found negative impacts of children at all levels, we find the negative effect of children at the point of entry into tenure-track jobs only. What accounts for these very different results?

There are some small differences in our research that are *not* responsible for the large discrepancies in results. For instance, our analysis uses the most recent data available from the 2001 SDR. Also, other studies stopped their analysis in 1999 or earlier. The NSF (2004a) included a somewhat different set of controls and did not include any publication controls.

Instead, the important explanation for differences between our results

15. See, for instance, Freeman et al. (2001).

and the others is that we are looking only at the life sciences, physical sciences, and engineering. In contrast, both Long (2001) and NSF define science as including social science. Indeed, there is a gender difference in academic promotion in social sciences that we have demonstrated in previous work. Ginther (2002) and Ginther and Kahn (2004) estimates the probability and duration to promotion for faculty in the social sciences and economics, respectively. Ginther (2002a) finds a gender promotion gap in the social sciences that ranges between 10 to 12 percent (through 1997), with only half of the gap being explained by observable characteristics. In the field of economics, Kahn (1993) and Ginther and Kahn (2004) both find large gender promotion differences. Ginther and Kahn (2004) use data from the SDR (as well as independently collected data) through 2001 and find a 21 percent gender promotion gap in economics with less than half of the gap explained by observable characteristics. That paper also estimates an 8 percent promotion gap in social sciences, excluding economics, through 2001.

Our results on promotion in sciences also differ from findings by Ginther and Hayes (1999, 2003) for faculty in the humanities. Using the 1977 to 1995 waves of the SDR and performing similar estimates, Ginther and Hayes find a gender promotion gap ranging between 7 to 9 percent. Some of the promotion gap in the humanities is explained by fertility and the treatment of work experience.

Taking all of this work together, women's disadvantages in promotion to tenure not explained by any covariates are largest in economics and other social sciences, are smaller in the humanities (in part explained by marriage and family characteristics), and nonexistent in the physical or life sciences or in engineering once all variables are taken into account.

This is not to say that there are no gender differences at all in academic science careers once scientists enter tenure-track jobs. We have shown that promotion to full professorships is substantially different for men and women. Other research also finds different salaries of academic men and women in science. Ginther (2001, 2003, 2004) shows a significant gender salary gap in academic science especially at the full professor rank, after controlling for similar covariates including productivity. In 2001, male full professors in science earned 12 percent more than female full professors and one-third of this salary gap is not explained by observable characteristics (Ginther 2004). Although there is no significant difference in the likelihood of being promoted to full professor, compensation is apparently not equivalent.

Appendix

Table 5A.1 Probability of having a tenure-track appointment within nine years of Ph.D.: 1973–2001 survey of doctorate recipients

	Science			Life science			Physical science			Engineering		
Variables	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Female	−0.038***	−0.033***	0.156***	−0.041***	−0.077***	0.108***	−0.002	−0.015	0.206***	0.000	0.013	0.072
	(0.009)	(0.010)	(0.018)	(0.012)	(0.013)	(0.025)	(0.016)	(0.017)	(0.029)	(0.033)	(0.035)	(0.064)
Age at Ph.D.	—	0.002***	0.001	—	0.003**	0.002	—	−0.003	−0.004**	—	−0.008***	−0.010***
	—	(0.001)	(0.001)	—	(0.001)	(0.001)	—	(0.002)	(0.002)	—	(0.003)	(0.003)
African American	—	0.084***	0.104***	—	0.102***	0.117***	—	0.044	0.070*	—	0.081	0.103*
	—	(0.021)	(0.021)	—	(0.028)	(0.028)	—	(0.039)	(0.038)	—	(0.056)	(0.054)
Native American	—	0.041	0.025	—	0.091	0.072	—	0.008	−0.012	—	−0.103	−0.129
	—	(0.068)	(0.069)	—	(0.086)	(0.088)	—	(0.160)	(0.164)	—	(0.162)	(0.165)
Asian	—	−0.113***	−0.111***	—	−0.096***	−0.090***	—	−0.089***	−0.088***	—	−0.182***	−0.192***
	—	(0.017)	(0.017)	—	(0.025)	(0.025)	—	(0.028)	(0.029)	—	(0.041)	(0.042)
Other race	—	−0.019	0.014	—	−0.001	0.022	—	−0.039	0.003	—	—	—
	—	(0.093)	(0.093)	—	(0.126)	(0.126)	—	(0.139)	(0.139)	—	—	—
Foreign-born	—	−0.047***	−0.044***	—	−0.087***	−0.086***	—	−0.048**	−0.046*	—	0.032	0.044
	—	(0.015)	(0.015)	—	(0.022)	(0.022)	—	(0.025)	(0.025)	—	(0.033)	(0.033)
Year of Ph.D.	—	0.000	0.000	—	−0.004***	−0.005***	—	0.005***	0.005***	—	0.007***	0.007***
	—	(0.001)	(0.001)	—	(0.001)	(0.001)	—	(0.001)	(0.001)	—	(0.002)	(0.002)
Ph.D. from Research I	—	0.052***	0.052***	—	0.043	0.043*	—	0.112**	0.122**	—	0.034	0.003
	—	(0.021)	(0.021)	—	(0.024)	(0.024)	—	(0.054)	(0.054)	—	(0.076)	(0.077)
Ph.D. from Research II	—	0.062***	0.054**	—	0.023	0.018	—	0.155***	0.156***	—	0.085	0.048
	—	(0.023)	(0.023)	—	(0.029)	(0.029)	—	(0.050)	(0.050)	—	(0.074)	(0.081)
Ph.D. from Doctorate I	—	0.100***	0.099***	—	0.095***	0.099***	—	0.199***	0.198***	—	−0.092	−0.119
	—	(0.026)	(0.026)	—	(0.036)	(0.036)	—	(0.048)	(0.048)	—	(0.099)	(0.103)
Ph.D. from Doctorate II	—	0.066***	0.062**	—	0.022	0.026	—	0.197***	0.200***	—	0.018	−0.025
	—	(0.031)	(0.031)	—	(0.043)	(0.043)	—	(0.051)	(0.051)	—	(0.097)	(0.105)
Married	—	—	0.218***	—	—	0.220***	—	—	0.222***	—	—	0.221***
	—	—	(0.016)	—	—	(0.023)	—	—	(0.026)	—	—	(0.045)
Total children	—	—	0.029***	—	—	0.036***	—	—	0.021*	—	—	0.025*
	—	—	(0.007)	—	—	(0.010)	—	—	(0.012)	—	—	(0.014)

(continued)

Table 5A.1 (continued)

Variables	Science Model 1	Science Model 2	Science Model 3	Life science Model 1	Life science Model 2	Life science Model 3	Physical science Model 1	Physical science Model 2	Physical science Model 3	Engineering Model 1	Engineering Model 2	Engineering Model 3
Children < 6 = 1	—	—	−0.022	—	—	−0.026	—	—	−0.001	—	—	−0.069*
	—	—	(0.016)	—	—	(0.023)	—	—	(0.029)	—	—	(0.037)
Female * Married	—	—	−0.171***	—	—	−0.149***	—	—	−0.236***	—	—	0.009
	—	—	(0.024)	—	—	(0.033)	—	—	(0.041)	—	—	(0.092)
Female * Total children	—	—	−0.029**	—	—	−0.022	—	—	−0.055***	—	—	−0.053
	—	—	(0.013)	—	—	(0.017)	—	—	(0.022)	—	—	(0.045)
Female * Young children	—	—	−0.059**	—	—	−0.068*	—	—	−0.021	—	—	0.000
	—	—	(0.028)	—	—	(0.038)	—	—	(0.050)	—	—	(0.100)
Academic Field												
Computer science / mathematics	—	0.137***	0.154***	—	—	—	—	0.232***	0.245***	—	—	—
	—	(0.022)	(0.022)	—	—	—	—	(0.022)	(0.022)	—	—	—
Physics	—	−0.256***	−0.244***	—	—	—	—	−0.162***	−0.156***	—	—	—
	—	(0.023)	(0.024)	—	—	—	—	(0.025)	(0.025)	—	—	—
Chemistry	—	−0.229***	−0.218***	—	—	—	—	−0.137***	−0.130***	—	—	—
	—	(0.023)	(0.024)	—	—	—	—	(0.025)	(0.025)	—	—	—
Earth science	—	−0.109***	−0.102***	—	—	—	—	—	—	—	—	—
	—	(0.028)	(0.028)	—	—	—	—	—	—	—	—	—
Biology and life sciences	—	−0.166***	−0.161***	—	—	—	—	—	—	—	—	—
	—	(0.020)	(0.020)	—	—	—	—	—	—	—	—	—
Biochemistry	—	—	—	—	−0.126***	−0.126***	—	—	—	—	—	—
	—	—	—	—	(0.018)	(0.018)	—	—	—	—	—	—
Microbiology	—	—	—	—	−0.072***	−0.075***	—	—	—	—	—	—
	—	—	—	—	(0.024)	(0.025)	—	—	—	—	—	—
Zoology	—	—	—	—	0.034	0.034	—	—	—	—	—	—
	—	—	—	—	(0.029)	(0.029)	—	—	—	—	—	—
Health sciences	—	—	—	—	0.111***	0.111***	—	—	—	—	—	—
	—	—	—	—	(0.017)	(0.017)	—	—	—	—	—	—
Environmental science	—	—	—	—	−0.052	−0.033	—	—	—	—	—	—
	—	—	—	—	(0.049)	(0.050)	—	—	—	—	—	—
Agriculture and food	—	—	—	—	0.158*	0.152***	—	—	—	—	—	—
	—	—	—	—	(0.020)	(0.021)	—	—	—	—	—	—
Engineering	—	−0.007	−0.005	—	—	—	—	—	—	—	—	—
	—	(0.024)	(0.024)	—	—	—	—	—	—	—	—	—
Aerospace	—	—	—	—	—	—	—	—	—	—	0.092	0.092
	—	—	—	—	—	—	—	—	—	—	(0.059)	(0.059)
Chemical	—	—	—	—	—	—	—	—	—	—	0.055	0.067
	—	—	—	—	—	—	—	—	—	—	(0.042)	(0.041)
Civil	—	—	—	—	—	—	—	—	—	—	0.157***	0.160***
	—	—	—	—	—	—	—	—	—	—	(0.033)	(0.033)
Electrical	—	—	—	—	—	—	—	—	—	—	0.091***	0.100***
	—	—	—	—	—	—	—	—	—	—	(0.029)	(0.029)
Mechanical	—	—	—	—	—	—	—	—	—	—	0.135***	0.148***
	—	—	—	—	—	—	—	—	—	—	(0.033)	(0.033)
Industrial	—	—	—	—	—	—	—	—	—	—	0.273***	0.277***
	—	—	—	—	—	—	—	—	—	—	(0.030)	(0.028)
Observations	12,745	12,745	12,745	6,826	6,826	6,826	4,365	4,365	4,365	1,554	1,554	1,554
Likelihood ratio stat	17.42	820.28	1,156.36	10.93	368.44	545.49	0.01	555.55	691.06	0.00	102.37	147.38

Notes: Coefficients report change in probability. Standard errors in parentheses.

***Significant at the 1 percent level.

**Significant at the 5 percent level.

*Significant at the 10 percent level.

Table 5A.2 **Probit estimates of the probability of tenure within eleven years of Ph.D. by field**

	Science	Life science	Physical science	Engineering
Female	0.003	−0.032	0.010	0.017
	(0.017)	(0.024)	(0.029)	(0.052)
Age at Ph.D.	0.008***	0.008***	0.001	−0.002
	(0.002)	(0.003)	(0.003)	(0.005)
African American	−0.048	−0.037	−0.048	−0.066
	(0.035)	(0.050)	(0.061)	(0.083)
Native American	−0.057	0.036	0.070	−0.498**
	(0.103)	(0.134)	(0.246)	(0.195)
Asian	0.001	−0.004	0.028	0.043
	(0.030)	(0.047)	(0.047)	(0.061)
Other race	0.250	—	0.143	
	(0.143)	—	(0.215)	—
Foreign-born	−0.062***	−0.120***	−0.060	−0.016
	(0.025)	(0.039)	(0.042)	(0.050)
Year of Ph.D.	−0.008***	−0.017***	0.001	0.005
	(0.002)	(0.003)	(0.003)	(0.005)
Ph.D. from Research I	0.054	0.060	−0.015	0.029
	(0.039)	(0.044)	(0.096)	(0.136)
Ph.D. from Research II	0.038	0.050	−0.023	0.023
	(0.043)	(0.055)	(0.105)	(0.137)
Ph.D. from Doctorate I	0.058	0.134**	−0.044	0.039
	(0.049)	(0.066)	(0.111)	(0.148)
Ph.D. from Doctorate II	0.077	0.122	0.030	−0.020
	0.056	0.079	0.115	0.185
	11 years after Ph.D.			
Married	0.046**	0.033	0.067*	0.124
	(0.021)	(0.029)	(0.036)	(0.065)
Total children	0.015	0.023	0.005	0.005
	(0.008)	(0.012)	(0.015)	(0.019)
Children < 6	−0.028	−0.039	−0.009	−0.016
	(0.020)	(0.028)	(0.036)	(0.047)
Cumulative employers	−0.161***	−0.137***	−0.211***	−0.140***
	(0.009)	(0.012)	(0.016)	(0.025)
Private university	−0.108***	−0.155***	−0.068**	−0.045
	(0.017)	(0.024)	(0.029)	(0.046)
Research I	0.044**	0.044*	−0.002	0.057
	(0.018)	(0.025)	(0.035)	(0.045)
Liberal arts I	0.097***	0.105***	0.121***	0.011
	(0.021)	(0.033)	(0.032)	(0.058)
Medical school	−0.100***	−0.095***	−0.047	−0.121**
	(0.020)	(0.024)	(0.047)	(0.063)
Primary work research	0.090***	0.137***	0.087	0.094
	(0.035)	(0.044)	(0.076)	(0.105)
Primary work teach	0.435***	0.442***	0.498***	0.406***
	(0.030)	(0.037)	(0.065)	(0.100)
Primary work manage	0.210***	0.213***	0.214***	0.146
	(0.035)	(0.049)	(0.064)	(0.089)

Table 5A.2 (continued)

	Science	Life science	Physical science	Engineering
Secondary work research	0.011	−0.045	0.026	0.081
	(0.030)	(0.046)	(0.045)	(0.077)
Secondary work teach	0.260***	0.138***	0.388***	0.221***
	(0.029)	(0.047)	(0.036)	(0.063)
Secondary work manage	0.077**	−0.021	0.145***	0.193**
	(0.034)	(0.051)	(0.048)	(0.061)
Secondary work other	−0.071**	−0.147***	−0.038	0.064
	(0.036)	(0.048)	(0.060)	(0.088)
Government support in current year	0.003	0.007	0.023	−0.075
	(0.022)	(0.031)	(0.040)	(0.052)
Cumulative years of government support	0.004	0.006	−0.002	0.048***
	(0.006)	(0.009)	(0.012)	(0.016)
Cumulative papers	0.002***	0.001	0.001	0.005***
	(0.001)	(0.001)	(0.001)	(0.002)
Cumulative publications	0.007***	0.009***	0.006***	−0.002
	(0.001)	(0.001)	(0.002)	(0.002)
	Academic fields			
Computer science / mathematics	−0.010	—	0.085***	
	(0.039)	—	(0.041)	
Physics	−0.235***	—	−0.146***	
	(0.041)	—	(0.047)	
Chemistry	−0.198***	—	−0.125***	
	(0.041)	—	(0.046)	—
Earth science	−0.104**	—	—	—
	(0.047)	—	—	—
Biology and life sciences	−0.215***	—	—	—
	(0.033)	—	—	—
Biochemistry	—	−0.100***	—	—
	—	(0.033)	—	—
Microbiology	—	−0.079*	—	—
	—	(0.043)		—
Zoology	—	0.124***	—	—
	—	(0.047)	—	—
Health sciences	—	0.142***	—	—
	—	(0.030)	—	—
Environmental science	—	0.162**	—	—
	—	(0.080)	—	—
Agriculture and food	—	0.216***	—	—
	—	(0.035)	—	—
Engineering	−0.047	—	—	—
	(0.039)	—	—	—
Engineering	—	—	—	—
Aerospace	—	—	—	−0.059
	—	—	—	(0.109)

(continued)

Table 5A.2 (continued)

	Science	Life science	Physical science	Engineering
Chemical	—	—	—	0.017
	—	—	—	(0.076)
Civil	—	—	—	0.009
	—	—	—	(0.063)
Electrical	—	—	—	0.002
	—	—	—	(0.052)
Mechanical	—	—	—	0.013
	—	—	—	(0.065)
Industrial	—	—	—	−0.043
	—	—	—	(0.100)
Observations	5,187	2,756	1,757	669
Likelihood ratio stat	1,393.41	768.98	570.18	145.83

Source: 1973–2001 *Survey of Doctorate Recipients.*
Notes: Coefficients report change in probability. Standard errors in parentheses.
***Significant at the 1 percent level.
**Significant at the 5 percent level.
*Significant at the 10 percent level.

Table 5A.3 **Probit estimates of the probability of full professor within fifteen years of Ph.D. by field**

	Science	Life science	Physical science	Engineering
Female	−0.048**	−0.085***	−0.024	0.088
	(0.021)	(0.028)	(0.037)	(0.097)
Age at Ph.D.	0.004**	0.002	0.004	0.011
	(0.002)	(0.003)	(0.004)	(0.008)
African American	−0.102**	−0.058	−0.132*	−0.224*
	(0.040)	(0.057)	(0.069)	(0.127)
Native American	−0.091	−0.216	−0.129	0.221
	(0.138)	(0.161)	(0.229)	(0.275)
Asian	0.028	−0.023	0.122***	0.001
	(0.038)	(0.055)	(0.063)	(0.106)
Other race	0.367	—	—	—
	(0.217)	—	—	—
Foreign-born	0.036	−0.022	0.050	0.114
	(0.032)	(0.049)	(0.053)	(0.083)
Year of Ph.D.	−0.016***	−0.016***	−0.014***	−0.030***
	(0.003)	(0.004)	(0.004)	(0.009)
Ph.D. from Research I	0.049	0.062	0.127	−0.175
	(0.048)	(0.050)	(0.153)	(0.245)
Ph.D. from Research II	0.034	0.076	0.071	−0.081
	(0.056)	(0.065)	(0.172)	(0.281)

Table 5A.3 (continued)

	Science	Life science	Physical science	Engineering
Ph.D. from Doctorate I	0.097	0.158**	0.215	−0.528**
	(0.065)	(0.084)	(0.172)	(0.071)
Ph.D. from Doctorate II	0.075	0.105	0.197	−0.322
	(0.070)	(0.090)	(0.180)	(0.240)
	15 years after Ph.D.			
Married	0.014	−0.005	0.074	−0.061
	(0.024)	(0.033)	(0.040)	(0.097)
Total children	0.009	0.013	−0.020	0.061**
	(0.009)	(0.013)	(0.016)	(0.032)
Children < 6 = 1	−0.029	−0.039	0.001	−0.065
	(0.024)	(0.033)	(0.041)	(0.083)
Cumulative employers	−0.044***	−0.034***	−0.069***	−0.061*
	(0.009)	(0.011)	(0.017)	(0.037)
Private university	−0.050**	−0.055*	−0.047	0.045
	(0.021)	(0.030)	(0.034)	(0.070)
Research I	−0.003	−0.024	−0.005	0.039
	(0.022)	(0.029)	(0.043)	(0.074)
Liberal arts I	0.108***	0.099***	0.150***	0.044
	(0.025)	(0.038)	(0.038)	(0.092)
Medical school	−0.107***	−0.085***	−0.096*	−0.056
	(0.024)	(0.029)	(0.056)	(0.100)
Primary work research	0.055	0.042	0.109	0.379**
	(0.050)	(0.058)	(0.116)	(0.168)
Primary work teach	0.161***	0.135**	0.276***	0.361*
	(0.049)	(0.060)	(0.101)	(0.190)
Primary work manage	0.231***	0.203***	0.291**	0.326*
	(0.054)	(0.067)	(0.115)	(0.153)
Secondary work research	0.002	−0.063	−0.019	0.111
	(0.042)	(0.066)	(0.058)	(0.164)
Secondary work teach	0.136***	0.026	0.264***	0.179
	(0.046)	(0.071)	(0.072)	(0.170)
Secondary work manage	0.101***	0.024	0.106	0.255
	(0.047)	(0.073)	(0.069)	(0.148)
Secondary work other	0.046	−0.002	0.015	0.042
	(0.051)	(0.075)	(0.079)	(0.197)
Government support in current year	0.010	0.004	0.048	−0.056
	(0.026)	(0.034)	(0.045)	(0.087)
Cumulative years of government support	0.012**	0.007	0.031***	0.015
	(0.006)	(0.007)	(0.010)	(0.019)
Cumulative papers	0.002**	0.000	0.002	0.005**
	(0.001)	(0.001)	(0.002)	(0.003)
Cumulative publications	0.008***	0.009***	0.008***	0.004
	(0.001)	(0.001)	(0.002)	(0.003)
	Academic field			
Computer science / mathematics	−0.045	—	0.046	—
	(0.040)	—	(0.046)	—

(continued)

Table 5A.3 (continued)

	Science	Life science	Physical science	Engineering
Physics	−0.115**	—	−0.073	—
	(0.045)	—	(0.052)	—
Chemistry	−0.139***	—	−0.083	—
	(0.041)	—	(0.050)	—
Earth science	−0.060	—	—	—
	(0.047)	—	—	—
Biology and life sciences	−0.125***	—	—	—
	(0.036)	—	—	—
Biochemistry	—	−0.081**		—
	—	(0.039)	—	—
Microbiology	—	0.005	—	—
	—	(0.051)	—	—
Zoology	—	0.121**	—	—
	—	(0.051)	—	—
Health sciences	—	0.105***	—	—
	—	(0.038)	—	—
Environmental science	—	0.044	—	—
	—	(0.091)	—	—
Agriculture and food	—	0.156***	—	—
	—	(0.042)	—	—
Engineering	0.022	—	—	—
	(0.045)	—	—	—
Engineering	—	—	—	—
Aerospace	—	—	—	−0.112
	—	—	—	(0.180)
Chemical	—	—	—	−0.129
	—	—	—	(0.127)
Civil	—	—	—	−0.028
	—	—	—	(0.097)
Electrical	—	—	—	−0.029
	—	—	—	(0.082)
Mechanical	—	—	—	−0.181*
	—	—	—	(0.103)
Industrial	—	—	—	−0.001
	—	—	—	(0.169)
Observations	3,223	1,728	1,161	330
Likelihood ratio stat	355.72	187.11	187.23	66.27

Source: 1973–2001 *Survey of Doctorate Recipients.*

Notes: Coefficients report change in probability. Standard errors in parentheses.

***Significant at the 1 percent level.

**Significant at the 5 percent level.

*Significant at the 10 percent level.

References

Congressional Commission on the Advancement of Women and Minorities in Science, Engineering, and Technology (CAWMSET). 2000. Land of plenty: Diversity as America's competitive edge in science, engineering, and technology. Report available at http://www.nsf.gov/publications/pub_summ.jsp?ods_key-cawmset0409.

Freeman, R., E. Weinstein, E. Marincola, J. Rosenbaum, and F. Solomon. 2001. Competition and careers in biosciences. *Science* 294 (5550): 2293–4.

Ginther, D. K. 2001. Does science discriminate against women? Evidence from academia 1973–1997. Federal Reserve Bank of Atlanta Working Paper 2001-02, February.

———. 2002. Gender differences in employment outcomes for academics in the social sciences. Working Paper. University of Kansas.

———. 2003. Is MIT the exception? Gender pay differentials in academic science. *Bulletin of Science, Technology, and Society* 23 (1): 21–26.

———. 2004. Why women earn less: Economic explanations for the gender salary gap in science. *AWIS Magazine* 33 (1): 6–10.

Ginther, D. K. and K. J. Hayes. 1999. Salary and promotion differentials by gender for faculty in the humanities. *American Economic Review, Papers and Proceedings* 89 (2): 397–402.

———. 2003. Gender differences in salary and promotion for faculty in the humanities, 1977–1995. *The Journal of Human Resources* 38 (1): 34–73.

Ginther, D. K. and S. Kahn. 2004. Women in economics: Moving up or falling off the academic career ladder? *Journal of Economic Perspectives* 18 (3): 193–214.

Goldberg, C. 1999. MIT acknowledges bias against female professors. *The New York Times,* March 23.

Government Accountability Office (GAO). 2004. Women's participation in the sciences has increased, but agencies need to do more to ensure compliance with title IX. Washington D.C.: GAO. Available at http://www.gao.gov/cgi-bin/getrpt?-GAO-04-639.

Kahn, S. 1993. Gender differences in academic career paths of economists. *American Economic Review, Papers and Proceedings* 83 (2): 52–56.

Long, J. S., P. D. Allison, and R. McGinnis. 1993. Rank advancement in academic careers: Sex differences and the effects of productivity. *American Sociological Review* 58 (5): 703–22.

Mitchell, S. B., R. Moonesinghe, and B. G. Cox. 1998. Using the survey of doctorate recipients in time-series analyses: 1989–1997. Working Paper. National Science Foundation, Washington, D.C.

National Science Foundation (NSF). 2004a. *Gender differences in the careers of academic scientists and engineers.* NSF 04-323, Project Officer, Alan I. Rapoport. Arlington, VA: NSF.

———. 2004b. Women, minorities, and persons with disabilities in sciences and engineering: 2004. NSF 00-327. Arlington, VA: NSF.

National Science Foundation (NSF), National Science Board. 2006. *Science and engineering indicators (2006).* Available at http://www.nsf.gov/statistics/seind06/2006.

Nelson, D. J., and D.C. Rogers. 2005. A national analysis of diversity in science and engineering faculties at research universities. Available at http://cheminfo.chem.ou.edu/~djn/diversity/briefings/Diversity%20Report%20Final.pdf.

Preston, A. E. 2004. *Leaving science: Occupational exit from scientific careers.* New York: Russell Sage Foundation.
Rosser, S. V. 2004. *The science glass ceiling.* New York: Routledge.
Xie, Y., and K. A. Shauman. 2003. Women in science: Career processes and outcomes. Cambridge, MA: Harvard University Press.

6 Patterns of Male and Female Scientific Dissemination in Public and Private Science

Kjersten Bunker Whittington

6.1 Introduction

Information on the patenting and publishing activity of scientists and engineers has long been an interest among scholars of science and technology. Publishing transmits valuable knowledge and resources to other scientists, both in the academy and in industry, while patenting is thought to spur innovation through economic and proprietary incentives. Traditionally, scientists within academia have primarily published, shying away from pursuing economic ends through patenting or other marketable ventures, while industrial scientists have predominantly pursued commercial goals. Aided by federal and state promotion as well as university infrastructure, the organization of scientific research within universities and industrial firms has undergone a sea change in the past two decades. Academic scientists are now commonly involved in a variety of commercial activities, including patenting, licensing, start-up incubation, and firm founding, especially in the life sciences (Rosenburg and Nelson 1993; Cohen, Florida, and Goe 1994; Kleinman and Vallas 2001; Owen-Smith and

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