ABSTRACT

Title of Document: MANAGING AN ACADEMIC CAREER IN SCIENCE: WHAT GENDER DIFFERENCES EXIST AND WHY?

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The present study examines the career trajectories of academic scientists during the period from 1993 to 2001 to explore gender differences in mobility. Data from the National Science Foundation's Survey of Doctorate Recipients are used to examine and compare gender differences in the odds of promotion.

The effects of age, marital and family status, duration of time to complete doctorate, academic discipline, cumulative number of publications and time in the survey are considered as explanatory variables. Event history analyses are conducted for all scientists, for scientists in four major academic disciplines and for scientists in various academic ranks.

While no overall gender differences were observed in the odds of promotion, several important similarities and differences were evident. Expectedly, publications had a significant and positive relationship with advancement for both women and men. The role of parent influenced promotions quite differently for women and men.

Contrary to expectations based on prior research, academic women scientists who were mothers advanced at similar rates as women without children. Consistent with expectations based on traditional roles, married men and men with children generally advanced more quickly than single or childless men, respectively. Two surprising patterns emerged among subgroups of women. Marriage was associated with greater odds of advancement for women engineers and motherhood was associated with greater odds of advancement for among assistant professors. Possible explanations for these findings are presented.

MANAGING AN ACADEMIC CAREER IN SCIENCE: WHAT GENDER DIFFERENCES EXIST AND WHY?

By

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Dedication

This work is dedicated to my family who taught me to appreciate discovery, to love reading, and to value the formal system of education. I thank them for helping me to aspire to and attain a Doctorate.

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I gratefully acknowledge the National Science Foundation for their generosity in making the Survey of Doctorate Recipients available for this study. Their commitment to science and their support of scientists benefits all.

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Chapter 1: Introduction

At 70 years of age, Janet Davison-Rowley works at the top ranks of the scientific community. She is Deputy Dean for the University of Chicago's Biological Sciences Division as well as the Blum-Riese Distinguished Service Professor in Medicine. In 1998 she was awarded the National Medal of Science. Commenting on blending a career in science with family responsibilities Rowley suggests, "Women should be patient with the course of their careers and be willing to take chances and tackle new challenges. The notion that you are over the hill if you are 30 or 35 and haven't done something astonishing is absurd… I counsel women that you have to look at your life in chapters… It will evolve, particularly as your children get older and you have more freedom" (Guy 2002:74). Dr. Davison-Rowley (Guy 2002) suggests that women may need to adjust the timing of career advancement to allow for periods largely devoted to childrearing.

Stephanie Dimant (1995), a scientist turned writer, offers a less optimistic view of the careers of women scientists. In "Science is for Childless Women," a New York Times Letter to the Editor, she explains her departure from a career in science (Dimant 1995). She argues that careers in bench science cannot accommodate the demands of child-rearing, demands that ultimately led Dimant to leave a career in the science. The absence of women in most scientific and engineering careers lends some credence to this conflict. In 1997, only 22.8 percent of all scientists and engineers were women (National Science Foundation (NSF), 2000 Appendix Table 5-1), even though women represented 43 percent of the civilian labor force 16 years and older (U.S. Bureau of Labor Statistics 1998).

Sociologists Linda Grant, Ivy Kennelly and Kathryn B. Ward (2000) interviewed and surveyed scientists who taught at doctoral–granting departments of American universities and uncovered conflicts between science careers, marriage and family life, with greater conflicts for women. In their sample of 602 scientists, Grant et al. (2000) noted that while most scientists were ever married and had children, fewer of the women scientists than men were ever married (84 percent of the women compared to 92 percent of the men). Similarly fewer women than men scientists had children, 72 percent of women compared to 89 percent of the men. Summing these observations, they noted, "Thus among scientists, but especially the natural and physical scientists, there was a widespread belief that scientific careers, as normatively structured, did not easily accommodate parenthood," (Grant et al. 2000:74).

These three contradictory explanations suggest a need for a better understanding of the normative structure of science careers, particular those in the academic sector which employs the largest number of scientists and engineers. (NSF 2000:58). These three explanation also suggest how careers might differ for women in terms of the timing of career milestones or decisions about marriage and family formation. Which of these three perspectives (the successful yet delayed career, the exit from science, and the modification of marital and family decisions) about career trajectories for women scientists is more accurate? Are there other more accurate descriptions of the gender differences and similarities in managing a career in science? Clearly one description will not fit all cases, and this project does not seek to identify a single normative career trajectory for all academic women scientists; rather it explores differences in the careers of women and men academic scientists that may be attributed to three primary factors: differences in the years of experience, differences in productivity and differences in decisions about marriage and family formation. Additionally other secondary factors that frequently appear in the mobility literature will also be considered; these include age, birth cohort, and academic discipline.

The academic focus is particularly interesting because of the limited research in this area. Most studies of mobility among scientists focus on the business sector of the labor market and define mobility as a move into management. Very few studies examine women scientists in the academic setting and the present study adds to that body of work. In addition, the study capitalizes on differences in the business sector and academic sector. The most important differences lie in flexibility and autonomy which are characteristic of the tenure system plus the formal timing and rules that guide promotions in the tenure system.

Rachel Rosenfeld (1992) organizes the literature on job mobility along three dimensions that are well-suited to understanding advancement in the academic setting: opportunity structures, individual differences and timing. Opportunity structures include the tenure system which organizes career advancement at most American colleges and universities. This nearly universal measure of career advancement provides consistent rules for tenure and promotion decisions. The second dimension, individual differences are measured in three equally well-established terms: service, teaching and research. The third dimension, time, is often expressed as years of labor force experience and is strongly associated with mobility.

Another important aspect of this dimension includes the timing of family formation decisions related to marriage and childbirth. Demographic evidence on differences in marriage and families previously raised by Grant et al. (2000) suggests that marriage might place greater demands on women.

The three observations of Davison-Rowley (Guy 2000), Dimant (1995) and Grant et al. (2000) also suggest the need to look closely at the patterns of occupational segregation by gender in science and engineering careers, patterns that have persisted in the American workplace in general and are especially pronounced in scientific careers. By the 1970s and 1980s, labor force statistics illustrated that the increasing flow of women into the workforce, the 1964 Civil Rights Act and the women's equality movement had not resulted in equal participation of women in all occupations. In 1980, women represented 40 percent of the civilian workforce over age 16, but only 7.0 percent of the scientific and engineering occupations (U.S. Census Bureau 2003.)

These descriptive statistics illustrate the degree to which women are absent from the struggle to cure diseases or the search for alternative sources of energy. Without a doctorate in science, women are less likely to occupy influential positions that direct research to address concerns that are more likely to affect women, or that include women in clinical trials. This absence extends far beyond the laboratory to the ability to improve the quality of life for the wider society.

Taken together, these three observations may help our understanding of how the careers of women might differ from men. This project examines how these explanations might operate independently or collectively to explain the mobility women experience in careers as scientists. Do the prospects for mobility differ along gender lines among scientists? If present, are these differences the result of a complex interaction among marital and family status and timing of life course events? In addition, do factors related to mobility, namely human capital operate differently for women and men scientists? In other words this project analyzes how and why the career paths of women in the sciences might differ from their male counterparts.

In sum, the thesis for this project is as follows— Does mobility among academic scientists occur at the same pace for women and men and is it influenced by the same factors for women and men? As the following chapter explains, the picture of mobility is complex and explained by both the primary factors of time, measures of individual resources and family decisions and also the secondary factors of age, birth cohort (a group who share a common experience such as year of birth) and academic discipline.

Chapter 2: Literature Review

This chapter reviews the recent literature on occupational mobility in general and the recent literature specific to mobility in scientific careers. Particular attention is given to competing explanations and findings. One of the central problems in studying mobility is maintaining both a macro-level perspective that accounts for structural factors and a micro-level one that addresses individual factors. This study will attempt to address both levels of analysis.

Norms for career movement vary across employment sectors, thus making it important to understand where scientists are employed. While the pattern is shifting, as of 2000, the largest concentration of scientists is found in the academic sector where 54 percent of all women scientists are employed and 44.5 percent of all male scientists are employed. Only 19.8 percent of all women scientists are employed in business/industry while 37.7 percent of all male scientists work in the private sector. Nine percent of all women scientists are employed in government, as are 9.3 percent of all male scientists. Interestingly, 16.8 percent of all women are employed in the "other" sector which includes primary and secondary schools but only 8.6 percent of all male scientists work in what might be considered the 'margins' of the scientific community (see NSF 2000:58). For the purpose of this study, mobility in the largest sector, the academy, will be addressed.

As mentioned in the introduction, Rachel Rosenfeld (1992) offers a thorough summary of the literature on intragenerational mobility, giving considerable attention to the issue of labor market segmentation by race and gender and its impact on career changes. Importantly, Rosenfeld's article offers a schema for understanding mobility in terms of both macro level structural forces and micro level individual forces. She notes that "to understand career processes fully, one needs to consider all these factors (the opportunity structure, individuals' resources and characteristics, and time), as well as the specific ways in which particular workers come to find out about or to be chosen for new jobs" (Rosenfeld 1992: 41). This explanation of mobility is consistent with the life course perspective used in this study. Thus in understanding mobility in the academy, attention must be paid both to the opportunity structure of the tenure system, historical events that affect birth cohorts differently and also to individual characteristics such as productivity, family and marital status. In addition, consideration should be given to issues of labor market segmentation, for example the fact that women are more likely to be employed in specific sectors of the labor market, such as in the academy rather than in private industry. In the science and engineering community, labor force segmentation results in a greater concentration of women scientists in the life sciences. This suggests that the present study should examine mobility within each discipline: mathematics and computer science, life sciences, physical sciences, and engineering.

Alan C. Kerckhoff (1995) offers additional insights on the central concepts in understanding mobility. Building on the status attainment model of Blau and Duncan (1978) he advances several theoretical observations. Working from the structuralist perspective, he focuses on how institutional arrangements shape the links between the first job (or origin) and subsequent jobs or final job (destination).

Kerckhoff notes that the status attainment model does not include structural factors that “constitute societies sorting machine” (Kerckhoff 1995:326). These structural factors, along with individual ones, prevent movement between origin and destination from being purely random events, but rather tied to specific careers, and specific organizations. In addition the status attainment model failed to fully consider the range of variation, not just the orderliness in career paths.

Two concepts discussed by Kerckhoff (1995) are especially relevant to the academic setting --- Internal Labor Markets (often referred to as job ladders) and the broader concept of career lines. ILM’s exist within firms and organize positions into a hierarchy. When a vacancy occurs at the top of the hierarchy it is filled by an internal candidate at the next lower level. This creates a “vacancy chain” that is filled with individuals within the firm. Career lines, a related concept, are “sequences of job locations that are occupied with sufficient frequency that they many be viewed as a socially provided pathway” (Kerckhoff 1995:338). The sequence of off-track, assistant, associate and full professor forms a career line. Like ILM’s, career lines typically limit access to top level jobs (such as full professors), to individuals in the next lower position (such as associate professors).

J. Scott Long and Mary Frank Fox (1995) also offer important dimensions for understanding mobility among scientists that are especially relevant to this study: participation, position, and productivity. Advancement among scientists should consider the extent to which women and minorities participate in science. Position refers to organizational location (such as business sector or academic sector) and to rank, both of which are important measures in understanding mobility. Productivity is also key and publications are a critical indicator of this dimension. While Long and Fox (1995) note that women typically lag behind men on this indicator, the authors also cite the finding by Ward and Grant (1995) that women in the social science and biology are approaching the same rate of publication as men.

As previously cited, several recent empirical studies examine career mobility in the scientific community (See Long, Ed. 2001, Sonnert 1995, Shenhav 1992, and Tang 1997a and Xie and Shauman 2003, Morgan 1998). To date, each study approaches the problem from a different perspective, although frequently using the same datasets and explanatory variables. Understandably, different conclusions are presented by each study. Still somewhat similar themes emerge, particularly regarding the role of family and academic discipline. Following Rachel Rosenfeld's (1992) schema, the structural factors that these researchers use are academic discipline and type of employer (academy, government, business/industry sector). The individual resources and characteristics in Rosenfeld's (1992) schema are years of experience, education, marital and family status. A brief summary of each study follows.

Tang (1997a) presents an analysis of mobility that is an exemplar for this study. She uses the NSF's Survey of Natural and Social Scientists and Engineers[1] (SSE/NSCG), a panel study of scientists and engineers that includes all who self-report their occupation as scientist or engineer and posses a 4-year degree. Tang (1997a) examines mobility, defined as the odds of moving into management during the period between 1982 and 1989. Her central question is whether Asians have greater odds of mobility (as suggested by the 'Model Minority' thesis) compared to whites or other minorities. The significant findings are that, contrary to the "Model Minority Thesis', Asian scientists did not attain higher rates of promotion into management than white men. In fact, Asian male engineers had significantly lower odds of promotion into management as did Asian women in natural science and social science. Surprisingly, white women in computer science attained higher odds of promotion. Marital status had a limited effect; never marrieds in engineering had lower rates of promotion. Family status also had a limited effect. This study suggests the need to consider under certain conditions women might enjoy greater rates of mobility than men. It also suggests that the effect of marriage and children may not be as powerful as generally assumed or, alternative, the influence of marriage and children might be moderated by an intervening variable.

Like Tang (1997a), Shenhav (1992) also investigated the movement of minorities and women scientists into the managerial ranks using the same dataset, the SSE/NSCG, from the period 1982-1986. He also operationalized the type of employer as either public or private sector (rather than academy, government, business/industry), hypothesizing that women and minorities will have better rates of promotion in the public sector with its more rule-driven, bureaucratic style. Shenhav's (1992) findings were unexpected; in the private sector, women were significantly more likely to be promoted into management than men. Further analysis by Shenhav suggests that this finding was "true for white women compared to white men but not for black women compared to black men" (Shenhav 1992:896). This, combined with Tang's (1997a) findings, suggests that under certain circumstances, women's careers may benefit from a gender difference; this claim will be explored in the present study.

Laurie Morgan (1998) examined the earnings of women engineers, using a subsample of the SSE/NSCG and points to the importance of birth cohorts in understanding career patterns of women. Her research model centered on the importance of birth cohorts in explaining the earnings gap between women and men engineers. Building on the work of Paula England (1992), Morgan describes the cohort effect such that "women who have entered the professions recently face fewer career obstacles than did those who entered earlier," (1998). This effect is invariant over time, such that younger scientists, reaping the benefits of the women's movement and federal antidiscrimination laws, may expect to earn the same as men over the course of their lifetime. Morgan's results demonstrated that women scientists in the youngest cohort, those who graduated from college between 1977 - 1981, earned roughly the same as men in 1982, 1984, 1986 and 1989. The gender gap in earnings is also absent for the next oldest cohort (1972-1976) for 1984, 1986, and 1989. Women in the older birth cohort (born 1971 and earlier) earned significantly less than men, a pattern consistent with wage gap findings for women in general (DiNatale and Boraas 2002).

Like Tang's (1997a) work, the mobility analysis presented by Xie and Shauman (2003) provides an exemplar for this study. Their work presents a thorough analysis of gender differences through the use of a synthetic cohort [2], which allows them to look at mobility from 7th grade through college, graduate school and the profession of scientist or engineer. The segment of the synthetic cohort that is most relevant here uses the SSE/NSCG from 1982 to 1989, also used by Tang 1997a and Shenhav 1992). Xie and Shauman (2003) analyze mobility in terms of three different outcomes, odds of employment, earnings rates and odds of promotion into management position. Controls are established for demographic factors of age, age squared, race. Controls for human capital include attainment of a masters or doctorate degree. Family condition was controlled by using one of three categories: unmarried, married without children and married with children. Unlike the previous work by Tang (1997a), the only controls that had a significant effect were marital and family status. Married women with children were less than 25 percent as likely to be promoted to management as other women. The odds for promotion for unmarried women and married women without children were roughly the equal to the rates for men. This study offers additional evidence that under certain conditions, women scientists may experience career mobility at rates equal to men.

While Shenhav (1992), Tang (1997a) and Xie and Shauman (2003) examined career mobility in the context of movement into management, Sonnert (1995) and Long, Ed. (2001) consider career mobility within the academic setting, the site where most scientists and engineers may be found. Both Sonnert (1994) and Long, ed (2001) build models that test fairly complex relationships to explain variations in rank attained by women scientists. Both studiesinclude similar variables describing individual characteristics and resources and structural factors describing employment sector and field.

In Sonnert's (1995) analysis, women outside the field of biology, were significantly less likely to attain the same rank as men after controlling for productivity (publications per year) and academic age. He notes, "The women's disadvantage in academic rank was concentrated in the non-biological science fields, notably in the physical sciences, mathematics, and engineering, where the women's average rank was much lower than that of comparable men" (Sonnert 1995:44). Tang (1997a) does not isolate specific fields of study, and only compared engineering, computer science, natural science and social science, thus it is impossible to determine if her findings are consistent with Sonnert's (1995) observation about biology.

The research of Long, Ed. (2001), the third exemplar for this study, is particularly valuable because it uses the Survey of Doctorate Recipients (SDR) data from 1973 to 1995 and provides the most current published analysis to date. The present study uses several additional waves of the SDR and will add to the baseline data provided by Long's, Ed. (2001) research. Long, Ed. (2001) does not use an event-history analysis for these longitudinal data, but instead provides a separate analysis for each year using logistic regression. Still Long, Ed. (2001) offers important findings from both descriptive and multivariate analysis. Women continue to be overrepresented in off-track positions, a finding that Long, Ed. (2001) points out is unchanged since the early work of Ahern and Scott (1981). The percent of tenure track positions declined from 1979-1995. However, by the 15^{th} year after receiving a Ph.D., men are still more likely to be in a tenure track position. Gender differences were evident in the timing of earning a doctorate; men were less likely to work in a tenure track position if there was a gap of more than 10 years between the time they earned their bachelor's degree and their doctorate. Exactly the opposite was true for women; women who had a lag between their two degrees were more likely to be in a tenure track position. Long, Ed. (2001) suggests this might reflect a positive effect of women delaying their careers because of child-rearing.

Long, Ed. (2001) also looks at the intersection of gender and family status in greater detail. In the earlier waves of the survey such as 1979, having young children lessened the likelihood that women would hold a tenure track position. The effect was the opposite for men. This effect decreased over time for women, but became more pronounced for men.

Long, Ed. (2001) also notes a discipline-specific finding. In general women lagged behind men in attaining tenure in every discipline except life sciences, a finding that echoes Sonnert (1995). Other findings are that being a foreign citizen and working at a private institution lessened the chances of men and women attaining tenure. Being married had a positive effect on attaining tenure though the effect was stronger for men.

Long, Ed. (2001) offers a very different picture of mobility among scientists and engineers in the academy. Women benefit from a delay in earning a Ph.D. Women are equally likely as men to attain tenure in the life science, but are underrepresented in tenured positions in the other disciplines.

Collectively, the research by Shenhav (1992), Tang (1997a), Morgan (1998) and Xie and Shauman (2003), Long, Ed. (2001) and Sonnert (1994) offers several important clues to how mobility might operate. Under five conditions, women experience lower rates of advancement than men; moreover birth cohort, academic discipline and family status appear to explain the difference. First, Morgan (1998) found that women engineers in older birth cohorts (those graduating from college prior to 1971) had significantly lower earnings then men. Second, Long, Ed. (2001) observed that women in every discipline except life sciences are less likely to be tenured faculty than men. Third, Sonnert (1994) noted that except for those in biology, women attain lower academic ranks than men. Fourth, Xi and Shauman (2003) reported that married women with children had lower rates of promotion. Last, Long, Ed. (2001) also observed that women with children are less likely to be full professors, while men with children are more likely to be full professors.

By contrast, under four limited conditions, women experience *equivalent* rates of career progress as men. The findings suggest that marriage, family status, academic discipline, organization type of employer, and birth cohort are pertinent. Xie and Shauman (2003) report that unmarried women and married women without children had the same rates of promotion to management as men. Shenhav (1992) found that women working in public sector had the same rates of promotions as men. Morgan (1998) observed that women engineers in younger birth cohorts (those who graduated between 1972 and 1981) had the same earnings gains as men. Sonnert (1994) noted that women in biology attain academic ranks equivalent to men. Long, Ed. (2001) noted that in 1995 women in the physical sciences and life sciences were equally likely to attain tenure.

Perhaps the most unexpected findings were two conditions under which women had *higher* rates of promotions than men. While these findings are very limited in scope, they are critical in suggesting that women scientists may experience greater career success than men. First, Shenhav (1992) found that women working in the private sector had higher rates of promotion to management than men. Second, Tang (1997a) reported that White women in computer science experienced higher rates of promotion of management than their male counterparts.

To summarize the literature, understanding mobility requires concern for a number of dimensions. The role of marriage and family appear to be highly relevant factors, with children appearing to decrease chances of promotion for women (Xie and Shauman, 2003; Long, Ed. 2001) although not always (Shenhav, 1992). Academic discipline, particularly the effect of working in the life sciences, seems to determine whether women will have academic careers that match those of men (Long, ed 2001; Sonnert, 1994). There are antecedent conditions such as birth cohort that also appear to influence the career success of women. When looking at academic careers, specific milestones such as the time of the doctorate award are important measures of progress. All of these factors will be considered in examining the career progress of women scientists.

Chapter 3: Theory and Hypotheses

The literature on life course, mobility processes and human capital offer theoretical perspectives that guide this project. These perspectives are interconnected; the life course and human capital literature both address of career processes and all three topics address the issue of gender differences, particularly differences related to marriage and family and its impact on careers.

Like human capital theory, the life course perspective is a structural theory, one that has considerable explanatory power in longitudinal studies in general and mobility studies in particular. Janet Z. Giele and Glen H. Elder Jr. (1998) and Linda K. George (1996) present the key tenets of this perspective. First lived experiences are best viewed longitudinally and in the context of four core factors. 'Time and Place' (core factor 1) structure lives in the life course such that today's young women in high school may benefit from innovative programs that encourage women's participation in science. Programs such as the National Science Foundations' ADVANCE Program for Increasing the Participation and Advancement of Women in Academic Science and Engineering Careers (NSF 2004), offer learning opportunities and support that help young women persist in the rigorous training and enter science careers. Additionally women entering science more recently are far more likely to benefit from the greater presence of women faculty who can serve as mentors and may be in positions of influence (e.g. promotion review committees).

'Linked lives' (core factor 2) refers to the influence of other individuals and institutions in shaping lives. One's life is 'linked to' the lives of others such as spouse and children. This factor addresses to the differing social roles of men and women. In particular it speaks to the challenge for women combine demanding career roles with demanding roles in the family.

'Human Agency' (core factor 3) or the individual ability to chose and pursue a career in science is critical. Thus the influence of socialization may steer women toward occupations traditionally held by women, but through agency she may choose an alternative to the traditional choices. Agency is also apparent when women find inventive ways to combine family and an academic career. Importantly, agency is reflected in the commitment to advance and excel in the three requirements for success in the academy: teaching, publishing and service.

'Timing of Lives' (core factor 4) is concerned with the notion of normative times for completing education, establishing a career, union and family formation. This factor addresses the importance of looking at normative patterns that establish a sense of being "on-time" or "delayed" in achieving these milestones. Giele and Elder (1998) and George (1996) are quick to point out the wide range of variability in the timing of key life events. Phyllis Moen and Shin-Kap Han (2001) offer important evidence from a cohort of adults born between 1926 and 1945 that points to personalized rather than standardized career trajectories. Moen and Han (2001) found that most men as well as some women were likely to follow an orderly career trajectory of full-time work, upwardly mobile employment followed by retirement. By contrast, women were more likely to follow several different trajectories, including a delayed entry into the labor force, steady part-time work throughout the career, or intermittent work in the early part of the trajectory followed by full-time work and retirement (Moen and Han 2001:47). The notion of timing of milestone events, such as a delayed entry into the labor force and intermittent work may be useful in understanding the advancement of women scientists in the academy.

Considerable evidence supports the four core factors of the life course perspective. Morgan (1998) and DiNatale and Boraas (2002) support the concept of the importance of 'time and place' with evidence that younger birth cohorts of women in the labor force experience more equal footing with men in the workplace with respect to earnings. Little evidence, however, tests whether younger cohorts of women experience advancement in rank at the same pace as men. Mixed evidence exists to explain the extent to which women succeed in linked lives of scientist, wife and mother. Little evidence addresses the idea of agency as a factor of success, particularly in the areas of teaching . Lastly limited evidence from Long, Ed. (2001) suggests that the timing of key events such as completion of doctorate may be associated with different outcomes for women and men..

The challenge for married women scientists, especially mothers, involves domestic labor, the housework and childrearing work that exists outside the capitalist mode of production (Paul Smith, 1978). This work which consumes time but is unpaid, is often referred to as non-market work. The essential challenge for these women becomes one of integrating the demanding market work necessary to succeed as an academic scientist with non-market work. How do various theories suggest that women will integrate these tasks? Life course theory would suggest timing key events to accommodate periods primarily devoted to non-market work and periods devoted to market work.

Human capital theory offers a very different explanation. Human capital refers to the knowledge, experience and skill of workers that have value in the workplace. Gary S. Becker ([1964]1993) offers both a formal statement of human capital theory and substantial empirical support for the theory. The vital assumption about human capital theory is that with greater knowledge, experience and skill, workers can demand greater rewards in the form of wages or status from the employer. This view is supported by evidence that, on average, individuals without a high school diploma earn the least, individuals with high school diplomas but no college consistently earn more, and college graduates consistently earn even more. In a recent study on earnings in 1998, the Bureau of Labor Statistics reported that weekly earnings for individuals with a high school diploma average $479, earnings for those with a bachelor's degree average $753, and earnings for those with an advanced degree average $956 (U.S. Bureau of Labor Statistics 1999:1). In the research mentioned previously, Tang (1997a) found that formal business training significantly improved the probability that a scientist in the business sector would move into management --- further support for human capital theory.

Human capital theory argues that any gender gaps in career mobility are associated with differences in the knowledge, experience, and skill the worker brings to the job. For example Tony Tam (1997) offers empirical evidence that specialized training, experience and working in specific industries, rather than the devaluation of 'women's work' explains the wage gap between men and women. One must question, however, the conditions under which training and location in specific industries and occupations may be differentially allocated to men and women.

Human capital theory also explains the segregation of women in certain occupations (for example, in occupations outside of science and engineering) in terms of women's greater concern for child rearing. Michelle J. Budig and Paula England (2001) note that human capital theory argues mothers may be less productive on the job than non-mothers because they are tired from home duties or because they are 'storing' energy for anticipated work at home. Thus mothers may not devote the same energy to advancing into and through the tenure track. This might be reflected in the tendency for mothers to forego promotions and remain in a lower level or lower paying position.

Budig and England (2001) test this claim along with other possible explanations of the wage gap such as discrimination, career interruptions, and more women working in lower paying but 'mother-friendly' jobs. Using the National Longitudinal Survey of Youth 1982-1993, they analyzed hourly wage while controlling for the number of children and marital status. Mothers earned significantly less in hourly wages than did women without children, net the effect of control variables. While some of the wage gap was attributed to fewer years of experience, a significant gap in earnings remained. This gap or 'wage penalty' to use Budig and England's (2001) term, may be the result of lower productivity or discrimination but without the means to assess productivity levels, Budig and England (2001) could not offer a specific answer. Still this finding on lower wages of mothers suggests that women might also attain lower rates of mobility and that the same mechanisms that depress wages for women might also depress their chances to attain higher ranking jobs.

In earlier research England (1982) demonstrated limitations in the ability of human capital theory to explain occupational segregation. She offered empirical evidence that women who temporarily exit the workforce in adulthood are no more likely to work in predominantly female occupations than women with continuous workforce participation (England 1982:360). Her empirical findings refute the human capital argument that women tend to seek jobs that are more flexible because of their child-rearing concerns and these flexible jobs tend to be lower paying and lower status.

While empirical evidence such as the earnings advantage associated with increased levels of education, and evidence from Tam (1997) supports the theoretical concept of human capital at least on a broad, general level, weaknesses in the theory are evident. Notably, Paula England's (1982) insightful research on "the failure of human capital theory to explain the gender gap in earning" suggests that systems of gender and class inequalities are deep schemas that alter the way in which human capital operates. A more effective approach to the question of mobility is not to treat human capital theory as "grand theory," but rather to carefully build an explanation of mobility that layers theories that work in concert with each other.

Collectively, the life course perspective, mobility literature and human capital theory offer major and supporting explanations for possible gender differences in the careers of scientists and engineers. The concerns that are most prominently noted are union formation and family formation. The literature suggests that gender differences exist in how marriage and family concerns intersect with careers. Consequently women should use strategies that differ from men, to accommodate their marriage, childrearing and careers. One such strategy might be delaying milestones such as undergraduate and graduate degrees, to allow time that can be devoted to forming families. Later in the career, women may also postpone childbirth until securing a tenure track position or even securing tenure.

Hypotheses

Theory and prior research suggests that overlapping internal and external forces influence the careers of women differently from those of men. Internal factors, namely a woman's understanding of her role as a worker and, in some cases, as a parent may lead to the development of gender-specific strategies. To increase the likelihood of success in the roles they choose, women may develop strategies that stagger tasks that are perceived as especially demanding. Women may delay entry into a career in order to form a family; alternatively, women with a family may forgo or delay promotions. Because men are not as likely to perceive conflict among the roles of worker, spouse and parent, they will be less likely to use these strategies. Productivity, an internal measure of a person's ability and effectiveness in advancing science is critically important in securing tenure and promotions in the academy. To the extent that women scientists publish at a rate on a par with men, the career trajectories of women should mirror those of men. The first three hypotheses are generated from these internal factors.

External factors, such as the historical timing of one's birth also influence the careers of women differently than men. Women who belong to the most recent birth cohort may have benefited from the social and legal changes that increased gender equity in general. These women may participate in the community of academic scientists on a more equal footing with men as compared to women from earlier birth cohorts, and consequently experience career advancement at the same rate as men. Academic discipline, another external influence on career trajectories, should be influenced by the presence of women colleagues. A discipline where women work in greater numbers and where they are positioned at all ranks of the tenure system is qualitatively different than a discipline where women are severely underrepresented. Women should have career outcomes equal to men in disciplines, such as life sciences, where women are fully represented. The last three hypotheses are advanced to test these issues of career mobility.

Hypothesis One – Women with children will have lower rates of mobility than childless women.

H1 Increased responsibility for nonmarket work will limit the resources that women many devote to advancing their career. Women may either choose to remain in lower ranks, because they ration their time between childrearing and work in such a way that they do not advance at the same rate as men. Alternatively women with children may want to, but not have the time to devote to this aspect of work because of the demands of childrearing. Regardless of whether, by choice or due to external forces, the presence of children will depress the rates of mobility for women.

Hypothesis Two – Women who delay completion of the doctorate, will have higher rates of mobility than women who complete their education more rapidly.

H2 Women who delay obtaining a doctorate (defined as a 10-year or greater gap between the award dates of the baccalaureate and doctorate degrees, following Long, Ed. (2001) may use this gap as part of a strategy to stagger the time-demanding activities of entering an academic career and rearing young children. Strategic timing of degree and family formation may benefit women because they are likely to assume more non-market work associated with child rearing. By contrast, men will be less likely to devote large amounts of time to rearing children and thus not need to stagger family formation and establishing an academic career. For that reason, men who have a 10 year or greater gap between baccalaureate and doctorate degrees should not have greater career success.

Hypothesis Three – Women with greater levels of productivity should advance at faster rates than less productive women. More productive women should have mobility rates that approximate those of men.

H3 Building on the work of Budig and England (date), this hypothesis tests whether gender differences in mobility are explained by differing levels of productivity (rather than the effect of children) Productivity, rather than child-rearing or other non-market work, may be the mechanism that is associated with greater career progress experienced by men. Thus women who have favorable living arrangements (such as a supportive spouse, or fewer childcare responsibilities), plus the internal drive and ability to be more productive may advance at a rate on par with men.

Hypothesis Four – Women in the youngest birth cohorts will experience higher mobility rates than older women. The mobility of younger women should be similar to the rates of men.

H4 Women in the youngest birth cohort will have benefited from changes such as Title IX of Education Amendment which prohibited discrimination in federally funded programs and Title VII of the 1964 Civil Rights Act prohibiting employment discrimination. Younger women also may have benefited from the research findings and special programs developed by the National Research Council's Committee on Women in Science and Engineering and the NRC's Committee on Women's Education and Employment in Science and Engineering. As a result, women born more recently will have rates of mobility similar to those of men; women and men in the oldest birth cohort will have dissimilar rates of mobility.

Hypothesis Five – Women employed in the life sciences will experience mobility rates equal to men. This similarity between genders will not appear in other academic disciplines.

H5 Women life scientists will benefit from the greater presence of other women in their discipline as suggested by Long, ed (2001) and Sonnert (1994). They may benefit from tenure and promotion reviews where women are likely to serve on the review committees. Similarly women in the life sciences will have the opportunity to be mentored by other women, women who have successfully navigated careers in the academy. By contrast, women in other scientific disciplines will experience lower rates of mobility than men. The large numbers of women in the life sciences may provide an atmosphere with supportive mechanisms (such as mentoring and co-authorship) that are absent from other academic disciplines.

Chapter 4: Data, Methods and Procedures

The central task of this project is to determine what, if any, gender differences exist in a segment of the career trajectories of scientists and engineers from 1993 to 2001. The data, methods and procedures described in this chapter outline a course for determining if there are gender differences in the underlying correlates of occupational mobility. Additionally, this chapter describes the procedures used to explore the mechanisms and conditions that might underlie any gender differences. In looking at mobility, this study uses a longitudinal dataset which allows a prospective view of changes in occupational rank and a host of other explanatory variables, such as birth cohort, marital and family status. The statistical tool used in this analysis is an event history technique, discrete-time logistic regression, which allows for modeling changes in a categorical dependent variable over time.

Data

The primary source of data will be the National Science Foundation's SDR, a longitudinal survey that samples from the target population of all persons under age 76 who received a doctorate in science or engineering and reside in the US. Data are collected from the initial 1993 panel and follow-ups in 1995, 1997, 1999 and 2001. Additional new doctorates are added to the sample in each of the follow-up years. A key characteristic that sets the SDR apart from the SSE/NSCG used by several researchers (Shenhav 1992, Tang 1997a) is that it uses a "demand" definition of scientists. While the SSE/NSCG uses a "supply" definition where individuals self-identify themselves as scientists and meet minimal degree requirements, in the SDR the sample population consists of all who are defined as scientists by employers. The SDR uses a more rigorous definition—those who possess a doctorate in science—which excludes individuals who hold lower degrees but still work as scientists. Thus the SDR samples exclusively from the pool of those with educational credentials necessary to attain the highest rank in the academic setting.

Response rates for the SDR have been high in recent years. The unweighted response rates were 88 percent in 1993, 76 percent in 1995, 85 percent in 1997, 81.5 in 1999 and 82.6 percent in 2001 (NSF, 2006). Response rates at this level minimize the risk of nonresponse bias.

The design of the SDR is well-suited for this project for two reasons. The panel design of this survey will allow for the analysis of the career paths of individual scientists and engineers over time. This design provides a prospective view of career changes, rather than a retrospective view which is more likely to be subject to recall errors. Secondly, the SDR includes variables that allow for the detailed study of work histories such as data on job changes (including reasons for the change), data on publications, patents and commercializations (a measure of productivity and agency) and data on post-doctoral studies (a measure of social network).

Based on a search of the Social Science Citation Abstracts, relatively few published studies have used the SDR and the present study will build on that body of knowledge. The SDR was used by Mary Fox and Paula Stephans (2001), Mary Fox (2001) and Xie and Shauman (1998). J. Scott Long, Ed. (2001) edited a detailed analysis of the SDR that ended with data from 1995; however, event history methods were not used and the data were treated as cross-sectional surveys. Still, these four works are useful examples of how SDR data can be used. In particular, it will be helpful to extend the Long, Ed. (2001) study beyond 1995 and compare differences in examining the data across time.

Because women less frequently work as scientists and engineers, it is important to conduct a preliminary analysis to ensure that the SDR contains an adequate number of participants who are women. As Table 2 illustrates, the SDR includes an adequate number of women (number of subjects=2,170). Data for minority women are much more limited and thus specific analyses of minority women will not be included in the present analysis; however, there is a clear need for future research on this important subgroup in the SDR.

Following findings of differences in mobility across different disciplines (Tang 1997a, Sonnert 1996, Xie and Shauman 2003), separate analysis will be conducted for each of the following disciplines: Mathematics/Computer Science, Life Science, Physical Science, and Engineering.

Methods and Procedures

As mentioned earlier, Long, Ed. (2001) analyzed the SDR by treating each survey year as a cross-section; however this study will fully exploit the longitudinal nature of the data and its potential to estimate trends in promotion rates over time. An event history approach will be used. Paul D. Allison (1984) describes an event history as "a longitudinal record of what events happened to a sample of individuals or collectivities" (1984:9). Along with these key events of interest (such as death, promotion, age at first birth), the longitudinal record also includes explanatory variables, some of which, like race and gender, remain constant over time and others, like marital status, that vary. In the present study, the event of interest is an upward change in academic rank between 1993 and 2001. A change will be determined by comparing the rank in adjacent years (1993-1995, 1995-1997, etc). The exact date of a change is rank is not available, however, it can be determined that the promotion took place during the *discrete* two year period ending in either 1995, 1997, 1999 or 2001. In addition, given the dichotomous dependent variable, a logistic regression should be used to model the data. Based on those two criteria, a discrete time logistic regression is the form of event history analysis that is most appropriate (Allison 1984 and Kleinbaum 2005).

An essential task in an event history analysis is constructing the data file that adheres to several basic rules. The file consists only of those for whom the event of interest (or promotion in this study) is possible. Since a promotion is only likely to occur once during the period 1993-2001, this analysis will look for the occurrence of one change in rank. After that promotion occurs, subjects are no longer "at hazard of promotion" and any subsequent records for those individuals must be discarded from the file. Similarly, individuals whose initial rank is full professor, are no longer at hazard of a promotion and are also excluded from the analysis.

Two factors add complexity to this file; individuals may exit the survey through attrition or fail to complete a wave then return in later years, as is typical of longitudinal surveys. In addition, individuals may have explanatory variables such as marital status or cumulative number of publications what change over the course of the survey period. The file will be constructed to account for both of these occurrences. While it is possible that more than one promotion occurred for an individual, it is likely to be a rare occurrence. Still, a future analysis could create a mobility table to analyze the origin (or beginning rank) and destination (or final rank) of each individual tracked between 1993 and 2001. The mobility table would identify anyone who either gained more than one rank during the observation period or dropped a rank.

The data file created for this analysis is known as a person-period file, which as Allison (1984) describes, includes a record for each period the subjects are eligible for a promotion. Alternatively, this file is said determine the hazard function or "the instantaneous potential per unit time for the event to occur, given that the individual has survived up to time *t*," (Kleinbaum and Klein, 2005). Each record includes a unique reference number each subject, a survey period identifier, a dependent variable and set of independent variables. Table 1 provides a segment of the person-period file that is used in this study as an example. Each individual has between two and five records in the person-period file. Note that the period during which a promotion occurs is always the final record for each individual. Also note that individuals may skip survey periods, but their records are included in the person-period file if they completed at least two surveys.

A logistic regression model is estimated for the dependent variable using the final person-period file. The logit represents the log odds of promotion at a given period (t) and is represented as Log(P(t)/1-P(t)). The odds of promotion change over time and as a result the y-intercept, a(t), is estimated for each of the four periods when a promotion might occur years (1995-2001) of the SDR. A slope, b, indicates the change in the y-intercept for each one-unit change in the independent variable, x.

Again, independent variables may be time-variant or time-invariant. Taken together, the model may be expressed as

$$\text{Log } (P(t)/1\text{-}P(t)) = a(t) + b_1 x_1 + b_2 x_2 t$$

The dependent variable, or change in rank, is defined broadly as an upward move in academic rank. It includes change from an "off-track" position to any tenure-track position, from an assistant professor to an associate or full professor, and from an associate professor to a full professor.

As mentioned before, the person-period file will be the foundation of this analysis and the logistic regression model will be fit to this dataset. Several files will be created to study specific aspects of mobility. The first person-period file will look at mobility broadly and include mobility across all academic disciplines and across all academic ranks. A separate person-period file will be created for each of the four academic disciplines to allow for an analysis of trends that may be unique to each discipline. Similarly, a separate analysis will be conducted among off-track, assistant, and associate ranks to discern difference in mobility at different points in the career trajectory. Each file will consist of the following variables.

Person-Period File

1. **Reference Identifier,** a unique identifier exists for each respondent in the SDR file and will be used in its unchanged form.
2. **Survey Year**, the four -digit year ranging from 1993 to 2001 referencing the year in which the SDR was administered and will be used in its unchanged form. Individuals must respond to a minimum of two survey years so that a change in rank can be determined.

3. **Academic Rank,** measured as one of four values, representing either off-track, assistant professor, associate professor or full professor. All individuals identified on the SDR file as instructors, lecturers and adjunct professors will be categorized as holding off- track positions. In addition, individuals who identify their tenure status as "not applicable for this position, "not applicable for this institution," or "other," also will also be categorized as off-track.
4. **Gender,** the principal independent variable exists in the SDR file and will be used in its unchanged form, "female" and "male." Men are the reference group.
5. **Age,** used in its unchanged form on the SDR file and refers to the individual's age in years at the time of data collection.
6. **Birth Cohort,** measured as one of five categories based on the SDR's birth year variable. All births between 1900 and 1935 will be grouped and used as the reference group. All births between 1936 and 1945 will be grouped. The later half of this group, born between 1941 and 1945 coincides with the early birth cohort used by Diatale and Boraas (2002). All births between 1946 and 1955 will be grouped. The earlier half of this group, born between 1946-1950, coincides with the early birth cohort used by Diatale and Boraas (2002). All births between 1956 and 1965 will be grouped. All births between 1966 and 1975 will be categorized grouped. This range is the same as used by Diatale and Boraas (2002).
8. **Marital Status,** measured as a dichotomy of "Not Married" referring to all individuals who are never married, widowed, divorced or separated and "Married" referring to all others. The 'not married' group will be the reference group.

9. **Gap between Baccalaureate and Doctorate Award Dates,** measured as the difference between these two degree award dates. Building on the work by Long, ed. (2001), the variable will be categorized as a gap of fewer than ten years or greater than ten years. The gap of fewer than 10 years will be the reference group.
10. **Academic Discipline,** used in its unchanged form: Mathematics/Computer Science, Engineering, Physical Science, and Life Sciences, the reference group. In the analysis of mobility within each discipline, respondents who change disciplines will be excluded from the analysis.
11. **Publications,** will be reported based on information reported in 1995 and 2001. Data will be used in its unchanged form and represents the cumulative number of publications reported by the respondent.
12. **Lives with Children,** used to in its unchanged form and measures all who are likely to have some form of childcare responsibilities. The reference group consists of those who do not live with children.
13. **Length of time in the survey,** measured as the number of survey periods an individual is eligible for a promotion, or at 'hazard of promotion.' The variable is the difference between the first year of exposure (either 1993, 1995, 1997, or 1999) and last year of exposure to hazard (either 1995, 1997, 1999, or 2001) and ranges from 2 to 5. Five years will be the reference group
14. **Promotion,** measured as '1' if the tenure ranking increased in a given year as compared to the previous year, or else measured as '0.' Promotion is defined as a move from off-track to a tenure track position (assistant, associate or full

professor); as a move from assistant professor to associate or full professor; or a move from associate professor to full professor.

As with any study, the present analysis must consider potential weaknesses that will interfere with data interpretation and the ability to make statistical references from the data. One of the overriding concerns is that of sample size. Sample size is problematic because small samples contain greater variances and greater variances make significant differences more difficult to detect. In extreme cases, small samples used to model variables with multiple categories (such as birth cohort) may be problematic.

By definition, event history analyses include repeated measures for each individual, so observations are *not* independent and a decision must be made on how to handle the lack of independence. One approach that may be used is to treat the repeated measures for each individual as a correlated cluster, and analyze the total dataset in terms of clusters for each individual. This correction, know as the Huber-White correction, creates what are termed as robust standard errors or empirical standard errors, (Allison 1999:187). For example, a traditional computation for standard errors would look at a person-period file of 100 observations as independent results, but the robust standard error computation treats the same person-period file as observations from 20 people who have clusters of 5 repeated measures. The Huber-White correction will be used in the present study.

This use of robust standard errors is a more conservative approach to data handling because it decreases the likelihood of achieving a statistically different p-value. This approach has important consequences for hypothesis testing and the ability to make statistical inferences about the general population of scientists. The robust standard errors make it far easier to reject the hypotheses of this study, thus giving greater assurance that a statistically significant difference is a true difference in the sample and can be generalized to the broader population. On the other hand, robust standard errors increase the risk of a "rejecting a true hypothesis" or a type I error (Blalock 1979:110). As a safeguard against this error, a *p*-value of <.10, rather than the traditional *p*<.05, will be used in all tests for statistical inferences.

In addition to sample size concerns, attrition is a concern with any longitudinal survey. It is particularly troublesome when attrition selectively affects one group. For example, the women scientists who agree to participate in a fairly lengthy longitudinal survey with somewhat intrusive questions (on topics such as income, age and number of publications) may differ from the larger population of women scientists on a host of dimensions such as higher rank and greater income. Women who agree to participate may have more successful careers, and women who have chosen to exit the field of science may be less likely to participate in the survey initially or exit the survey during one of the follow-up waves. If the participation rates vary in a nonrandom way, the data will be biased in favor of those who participate.

Concerns about attrition are particularly salient in a mobility study involving scientists. As Alessio and Andrzejewski (2000) note, the attrition rates of engineers in the SSE/NSCG are far greater for women than for men as evidence by 55 percent of the men responding in year 7 of the SSE/NSCG to only 42 percent of the women responding (2000:311).

For the present study attrition is defined as completing only one survey year. Respondents who skip a year or more before retuning to participate in the survey will not be considered to have dropped out, since there is enough information to determine if mobility occurred. As a precaution, survey attrition rates for men and women will be included in the results of this study.

Ethics

The major ethical concern will be preserving the anonymity of all respondents, particularly when small subgroups are discussed. In all analyses, women and men will be grouped to prevent divulging a career path that might be unique to a specific individual.

Chapter 5: Results

The results are introduced with a discussion of the descriptive statistics, followed by a discussion of a general analysis of mobility and then more specific analyses. It is important to note that the descriptive statistics describe the person-period file which is the basis for this event history analysis. The specific analyses begin with an examination of movement within each academic discipline and then investigate advancement within each faculty rank. The chapter concludes with a summary of key findings and a discussion of their implications.

Descriptive Statistics

Several gender differences emerge from the descriptive statistics (Table 2). The most pronounced differences are found in micro-level areas dealing with individual resources (publications) and family decisions (marital and parental status) and macro level areas ofbirth cohort and academic discipline. On average women have 5.64 publications compared to 7.55 publications for men (Table 2). This difference is critical in that published research is an important prerequisite for promotion. Fewer publications might be associated with lower rates of career advancement. However few publications may also be a function of the younger age of the women. It will be important to include publications as in a model that controls for other factors to understand more clearly its role in mobility.

As expected, the descriptive statistics for marriage and family look different for women and men. Most scientists are married; however 68 percent of the women combine marriage and science careers versus 79 percent of the men who do so and as

Table 2 indicates this difference is statistically significant. Similar differences exist in the percentages of scientists with children, slightly less than half (45 percent) of the women scientists have children living in their home while 57 percent of men have children (Table 2).

The difference in age is most apparent when viewed in terms of birth cohorts. A larger percentage of women fall into the two youngest cohorts (born 1966-1976 and 1956 - 1965) compared to men (Table 2). For instance, almost twice as large a proportion of women (7.89 percent) are born between 1966-1976 versus 4.57 percent of the men (Table 2). As might be expected given than the women in the person-period file are on average younger than the men, women have a later average year for receiving both their baccalaureate and doctorate degrees.

Academic rank also reflects gender differences. Women were more likely to be employed in lower academic ranks, especially as off-track faculty and assistant professors. Men are fairly evenly divided among off-track, assistant and associate positions. Very few individuals were promoted into the rank of full professor during the time covered by the SDR, but a larger percentage of men than women attained this rank during the survey period.

Women who remained in the survey had roughly the same average number of number survey periods as men, about 2.7 periods. However, 729 (34.72 percent) of the single observations came from women while women produced only 5,985 (27.85) percent) observations in the person-year file (Table 2). As previously mentioned, the definition of attrition for this study is having participated in the survey for only a single-year.

Interpretation guide

The intercept represents the odds of promotion during the period 1993-2001 for a person with values of zero for all coefficients (0 years of age or born between 1900-1935, has less than a 10-year gap between BA and PhD award dates, is single, does not live with children in the home, works in the life sciences, and has no publications in 1995 or 2001, and remained in the survey for all5 periods). The explanatory variables in the models (Tables 3-11) show the effect of each independent variable in comparison to the reference group. That comparison is stated as a ratio for the odds of promotion for the explanatory variable compared to the odds of promotion for the reference group with a value of zero. Coefficients that are greater than one represent an increased likelihood of promotion compared to the reference group. For example when referring to Table 3, the odds of promotion for married women (1.112) may be interpreted as an 11.2 percent increase in the odds of promotion for women who are married compared to the reference group who are single. Conversely, coefficients that are less than one represent a decreased likelihood of promotion. Again referring to Table 3, the odds ratio of promotion for women who are measured over two periods of time (.411) may be understood as a 41.1 percent lower chance of promotion compared to the reference group who are measured over five survey periods.

Overall Analysis of SDR

The first analysis looks at mobility broadly and examines all promotions that occur between 1993 and 2001 among all ranks and all academic disciplines. This overview is important for discerning wide-ranging gender patterns in mobility and testing the hypotheses at a macro-level.

Hypothesis One – Women with children will have lower rates of mobility than childless women.

Hypothesis one is not supported in the macro level analysis. While women scientists who are mothers and presumably have greater responsibility for nonmarket work associated with child care, women with children experience mobility rates that are not significantly different from women without children (Table 3, 1.113, n.s[3].). The presence of children does not appear to depress the rate of mobility for women. This result is unlike the findings of Xie and Shauman (2002) that women who had children had lower rates of promotions than women without children. By contrast, the presence of children has a positive effect on the rates of promotions for men.

Hypothesis Two – Women who delay completion of the doctorate, will have higher rates of mobility than women who complete their education more rapidly.

Hypothesis two is not supported. The longer gap between baccalaureate and doctorate degrees does not appear to benefit women (Table 3, 1.027, n.s.). Those who finished a degree more quickly (in under 10 years) are as likely to be promoted as those who took longer. On the other hand, men who take a longer time to earn doctorates (perhaps because they are starting a family, or working in the business sector, or publishing more works as graduate students) have slightly higher odds of promotion (Table 3, 1.134, $p<.05$). This finding stands in contrast to the results of Long, Ed. (2001) who noted that "having an interruption between the baccalaureate and the Ph.D. had a large position effect [on the probability of being a full professor] for women, over 10 percentage points, with a smaller effect for men (2001:178). However, Long Ed. (2001) used a cross sectional approach and this project looks at the data longitudinally. Still, delaying the completion of a doctorate does not appear to benefit the mobility of women as it does for men.

Hypothesis Three – Women with greater levels of productivity should advance at faster rates than less productive women. More productive women should have mobility rates that approximate those of men.

The results support hypothesis three. Productivity appears to yield the same positive career advantage for both genders. Overall, each publication increases the odds of promotion by 3 percent, regardless of gender (Table 3, 1.037, and 1.031, both $p<.001$). Net the effect of age, marital roles, and family roles, women receive the same increased rate of promotion as men for each published work. It should be noted that publications had the second largest effect on rate of promotion (following duration of time in survey) as observed in the Wald Chi-Square Statistic.

Hypothesis Four – Women in the youngest birth cohorts will experience higher mobility rates than older women. The mobility of younger women should be similar to the rates of men.

This hypothesis is not supported. Women in the two youngest birth cohort have mobility rates that are significantly lower than men (Table 4). Women in the older birth cohorts have mobility rates that are similar to men (Table 4). Generally the expected pattern that emerges is one where the relationship between mobility and age is positive but nonlinear, with more upward movement occurring early in the career, and tapering off to a plateau in the later career (Rosenfeld 1992). This pattern clearly emerges when looking at mobility among birth cohorts of men. Men in the youngest birth cohort, born 1966-1976, are almost three times as likely to be promoted as the oldest birth cohort, born 1900-1935 (Table 4, 2.989, $p<.001$). Similarly men in the next youngest birth cohort are more than three time as likely to be promoted as the oldest birth cohort (Table 4, 3.562, $p<.001$). For men, the rate of mobility peaks among the cohort born between 1956-1965; however none of the women's birth cohorts are not significantly different from the reference group (Table 4).

Overall, mobility rates are higher among the younger birth cohorts; for both men and women the three youngest cohorts experience promotions odds that are 2 -3 times the odds of the reference group born between 1900 and 1935.

Hypothesis Five – Women employed in the life sciences will experience mobility rates equal to men. This similarity between genders will not appear in other academic disciplines.

At the macro-level, academic discipline is not associated with differences in mobility for women or men. Contrary to Long, Ed. (2001) and Sonnert (1994), who found that career advancement for women in biology – the academic discipline where women are most often employed – mirrored that of men rather than lagged behind them as in other disciplines. This 'biology' effect is not present in this analysis. The odds of promotion for women across all four disciplines are essentially the same (Table 3, 1.032, 1.237 and .999 all n.s.).

Other significant findings emerge from looking at the duration of time (2, 3, 4 or 5 survey periods) that each respondent remained in the SDR. This duration of time helps to explain the temporal patterns in mobility. While the promotion from off-track to assistant might occur in a short period of time such as 2 years, it is unlikely that promotions in other academic ranks will occur that rapidly. Consequently when looking at promotions in all academic ranks and disciplines, we might expect a lower rate of promotion for individuals measured over a duration of 2 survey periods when compared to the reference group of intervals measured over 5 survey periods. In fact, women and men who are tracked over 2 survey periods support this expectation. During any two year span, women earn only 41 percent of the promotions as women who are studied for 5 periods (Table 3, .411, $p<.001$). Men experience a similar deficit (Table 3, .461, $p<.001$). However, a different pattern emerges for men and women after that point. Men are more likely to be promoted in 3 or 4 survey periods, compared to 5 survey periods (Table 3, 1.235, $p<.05$ and 1.508, $p<.001$). Women equally likely to be promoted in 3 or 4 survey periods, compared to the reference group (Table 3, .930, n.s. and 1.253, n.s.).

Analysis by Academic Discipline

The literature, particularly the discipline-specific findings reported by Sonnert (1994), Tang (1997a) and Long, Ed. (2001), suggests the need to examine mobility within specific academic disciplines. As outlined below, mobility among across disciplines is largely similar to the general group of scientists but important differences emerge from this more specific analysis. The most pronounced finding is one of no difference in mobility rates of men and women (Tables 5-8). No gender effect is evident in either the age model or the birth cohort model in any discipline.

Hypothesis One – Women with children will have lower rates of mobility than childless women.

Like the broader analysis of scientists, the increased nonmarket work associated with motherhood does not affect mobility of women in any discipline. (Table 5, Model 1, 1.185, n.s.; Table 6, Model 1, 1.154, n.s.; Table 7, Model 1, 1.002, n.s.; and Table 8, 1.538, n.s.). Men in the physical sciences and engineering receive a mobility 'premium' associated with fatherhood, (Table 7, Model 1, 1.300, $p<.05$ and Table 8, Model 1, 1.522, $p<.01$.) Women do not experience this 'premium' from parenting.

Similarly marital roles are generally not associated with mobility for women, with one exception. Women engineers who are married are promoted at twice the rate of their single counterparts (Table 7, 2.205, $p<.05$).

Hypothesis Two – Women who delay completion of the doctorate, will have higher rates of mobility than women who complete their education more rapidly.

Timing of completion of doctorate does not have significant consequences for mobility among women. (Table 5, Model 1, 1.401, n.s.; Table 6, Model 1, .931, n.s.; Table 7, Model 1, .908, n.s.; and Table 8, 1.956, n.s.). Among male engineers and mathematicians/computer scientists those who earned their doctorates more slowly (in over 10 years) had 50 percent higher rates of mobility (Table 5, Model 1, 1.488, $p<.01$ and Table 8, 1.519, $p<.01$). Evidence from the discipline-specific analysis does not support hypothesis two.

Hypothesis Three – Women with greater levels of productivity should advance at faster rates than less productive women. More productive women should have mobility rates that approximate those of men.

As in the previous analysis, publications are strongly associated for advancement for women and men across all disciplines. For example, among women in life sciences, each publication is associated with a 4 percent increase in mobility for women (Table 6 Model 1, 1.041, $p<.001$) and also a 4 percent increase for men (Table 6, Model 1, 1.039, $p<.001$). Even though women, on average, have fewer publications than men (Table 2 5.64 and 7.55), publications are generally associated with advancement for both genders. The relationship between publications and mobility is significant and roughly equivalent for men and women (Tables 5-7) although variation exists across academic disciplines. Men and women physical scientists appear to benefit least from each publication (Table 7, 1.014, $p<.001$, and 1.019, $p<.001$). In fact publications were not associated with career advancement for women in the birth cohort model for physical scientists (Table 7, 1.013, n.s.). By contrast, mathematicians/computer scientists reaped the largest reward for each publication; a publication increased the odds of a woman's rate of promotion by 9 percent (Table 5, Model 1, 1.092, $p<.001$) and increased the odds for men by almost 6 percent (Table 5, Model 1, 1.059, $p<.001$).

Hypothesis Four – Women in the youngest birth cohorts will experience higher mobility rates than older women. The mobility of younger women should be similar to the rates of men.

Within each discipline, cohortsexperience mobility differently based on gender.. Birth cohort is not associated with career advancement for women (Tables 5-7, Model 2); rather women experience advancement throughout most of their careers. By contrast, men are more likely to experience mobility earlier in their careers, with significantly higher rates in the youngest 2 or 3 birth cohorts, with the peak rate experienced by men born between 1956-1965 (Tables 5-7, Model 2). Among men, advancement was associated with youth but advancement is less age-dependent for women.

The duration of time in the person-period file seems to operate in a similar manner for women and men in the short term, but differs over longer durations (Tables 5-8, years in survey). Those who are observed for during only 2 survey periods are less likely to advance than the reference group who are observed for 5 periods (For example see Table 6, Model 1, .377, $p<.001$ and .393 $p<.001$). Except for engineers, men are increasingly more likely to be promoted in 4 periods rather than 5, for example (Table 5, Model 1, 1.846, $p<.001$). Women in the life sciences, not only receive fewer promotions in the two year period (Table 6, Model 1, .377, $p<.001$), but they still receive fewer promotions in the 3- and 4-year time frames (Table 6, Model 1, .766 n.s. and .860, n.s.).

Discussion of Promotion Rates within each Academic Rank

The analysis of gender differences within each academic rank produced a complex pattern. Consistent with the discipline-specific analysis, gender is not a significant explanatory variable; however subtle gender differences are evident in the delays in obtaining a doctorate, and role in marriage and family and the length of time to be promoted.

First, the absence of a gender difference in advancement among off-track professors is not entirely unexpected given findings in the general analysis and discipline-specific analyses already presented. Women working in off-track positions had promotions rates that were 98 percent of the rates of men (Table 9, Model 1, .988, n.s.). Women working at the level of assistant professor were promoted at 89 percent of the rates of men (Table 10, Model, .890, n.s.). Women associate professors advanced at a 17 percent higher rate than men (Table 11, 1.173, n.s.) This finding of 'no-difference' is consistent with earlier research by Shenhav (1992), Xie and Shauman (2003) for single women and married women without children.

Professional movement in the rank of assistant professors appears to be very similar for men and women. Not only is overall mobility similar for both genders as just stated, many of the same explanatory variables appear to be associated with mobility for both genders. Indeed Table 10 reflects the greatest similarity in mobility among any of the analysis in this study. While age is a significant variable, with each year increasing the rate of promotion by 3 percent (Table 10, Model 1, 1.031 $p<.05$ and 1.028, $p<.05$), birth cohort does not affect mobility. The gap between degrees differs for men and will be discussed below. The most unexpected finding is that the careers of both men and women, benefit from children (Table 10, Model 1, 1.330 $p<.10$ and 1.330, $p<.05$).

Hypothesis One – Women with children will have lower rates of mobility than childless women.

Hypothesis one was not supported. Among women in the off-track and associate professor ranks, there was no significant difference between the advancement of women with or without children (Table 9, Model 1, 1.014, n.s. and Table 11, .984, n.s.).

The most unexpected finding occurs in looking at parenting and advancement among assistant professors. Surprisingly, among assistant professors, women *with* children are more than 30 percent more likely to advance compared to women without children (Table 10, Model 1, 1.330, $p<.10$). While the careers of men at this rank also benefit from children (Table 10, Model 1, 1.330, $p<.01$)., families are clearly associated with better career outcomes for women.

Hypothesis Two – Women who delay completion of the doctorate, will have higher rates of mobility than women who complete their education more rapidly.

Overall, women who are awarded doctorates in 10 or more years after earning a baccalaureate degree have virtually the same rates of advancement as those who took less time (Table 9, Model 1, .921, n.s.; Table 10, Model 1, .916, n.s.; and Table 11, 1.073, n.s.). This effect is quite different for men at the assistant and associate professor level. Among assistant professors, men who obtain degrees more slowly also were promoted at a slower rate -- only 83 percent the rate of promotion than other men (Table 10, Model 1, .827, $p<.10$). This finding is consistent with the previously cited association of advancement and interruption of graduate study observed by Long, Ed.(2001). The relationship is the opposite for associate professors, among this group those with a longer period of graduate study became full professors at a 21 percent higher rate than other men (Table 11, 1.212, $p<.10$).

Hypothesis Three – Women with greater levels of productivity should advance at faster rates than less productive women. More productive women should have mobility rates that approximate those of men.

Hypothesis three is strongly supported. At all three ranks, women receive the same significant increase in mobility from each publication as do men (Tables 9, 10, and 11). Amongoff -track professors, women experience a 3.1 percent increase in rate of promotion for each publication (Table 8, Model 1, 1.031, $p<.001$); among assistant professors, the increase is 4.9 percent (Table 10, Model 1, 1.049, $p<.001$); and among associate professors the rate is 3.1 percent (Table 11, 1.031, $p<.001$). These rates are essentially the same in the age model and the birth cohort model (Tables 9, 10, and 11). The rates are also similar for men (Tables 9, 10, and 11). Thus, publication, a measure of individual ability and productivity, is significant.

Hypothesis Four – Women in the youngest birth cohorts will experience higher mobility rates than older women. The mobility of younger women should be similar to the rates of men.

Hypothesis four was not supported. (Due to limited number of women associate professors, a cohort model could not be estimated.) Among off track professors, cohorts are strongly associated with mobility; women in the three youngest cohort experience a significant advantage in mobility and men in the two youngest cohorts have a similar pattern, (Table 9, Model 2, birth cohorts). This pattern is consistent with overall patterns of intragenerational mobility, with more promotions in younger and early middle age compared to later years. However, among assistant professors, birth cohorts are not associated with mobility for women or men (Table 10, Model 2, birth cohorts).

Hypothesis Five – Women employed in the life sciences will experience mobility rates equal to men. This similarity between genders will not appear in other academic disciplines.

Among the off-track and associate ranks, women experienced roughly the same rates of promotion across academic disciplines (Tables 9 and 11, Model 1, academic discipline). Men in off-track positions experience lower rates of mobility in engineering and physical sciences compared to the life sciences (Table 9, Model 1, .582, p<.001 and .669, p<001). Male associate professors who experience lower rates of advancement in mathematics/computer science compared to the life sciences (Table 11, .783, p<.100).

The picture was quite different among assistant professors. Women were more likely to advance to tenured positions in engineering with an 87 percent higher rate of advancement compared to the life sciences (Table 9, Model 1, women in engineering, 1.872, p<.001). Men in engineering also almost twice as likely to experience promotion compared to men in the life sciences (Table 9, Model 1, 1.910, p<.001). A limited "biology effect" appears to operate among assistant professors.

The temporal pattern of mobility was quite different for men and women as evidenced by the significantly different coefficients for length of time in survey among off-track professors (Table 9). As seen previously, individuals who remain in the person-period file for only 2 periods are less likely to experience a promotion compared to those studied over the entire 5 periods included in the person-period file (For example, Table 9, Model 1, .583, p<.05). This disadvantage is generally evident for both men and women at the rank of assistant and associate professor (Tables 10 and 11) and for women at the off-track ranks. However, women experience a greater disadvantage in the short term as off-track professors. Women at this rank who were at hazard of promotion for two periods had only 58 percent of the promotions as women who were in survey for 5 periods (Table 9, Model 1, .583, $p<.05$). Men who participated for two periods experience 23 percent higher odds of promotion (Table 9, Model 1, 1.231, n.s.). At higher ranks, this gender gap between the short term advancement rates of women and men declined (Tables 10 and 11, Model 1). In addition, among the off-track academics women have significantly slower rates of promotion than men.

Men who are in the person-period file for either 3 or 4 survey periods consistently experience greater levels of promotions compared to the reference group (For example in Table 9, Model 1, 2.033, $p<.01$ and 1.837, $p<.01$). Except for assistant professors, the temporal pattern of promotions for women is much slower one than for men. Among women scientists at the off-track rank, greater rates of promotion are experienced with successively longer durations in the survey, but none exceed the rate of promotion for the reference group (Table 9, Model 1). A similar pattern exists among women associate professors (Table 11, .441, $p<.05$, .990, n.s., 1.265, n.s.). However men associate professors are 34 percent more likely to advance in 4 survey periods of observation (Table 11, 1.340, $p<.10$).

Summary

While several of the hypotheses were not supported, the analysis offers important insights on career mobility among academic women scientists. In certain cases a finding of 'no difference' is an important one. The key finding is that mobility looks decidedly different for women, in both expected and unexpected ways.

The productivity hypothesis was supported in all three analyses. Overall, women appear to receive roughly the same career benefit from each publication as men (Table 3, 1.037, p<.001 and 1.031, p<.001), roughly a 3 percent increase per publication among off-track faculty (Table 9, 1.031, p<.001), a 5 percent increase among assistants (Table 10, 1.049, p<.001) and a 4 percent increase among associates (Table 11, 1.031, p<.001). This suggests a slightly greater emphasis on publication among the ranks of assistant professors. It should be noted that the publication variable had the second largest effect on mobility (after duration of time in the person-period file). Still, although on average women have fewer publications, after controlling for publications, women are equally likely to advance.

Academic disciplines varied in the return on each publication , but women in Mathematics/Computer Sciences obtained the greatest benefit, an 9 percent increased odds of promotion, from each publication versus a 5 percent increase for men (Table 5, Model 1, 1.092, p<.001 and 1.059, p<.001). This offers evidence that advancement for men is associated with other factors in addition to publications, such as cohort or family status (both discussed below).

Following publications, duration of time in the survey is the second most consistent explanatory variable for mobility in women. Neither women or men are likely to be promoted in a shorter timeframe such as 2 survey periods. Except for those in the structured setting of assistant and associate professor, women lag behind men in the length of time for a promotion to occur. Men generally advance in rank after 3 or 4 periods of observation while women fail to do so. Net the effect of other variables, it appears that women in off-track positions advance more slowly than men.

While the birth cohort hypothesis found only mixed support, it is useful in uncovering a key gender difference in mobility. Only among off-track professors was cohort a significant explanatory variable for women. The pattern of advancement for men was consistent, younger men advanced a little, middle-aged men advanced at a very high rate, then the rates leveled off or even declined. Women had more variability to the point that advancement did not differ among cohorts. In other words, there appeared to be no norms for the timing of advancement for women. This may work to the advantage of women who delay careers to establish families, since they are not perceived as 'too old' to advance. While men do not appear to experience this flexibility, they benefit from entering academic careers at what is perceived to be "on time."

Perhaps the most unexpected finding was the lack of what Michelle J. Budig and Paula England (2001) describe as the "wage penalty" for motherhood --- a 7 percent drop in earnings for each child. Xie and Shauman (2003) also report a decreased rate of promotion to management among married women with children relative to unmarried women and relative to married men with children. In this analysis, not only did women with children advance at the same rate as those without, in a few situations mothers advanced more rapidly.

Women assistant professors were more likely to be promoted if they were also mothers and women engineers were more likely to be promoted if they were also wives. How could mothers and wives advance more than single women, who presumably have fewer responsibilities for non-market work? In the case of assistant professors, children may force women to exclude all other activities from their lives save work and family. Grant et al. (2000) found in their interviews of women scientists that "most women with children engaged in rigorous time management, so that not a moment was wasted. Nearly all their energies were focused on their families or their scientific work with no time for other involvements" (2000:79) Similarly, Anne Preston (2004) writes that findings from her interviews reject the human capital argument that women with children have less energy for work; rather, scientists who are mothers exclude all nonessential activities. (2004:91). This exclusion of all else suggests assistant professors who are mothers, focus on nothing but family and promotion to tenure.

The key lessons from this study are that the timing of career advancement is both slower and more variable for women but not delayed by marriage or children. Over a short duration, women and men have fewer promotion events (far fewer for women). Men are more likely to experience promotions during the 4 year and 6 year period, although promotions don't begin to occur more frequently until the 6 year period. This can simply be interpreted as women advance more slowly, net the effect of other variables.

Discussion

Overall this study identified some important factors that are associated for advancement among academic women scientists, but far more explanatory factors were identified for men.

In addition to the explanations outlined below, competing explanations must be taken into consideration. One concern, common to longitudinal surveys is the problem of attrition that affects one subgroup more than another. This concern in mobility studies is raised by Alessio and Andrzejewski (2000) who note, the attrition rates of engineers in the SSE/NSCG are far greater for women than for men as evidenced by 55 percent of the men responded in year 7 of the SSE/NSCG while only 42 percent of the women did so (2000:311). In the present study, a similar gender difference in attrition is evident. Women constitute 28 percent of the SDR between 1993-2001 but make up 35 percent of the respondents who only responded in a single year. Thus attrition does not appear to happen randomly, rather gender appears to play a role such that women are less likely to continue participating in the SDR than men. In addition to the problem of attrition, selection bias is also a competing explanation for these findings. In other words, women who possibly had average level of persistence, or average levels of support from family and friends or average levels of inner drive may never become academic scientists, leaving (or selecting) the most capable women to move into these career lines.

Consequently, the possibility of differential rates of attrition and the possibility of selection bias (and other competing explanations) mean than the findings reported here must be considered with a degree of caution. Still the results of the present study provide evidence for several observations about career trajectories and the strategies that women use to navigate them.

Overall, publications, length of time in the survey and to a limited extent age govern advancement for women, with publications yielding the largest positive influence on the rate of advancement. Men received the same positive effect from productivity, but their advancement also appears to be facilitated by membership in a younger birth cohort, by delaying the doctorate by 10 years or more, by marriage, and by family. On the surface it appears that publications are the single variable that benefits the careers of women, while many more factors help men advance. The possibility of other unknown and unspecified variables must be considered also, but the effect of the key explanatory variables will be addressed here.

A more appealing explanation is that fewer factors are understood about mobility for academic women scientists. The academic women sampled in the SDR appear to successfully navigate the challenge of landing a tenure track position and securing subsequent promotions, but why is the pace of their progress slower? One clue comes from the finding that women advance in the rank of assistant professors in roughly the same timeframe as men. Here it seems that a highly structured, time-limited, formal structure for tenure helps not just all women, but particularly women with children. This lack of a highly structured setting for advancement might explain Xie and Shauman (2003) finding that women scientists in the business sector were less successful at combining family and career. However, the Shenhav's (1992) finding that women working in the private sector had higher rates of promotion is inconsistent with this explanation.

Publications emerge as the most critical factor in for mobility among women. They are the most commonly used measure of individual resources in the academy. Publications head the list of what the group of leading scientists interviewed by Sonnert (1991) describes as determinants of "a good scientist." Publications are not only the norm for rewards in the academy, but the also provide institutions with a competitive advantage (Ohio State Legislative Office of Education Oversight, 1993).

The finding that women appear to rely more on credentials for advancement is akin to the work by Bart Landry (1987) on how advancement operates differently for black and white women. He notes that advancement, measured as earnings, is associated with education for minority women but not for nonminority women. This may be explained as the majority group relying more on factors other than credentials, such as years of experience. In the models reported here, men appear to rely more on factors such as cohort, marriage, a gap between baccalaureate and doctorate in addition to productivity. For example, in mathematics/computer science, advancement for men is linked to both age, a longer time spent earning the doctorate, and productivity (Table 5 Model 1, .969, $p<.001$, 1.488, $p<.01$, 1.059, $p<.001$). However, for women mathematicians/computer scientists, publications were the only significant variable that was associated with advancement (Table 5, Model 1, 1.092, $p<.001$).

Given the fact that on average women publish less than men, and the fact that each publication gives women the same benefit as men might suggest that women simply need to publish more in order to advance at the same rates as men. A more nuanced approach is to explore reasons for the difference in levels of publication. Do women choose to seek more balance between work and family life, and are less willing to commit the additional time needed to develop and publish their research? A better understanding of the reasons for publishing is needed.

The major difference in the pattern of timing for advancement emerges at the the assistant professor level, where advancement is structured by rules for promotion to tenure. Here, both women and men are more likely to advance in 4 survey periods compared to 5. Thus the formal rules guiding tenure appear to equalize the rate of promotion for both women and men assistant professors. Without rules governing the timing of advancement in the level of off-track and assistant professor, women appear the advance more slowly than men.

Overall, the timing of promotions over the life course is more regular for men and women at the entry point of their academic career, peaking during the middle years and then leveling off. For women however, after the initial peak, rates of promotion are less tied to age and far more variable and reflected in the large robust standard errors term. This is evident in the overall analysis where the rates of promotion for the youngest cohorts of women are significantly lower than the rates for men. On the face of it, this more varied pattern suggests that women have more latitude to advance at any point in their lifecourse, while men are more likely to move up in ranks in their early to middle adulthood. Men seem to be guided by a norm for "on-time" advancement when women have greater freedom to advance at any age. This may be related to the assumption that women delayed their careers in order to raise families, regardless of whether this assumption is supported or not.

One of the repeated findings across each analysis in this study is that women appear to blend marriage and career in science and also blend motherhood and a career in science. None of the analyses here supported the hypothesis that parental responsibilities would depress the mobility rates of women. Importantly, this finding suggests that mothers are successfully combiing the demanding roles of mother and academic scientist and are just as likely to advance professionally as women without children. Countering Dimant (1995), it appears from this finding that science is *not* for just for childless women.

It is important to note that marriage and the presence of children frequently had a positive effect on the rates of promotions for men. This may be associated with men assuming a role of economic provider when they become husbands and fathers and consequently seek out or receive more opportunities to advance. For example, men in the life sciences experience a career benefit from marriage with almost a 60 percent higher rate of advancement than single men.

In general women did not receive this advantage for marriage and parenthood, however there are surprising exceptions. Women engineers who are married are promoted at twice the rate of their single counterparts. This finding for women is quite unexpected given the greater responsibility that working wives are likely to have. As mentioned earlier, the most unexpected finding is that the careers of both men and women, benefit from children. This stands in contrast to the findings of Xie and Shauman (2001) that married women with children are less likely to move into the ranks of management. In the business sector, combining motherhood and nonmarketwork as a scientist appears more problematic. In the academic sector, there appears to be greater schedule flexibility (the working hours may be as long, if not longer than in the business sector, but there is greater latitude in scheduling work time) and that flexibility might accommodate childrearing more easily. While gender roles frequently suggest that men who become fathers are also more likely to earn larger salaries, it appears the role of mother also has career benefits for women in tenure track positions.

In light of the increased non-market duties that women are likely to perform in addition to demanding work as scientists, lower rates of advancement might be expected for mothers. Why do the assistant professors who are also mothers experience this career advantage? While this study cannot establish a causal link between parenting roles and increased mobility, one clue might be in the role of the assistant professor. Generally, one enters a tenure track position with the aspiration of attaining tenure, and the recognition that a portfolio of accomplishments is required. Perhaps women who assume the responsibilities of mothering in addition to the goal of attaining tenure are more committed to the role of scientists. Combining two very demanding roles may also require women to manage time and focus on the vital few tasks (such as publications). Some researchers such as Preston (2004) and Grant et al (2000) report the strategy of women devoting their time exclusively to work and family. This may ultimately concentrate more time on work compared to women who work and have other activities.

Alternatively, women who were mothers might have arranged for accommodations at the workplace that gave them an advantage over women without children. One, such accommodation is the practice of stopping the "tenure clock" for a year to have time for childbirth and caring for an infant. Mothers likely use the majority of this time for childrearing, but some might also use a small amount of the extra year to begin work on one or two publications. Thus the additional year when the tenure clock is stopped might have advantages for women beyond the ability to take care of an infant.

While women scientists are far more likely to be situated in the life sciences, their increased presence does not appear to benefit other women with greater rates of promotion. In general women across all academic disciplines have roughly the same rate of promotion, net the effect of other variables. The single exception was among engineers at the assistant professor rank who experience more rapid advancement. The opposite is true of male assistant professors who experience greater rates of advancement in all three disciplines compared to the life sciences. This is a clear example of what Sonnert (1994) refers to as the biology effect where those in biology advanced more slowly than other disciplines.

Overall, women and men assistant professors share most of factors in common that are associated for mobility. This may be linked to the more structured, rule-driven method of advancement in the tenure system. Among off-track professors there are fewer expectations of productivity, teaching and service. Among associate professors, there are greater expectations for these three criteria, but greater latitude in the time to demonstrate success. However, among associate professors the general rule is that individuals have a relatively short, fixed time to demonstrate their capabilities in research, teaching and service. This may create a more equitable environment for women and as a result the factors associated with their advancement resemble those of men.

Returning to the three perspectives of advancement described in the introduction, does this analysis support any of the observations about the careers of academic women scientists? Clearly the observation of Dr. Davison-Rowley (Guy 2002) most closely fits the evidence presented here. Women, it seems, should anticipate a different (slower) temporal pattern to their advancement than men, but expect to ultimately advance as far as men. The difference seems less tied to children and more tied to gender and additional study is needed to untangle the possible causes.

The opinion that science is for childless women (Dimant 1995) is clearly not supported by this study. The finding of ‘no difference’ in mobility of married women, women with children, and single women suggests that women successfully accommodate the increased responsibilities associated with families. Clearly sacrifices are made, and mothers who are academic scientists may have to exclude everything save work and family from their perceived role. However, this finding is encouraging for the 45 percent of women scientists who are also parents. The most surprising finding is that among assistant professors, mothers advance to tenure more rapidly than non-mothers.

Lastly productivity is key to the advancement of women, but does not entirely explain lower rates of advancement. They receive equal (in the case of mathematicians greater) returns on each publication as men. However, on average women publish less and this deficit is critical.

Essentially, women scientists advance at a slower rate than men in the life sciences and in off-track positions as seen in significant differences in the effect of length of time in survey, net the effect of other factors (including publications and children). This disadvantage is subtle and not readily apparent when simply considering gender differences more generally. However, the difference is important because women academic scientists are more likely to be situated in the life sciences or off-track positions. The possible cause for this delay should be explored. Possibly women chose to remain in off-track positions, because shorter workhours are required and consequently a more balanced life may be achieved, regardless of whether it involves family. On the other hand women may choose to remain in off-track positions, because they choose so live in an area with limited opportunities for tenure track positions.

Most importantly, women appear to effectively master the combined roles of wife, mother and scientist. Interviews with women would be especially useful in teasing out the reasons why they tend to work in off-track positions, publish fewer articles than men, and how they balance work and family demands. Another set of interviews might to help identify the factors that seemed to advantage assistant professors who are also mothers. Recent studies that include interviews with women scientists are helpful as background. Preston (2004) and Grant et al., (2000) offered a consistent set of strategies that women scientists used to balance work and family demands, such as foregoing promotions to remain in an off-track position, postponing parenthood until after a career was established and relying heavily on support from family, family-friendly employers, and restricting their time to only academic work and family responsibilities.

Beyond these strategies, it would be helpful to delve more deeply into the notion of career delays, or as Dr. Davison-Rowley (Guy 2002) suggests adjustments in the timing of advancement over one’s life course. The finding that in general men are more likely to benefit from advancement early, while women appear to advance throughout their career is intriguing. The surprising aspect of this finding is that net the effect of marriage and parenting, women appear not to restrict advancement to the early part of their life course. This greater variation in the timing of advancement for women is consistent with the research of Moen and Han (2001), who observe less "orderly' and uniform career trajectories among women. Still, this finding merits additional research. One possible explanation is that parenting and cohorts interact such that women with children in younger cohorts have slower rates of promotion than single women in those cohorts.

The study also identified other variables in addition to birth cohort that are not statistically significant in the model for mobility among women , but are still important considerations, namely marriage and parenthood. Contrary to several prominent works (Budig and England, 2001 and Xie and Shauman 2003) women do not pay an "advancement penalty" for motherhood. This finding should be weighed with the possibility that the true penalty that women scientists pay for combining an academic career with motherhood is that the compromises identified by Preston (2004) and Grant et al. (2000) become essential for advancement. With the women at the assistant professor level, women may not have paid an advancement penalty for motherhood, but they clearly did not receive the same benefit from parenting as did men.

Perhaps the most crucial finding is that net the effect of all other variables, men advanced in a few number of survey periods than did women. This finding suggests that either the models presented here are underspecified and important explanatory variables are not controlled for or men have an advantage in gaining promotions more quickly, typically in 3 or 4 survey periods which is not the case for women. Discrimination should be included as one of a several possible explanations.

The SDR data set is rich in variables that explain careers and valuable in understanding mobility among scientists, but a few limitations exists which if addressed may help in future research. The age at first birth would be quite useful in assessing the timing of parenthood for women and more importantly its timing in relation to earning a doctorate and entering the academic career. Unfortunately the main reasons for delaying the doctorate remain unknown. Since a longer gap between baccalaureate and doctorate degrees generally benefits men, and it appears that reasons might differ by gender.

Overall the SDR provides an opportunity to explore the career paths of academic scientists to identify key forces that possibly guide or impede advancement. The analysis points to general similarities in the overall rate of advancement between women and men; yet a smaller set of forces (mainly publications and very formal system of advancement) guide women. By contrast, a larger set of forces (namely marriage, family, delay in obtaining doctorate, and birth cohort) appear to guide advancement for men. Unexpectedly, children did not impede the advancement of women. Collectively these findings suggest that important features of mobility for academic women scientists are understood and that women scientists are successfully integrating work and family demands; however the underlying causes for gender differences require further study.

Footnotes

[1] The SSE was renamed the National Survey of College Graduates (NSCG) during the 1990's.

[2] A synthetic cohort approximates the life course of a hypothetical cohort by combining segments from different sources. The synthetic cohort of scientists used by Xie and Shauman (2003) combines data from the several sources to cover high school years, several additional sources to cover the college years and other sources to cover the career years (see Xie and Shauman 2003: 20-24).

[3] Not Significant.

Table 1. Hypothetical Person-Period File Created from 1993-2001 SDR

Reference Identifier	Survey Year	Time Period	Rank	Promotion	Marital Status	Gender
Subject 1	1993	2	Assistant	0	Single	Female
Subject 1	1995	2	Assistant	0	Married	Female
Subject 1	1997	3	Associate	1	Married	Female
Subject 2	1993	2	Off-Track	0	Married	Male
Subject 2	1995	2	Off-Track	0	Married	Male
Subject 2	1997	3	Off-Track	0	Married	Male
Subject 2	1999	4	Off-Track	0	Married	Male
Subject 2	2001	5	Off-Track	0	Married	Male
Subject 3	1997	2	Assistant	0	Married	Male
Subject 3	2001	4	Associate	1	Married	Male

Table 2. Descriptive Statistics for *All* Faculty Ranks and Scientific Disciplines from 1993-2001 SDR

Variable	Mean Women		Mean Men	Mean Total
Mean Age in years	41.39	↔	42.85	42.45
	(8.27)		(8.60)	(8.53)
Number in Birth Cohort				
1966-1976	472		708	1,180
	7.89%		4.57%	5.49%
1956-1965	2,752		6,309	9,061
	45.98%		40.70%	42.17%
1946-1955	1,921		5,785	7,706
	32.10%		37.32%	35.86%
1936-1945	707		2,163	2,870
	11.81%		13.95%	13.36%
1900-1935	133		537	670
	2.22%		3.46%	3.12%
Mean BA Degree Award Year	1977.59	↔	1976.05	1976.48
	(8.37)		(8.51)	(8.50)
Mean Doctorate Award Year	1986.86	↔	1984.46	1985.12
	(7.54)		(8.31)	(8.18)
Number Married	4,047		12,323	16,370
	67.62%		79.49%	76.19%
Number with Children in Home	2,705		8,812	11,517
	45.20%		56.84%	53.60%
Mean Publications	5.64	↔	7.55	7.02
	(7.07)		(9.00)	(8.54)
Academic Rank - Off-Track	2,412		4,671	7,083
	40.30%		30.13%	32.96%
Academic Rank - Assistant	2,016		4,543	6,559
	33.68%		29.31%	30.53%
Academic Rank - Associate	1,365		5,510	6,875
	22.81%		35.54%	32.00%
Academic Rank - Full	192		778	970
	3.21%		5.02%	4.51%
One Period in Survey*	729		1,371	2,100
Two Periods in Survey	4,131		10,612	14,743
	69.02%		68.46%	68.61%
Three Periods in Survey	1,053		2,701	3,754
	17.59%		17.42%	17.47%
Four Periods in Survey	547		1,470	2,017
	9.14%		9.48%	9.39%
Five Periods in Survey	254		719	973
	4.24%		4.64%	4.53%
N (observations)	5,985		15,502	21,487
N (subjects)	2,170		5,537	7,707

Note: Numbers in parentheses are standard deviations; ↔ coefficients differ at $p<.10$.
*Respondents who participated in only one survey period are not included in the analysis and therefore are omitted from the counts of observations and subjects.

Table 3. Odds Ratios for Promotion in SDR 1993 -2001 *(Age Model)*

Variables	Women		Men	Both
Gender (f)				1.027
Age in years	.988*	↔	0.960 ***	0.967 ***
Gap Between BA-Ph.D.				
Gap > 10 years	1.027		1.134 *	1.123 *
Marital Status				
Married	1.112		1.348 ***	1.232 ***
Family Status				
Children in Home	1.113		1.187 **	1.173***
Academic Discipline				
Math /Comp Science	1.032		1.019	1.021
Engineering	1.237		1.030	1.054
Physical Science	.999		0.900	0.902 †
Publications	1.037 ***		1.031 ***	1.032 ***
Length of Time in Survey				
Two Periods	0.411***		0.461 ***	0.438 ***
Three Periods	.930		1.235 *	1.111
Four Periods	1.253		1.508 ***	1.395 ***
N (observations)	5,985		15,502	21,487
N (subjects)	2,170		5,537	7,707

†*p*<.10 **p*<.05 ***p*<.01 ****p*<.001
↔coefficients differ at *p*<.10

Table 4. Odds Ratios for Promotion in SDR 1993-2001 *(Using Birth Cohort)*

Variables	for Women		for Men	for Both
Gender (f)				1.029
Birth Cohort				
1966-1976	1.013	↔	2.989 ***	2.188 ***
1956-1965	1.738	↔	3.562 ***	2.954 ***
1946-1955	1.516		2.473 ***	2.180 ***
1936-1945	0.942		1.180	1.114
Gap Between BA-Ph.D.				
Gap > 10 years	1.007		1.096 †	1.084 †
Marital Status				
Married	1.126		1.376 ***	1.256 ***
Family Status				
Children in Home	1.033		1.124 *	1.103 *
Academic Discipline				
Math /Comp Sci	1.026		1.034	1.030
Engineering	1.262		1.032	1.059
Physical Sci	0.983		0.892	0.895 *
Publications	1.036 ***		1.030 ***	1.032 ***
Length of Time in Survey				
Two Periods	0.436***		0.579 ***	0.525 ***
Three Periods	0.954	↔	1.411***	1.229 *
Four Periods	1.270		1.615 ***	1.472 ***
N (observations)	5,985		15,502	21,487
N (subjects)	2,170		5,537	7,707

†*p*<.10 **p*<.05 ***p*<.01 ****p*<.001 ;
↔coefficients differ at *p*<.10

Table 5. Odds Ratios for Promotion among *Mathematics and Computer Science* Faculty in SDR 1993-2001

Variables	Model 1 (Age) Women	Men	Both	Model 2 (Birth Cohort) Women	Men	Both
Gender (f)			1.018			1.026
Age in years	1.006	.969***	.979***			
Birth Cohort						
1966 to 1976				2.575	3.295*	2.993*
1956 to 1965				1.776	4.426 **	3.303**
1946 to 1955				1.087	21345	1.714
1936 to 1945				1.097	.776	.839
Gap Between BA-Ph.D.						
Gap >10 years	1.401	1.488**	1.494***	1.424	1.376*	1.404**
Marital Status						
Married	1.192	1.205	1.136	1.160	1.208	1.139
Family Status						
Children in Home	1.185	1.037	1.088	1.200	.956	1.041
Publications	1.092***	1.059***	1.067***	1.093***	1.060***	1.067***
Length of Time in Survey						
Two Periods	.531	0.377***	.440***	.571	.559*	.597*
Three Periods	1.581	1.218	1.270	1.616	1.537	1.513
Four Periods	1.909	1.846***	1.841*	1.922	2.063*	1.997**
N (observations)	834	2,158	2,992	834	2,158	2,992
N (subjects)	291	758	1,049	291	758	1,049

†*p*<.10 **p*<.05 ***p*<.01 ****p*<.001
↔Coefficients differ at *p*<.10

Table 6. Odds Ratios for Promotion a mong *Life Science* Faculty in SDR 1993-2001

Variables	Model 1 (Age) Women		Men	Both	Model 2 (Birth Cohort) Women		Men	Both
Gender women				1.018				1.026
Age in years	1.006		0.969***	0.944***	--		--	
Birth Cohort								
1966 to 1976					.724		2.050*	1.247
1956 to 1965					1.525		3.174**	2.278**
1946 to 1955					1.540		2.435	1.926**
1936 to 1945					.783		1.173	.959
Gap Between BA-Ph.D.								
Gap < 10 years	.931		1.015	1.004	.931		.978…..	978
Marital Status								
Married	.953	↔	1.570***	1.226*	.987		1.624***	1.270**
Family Status								
Children in Home	1.154		1.050	1.101	1.025		.972	1.004
Publications	1.041 ***		1.039***	1.040***	1.038***		1.038 ***	1.038
Length of Time in Survey								
Two	.377***		.393***	.390 ***	.378***		.463***	.432***
Four	.766	↔	1.235	1.024	.758	↔	1.370 †	1.088
Six	.820	↔	1.436*	1.204	.819	↔	1.505*	1.243
N (observations)	3,633		6,393	10,026	3,633		6,393	10,026
N (subjects)	1,337		2,330	3,667	1,337		2,330	3,667

†p<.10 *p<.05 **p<.01 ***p<.001
↔Coefficients differ at p<.10

Table 7. Odds Ratios for Promotion among *Physical Science* Faculty in SDR 1993-2001

	Model 1 (Age)			Model 2 (Birth Cohort)		
Variables	Women	Men	Both	Women	Men	Both
Gender (f)			.969			.977
Age in years	1.001	0.964***	1.033**			
Birth Cohort						
1966 to 1976				1.421	3.653***	.092**
1956 to 1965				2.900	3.732***	3.627***
1946 to 1955				3.642	2.590**	2.746**
1936 to 1945				2.259	1.649	1.744
Gap Between BA-Ph.D.						
Gap >10 years	.908	.950	.951	.856	.930	.912
Marital Status						
Married	1.521	1.185	1.198	1.563	1.183	1.204
Family Status						
Children in Home	1.002	1.300 *	1.249*	.907	1.255 †	1.190†
Publications	1.014**	1.019***	1.019***	1.013ns	1.019***	1.019***
Length of Time in Survey						
Two Periods	0.391*	0.645*	0.556**	.392*	.770*	.675*
Three Periods	.695	1.380	1.185	.701 ↔	1.552†	1.319
Four Periods	1.692	1.474†	1.486*	1.725	1.561	1.582*
N (observations)	932	3,568	4,500	932	3,568	4,500
N (subjects)	337	1,261	1,598	337	1,261	1,598

†p<.10 *p<.05 **p<.01 ***p<.001

↔Coefficients differ at p<.10

Table 8. Odds Ratios for Promotion among *Engineering* Faculty in SDR 1993-2001

	Age Model			
Variables	Women		Men	Both
Gender (f)				1.111
Age in years	.959		0.953***	0.954***
Gap Between BA-Ph.D.				
Gap >10 years	1.956		1.519**	1.535***
Marital Status				
Married	2.205*	↔	1.124	1.265
Family Status				
Children in Home	1.538		1.522**	1.490***
Publications	1.039*		1.031***	1.031***
Length of Time in Survey				
Two Periods	0.237*		0.323***	.347 ***
Three Periods	.987		.841*	.949**
Four Periods	2.861		1.276	1.555†
N (observations)	434		2,896	3,330
N (subjects)	165		1,058	1,223

[1] The limited sample size for women engineers did not permit the grouping of meaningful birth cohorts.
Numbers in parentheses are robust standard error estimates
†p<.10 *p<.05 **p<.01 ***p<.001
↔coefficients differ at p<.10

Table 9. Odds Ratios for Promotion among *Off-Track Academic Scientists* in SDR 1993-2001

Variables	Model 1 (Age) Women		Men	Both	Model 2 (Birth Cohort) Women		Men	Both
Gender (f)				.988				.994
Age in years	.975**		.955***	.961***	--		--	--
Birth Cohort								
1966 to 1976					4.537†		3.348***	.783***
1956 to 1965					6.923*		2.640***	2.881***
1946 to 1955					4.921*		1.247	1.565 †
1936 to 1945					3.161		.589	.842
Gap Between BA-Ph.D.								
Gap > 10 years	.921		1.048	1.017	.866		1.060	.997
Marital Status								
Married	.964	↔	1.545***	1.258*	.959	↔	1.539***	1.260*
Family Status								
Children in Home	1.014		1.080	1.070	.943		1.092	1.042
Academic Discipline								
Math /Comp Sci	1.176		.988	1.056	1.152		.993	1.072
Engineering	.786		.582 ***	.618***	.803		.602 **	.627 **
Physical Sci	.952		.669 ***	.712***	.934		.691***	.722 ***
Publications	1.031**		1.019 ***	1.022***	1.030 **		1.021***	1.023***
Length of Time in Survey								
Two Periods	.583*	↔	1.231	.889	.649†	↔	1.430	1.031
Three Periods	.959	↔	2.033 **	1.453 *	1.009	↔	2.209 **	1.560*
Four Periods	.884	↔	1.837*	1.381 †	.910	↔	1.873*	1.420†
N (observations)	2,696		5,153	7,849	2,696		5,153	7,849
N (subjects)	1,030		1,964	2,994	1,030		1,964	2,994

Note: Numbers in parentheses are robust standard error estimates

†p<.10 *p<.05 **p<.01 ***p<.001

↔coefficients differ at p<.10

Table 10. Odds Ratios for Promotion among *Assistant Professors* in SDR 1993-2001

	Model 1 (Age)			Model 2 (Birth Cohort)		
Variables	Women	Men	Both	Women	Men	Both
Gender (f)			.890			.914
Age in years	1.031*	1.028**	1.029***	--	--	--
Birth Cohort						
1966 to 1976				2.262 ↔	.856	.440
1956 to 1965				.705	2.453	1.272
1946 to 1955				1.042	3.298	1.744
1936 to 1945				.636	1.477	.903
Gap Between BA-Ph.D.						
Gap > 10 years	.916	.827 †	.847†	.966	.851 †	.881
Marital Status						
Married	1.420*	1.118	1.197†	1.428*	1.170	1.229*
Family Status						
Children in Home	1.330†	1.330**	1.311***	1.207	1.202*	1.184*
Academic Discipline						
Math /Comp Sci	1.097 ↔	1.732***	1.517***	1.120 ↔	1.861***	.594***
Engineering	1.872***	1.910***	1.847***	2.016***	1.992***	.925***
Physical Sci	1.084	1.423**	1.313**	1.070	1.508***	1.345**
Publications	1.0490***	1.040***	1.041***	1.049***	1.039***	1.041***
Length of Time in Survey						
Two Periods	.257***	0.383***	.328***	.212***	.306***	.261***
Three Periods	.848	1.181	1.001	.759	1.041	.871
Four Periods	1.666†	1.654*	1.528*	1.581	1.542*	1.418*
N (observations)	2,127	5,156	7,283	2,127	5,156	7,283
N (subjects)	764	1,900	2,664	764	1,900	2,664

Note: Numbers in parentheses are robust standard error estimates
†p<.10 *p<.05 **p<.01 ***p<.001; ↔ coefficients differ at p<.10

Table 11. Odds Ratios for Promotion *Associate Professors* in SDR 1993-2001
(Age Model Only*)

Variables	for Women	for Men	for Both
Gender (f)			1.173
Age in years	0.989	.966***	.972***
Gap Between BA-Ph.D.			
Gap > 10 years	1.073	1.212 †	1.181 †
Marital Status			
Married	1.221	1.356*	1.265 *
Family Status			
Children in Home	.984	1.200 †	1.156
Academic Discipline			
Math /Comp Science	.915	.783 †	.814 †
Engineering	.529	.844	.837
Physical Science	1.099	1.077	1.068
Publications	1.031 ***	1.041 ***	1.040 ***
Length of Time in Survey			
Two Periods	0.441*	0.315 ***	0.345 ***
Three Periods	0.990	1.049	1.057
Four Periods	1.265	1.340 †	1.304 †
N (observations)	1,162	5,193	6,355
N (subjects)	376	1,673	2,049

Note: The Birth cohort model for women and men could not be estimated due to an insufficient sample size.

†$p<.10$ $p<.06$ *$p<.05$ **$p<.01$ ***$p<.001$

↔coefficients differ at $p<.10$

Table 12. Coefficients and Standard Errors for Promotion in SDR 1993-2001
(Age Model)

Variables	Women		Men	Both
Gender (f)				.013
				(0.023)
Age in years	-.012*	↔	-.041 ***	-.0186 ***
	(.006)		(.003)	(0.003)
Gap Between BA-Ph.D.				
Gap > 10 years	.026		.126 *	1.123 *
	(.090)		(.055)	(0.052)
Marital Status				
Married	.106		.299 ***	1.232 ***
	(.097)		(.072)	(0.071)
Family Status				
Children in Home	.107		.171 **	1.173***
	(.087)		(.054)	(0.054)
Academic Discipline				
Math /Comp Science	.032		.019	1.021
	(.116)		(.072)	(0.063)
Engineering	.213		.030	1.054
	(.134)		(.062)	(0.059)
Physical Science	.000		-.105	0.902 †
	(.110)		(.063)	(0.049)
Publications	.036 ***		.030 ***	1.032 ***
	(.005)		(.003)	(0.003)
Length of Time in Survey				
Two Periods	-.890***		-.774 ***	0.438 ***
	(.159)		(.105)	(0.039)
Three Periods	-.073		.211 *	1.111
	(.162)		(.106)	(0.099)
Four Periods	.225		.410 ***	1.395 ***
	(.170)		(.112)	(0.129)
N (observations)	5,985		15,502	21,487
N (subjects)	2,170		5,537	7,707

Note: Numbers in parentheses are robust standard error estimates
†p<.10 *p<.05 **p<.01 ***p<.001
↔coefficients differ at p<.10

Table 13. Coefficients and Standard Errors for Promotion in SDR 1993-2001
(Using Birth Cohort)

Variables	Women		Men	Both
Gender (f)				1.029
				(0.048)
Birth Cohort				
1966-1976	.013	↔	1.095***	2.188 ***
	(.363)		(.223)	(0.411)
1956-1965	.553	↔	1.270 ***	2.954 ***
	(.327)		(.198)	(0.492)
1946-1955	1.516		.905 ***	2.180 ***
	(.328)		(.198)	(0365)
1936-1945	-.059		.166	1.114
	(.346)		(.210)	(0.198)
Gap Between BA-Ph.D.				
Gap > 10 years	.007		.092 †	1.084 †
	(.087)		(0.055)	(0.050)
Marital Status				
Married	.118		.319 ***	1.256 ***
	(.098)		(0.072)	(0.072)
Family Status				
Children in Home	.032		.117 *	1.103 *
	(.089)		(0.056)	(0.052)
Academic Discipline				
Math /Comp Sci	.025		.034	1.030
	(.117)		(0.073)	(0.064)
Engineering	.233		.032	1.059
	(.135)		(0.0635)	(0.060)
Physical Sci	-.017		-.115	0.895 *
	(.111)		(0.063)	(0.049)
Publications	.035 ***		.030 ***	1.032 ***
	(.005)		(0.003)	(0.003)
Length of Time in Survey				
Two Periods	-.830***		-.546 ***	0.525 ***
	(.153)		(0.101)	(0.044)
Three Periods	-.047	↔	.345***	1.229 *
	(.161)		(0.105)	(0.108)
Four Periods	.239		.419 ***	1.472 ***
	(.171)		(0.111)	(0.137)
N (observations)	5,985		15,502	21,487
N (subjects)	2,170		5,537	7,707

Note: Numbers in parentheses are robust standard error estimates
†p<.10 *p<.05 **p<.01 ***p<.001 ; ↔ coefficients differ at p<.10

Table 14. Coefficients and Standard Errors for Promotion among *Mathematics and Computer Science* Faculty in SDR 1993-2001

	Model 1 (Age)			Model 2 (Birth Cohort)		
Variables	Women	Men	Both	Women	Men	Both
Gender (f)			-.025			-.064
			(.124)			(.126)
Age in years	-.024	-.071***	.058***			
	(.015)	(.009)	(.008)			
Birth Cohort						
1966 to 1976				.946	1.192*	1.096*
				(.895)	(.602)	(.495)
1956 to 1965				.574	1.488 **	1.195**
				(.786)	(.547)	(.445)
1946 to 1955				.083	.758	.539
				(.794)	(.552)	(.449)
1936 to 1945				.092	-.253	-.175
				(.816)	(.576)	(.468)
Gap Between BA-Ph.D.						
Gap >10 years	.337	.398**	.401***	.354	.319*	.340**
	(.241)	(.138)	(.118)	(.232)	(.140)	(.119)
Marital Status						
Married	.175	.186	.128	.148	.189	.130
	(.296)	(.178)	(.151)	(.289)	(.180)	(.151)
Family Status						
Children in Home	.170	.037	.045	.182	.045	.040
	(.233)	(.140)	(.128)	(.237)	(.145)	(.124)
Publications	.088***	.057***	.065***	.089***	.058***	.065***
	(.020)	(.014)	(.012)	(.019)	(.013)	(.011)
Length of Time in Survey						
Two Periods	-.634	-.975***	-.821***	-.560	.581*	-.516*
	(.474)	(.288)	(.247)	(.462)	(.277)	(.237)
Three Periods	.458	.197	.239	.480	.439	.414
	(.468)	(.288)	(.247)	(.471)	(.285)	(.245)
Four Periods	.647	.613***	.610*	.653	.724*	.692**
	(.474)	(.291)	(0.248)	(.479)	(.291)	(.248)
N (observations)	834	2,158	2,992	834	2,158	2,992
N (subjects)	291	758	1,049	291	758	1,049

Note: Numbers in parentheses are robust standard error estimates

†*p*<.10 **p*<.05 ***p*<.01 ****p*<.001

↔coefficients differ at *p*<.10

Table 15. Coefficients and Standard Errors for Promotion among *Life Science* Faculty in SDR 1993-2001

	Model 1 (Age)				Model 2 (Birth Cohort)		
Variables	Women		Men	Both	Women	Men	Both
Gender (f)	--		--	.018 (.064)	--	--	.026 (.064)
Age in years	.006 (.007)		-.031*** (.009)	-.021*** (.004)	--	--	
Birth Cohort							
1966 to 1976					-.323 (.432)	.178* (.385)	.220 (.284)
1956 to 1965					.422 (.366)	1.155 ** (.322)	.823** (.237)
1946 to 1955					.432 (.365)	.890 (.323)	.656 ** (.237)
1936 to 1945					-.244 (.395)	.160 (.241)	-.042 (.254)
Gap Between BA-Ph.D.							
Gap < 10 years	- .071 (.113)		.015 (.085)	.004 (.068)	-.072 (.111)	-.022 (.086)	-.023 (.067)
Marital Status							
Married	- .048 (.123)	↔	.451*** (.122)	.203* (.086)	-.013 (.124)	.485*** (.121)	.239** (.086)
Family Status							
Children in Home	.143 (.115)		.049 (.087)	.096 (.069)	.025 (.117)	.028 (.090)	.004 (.071)
Publications	.041 *** (.006)		.039*** (.005)	.039*** (.004)	.037*** (.006)	.037 *** (.004)	.037 (.004)
Length of Time in Survey							
Two	.976*** (.193)		.934*** (.162)	-.942 *** (.126)	-.972*** (.192)	-.770*** (.158)	-.839*** (.122)
Four	- .266 (.205)	↔	.211 (.164)	.024 (.128)	-.276 ↔ (.205)	.370 † (.164)	.084 (.128)
Six	-.198 (0.222)	↔	.362* (0.174)	.185 (0.137)	-.119 ↔ (.223)	.409* (.175)	.217 (.137)
N (observations)	3,633		6,393	10,026	3,633	6,393	10,026
N (subjects)	1,337		2,330	3,667	1,337	2,330	3,667

Note: Numbers in parentheses are robust, standard error estimates

†p<.10 *p<.05 **p<.01 ***p<.001

↔coefficients differ at p<.10

Table 16. Coefficients and Standard Errors for Promotion among *Physical Science* Faculty in SDR 1993-2001

	Model 1 (Age)			Model 2 (Birth Cohort)		
Variables	Women	Men	Both	Women	Men	Both
Gender (f)			-.031			-.023
			(.111)			(.111)
Age in years	.000	-.037***	-.032**			
	(.014)	0.007)	(.006)			
Birth Cohort						
1966 to 1976				.352	1.295***	1.129**
				(1.278)	(.392)	(.377)
1956 to 1965				1.065	1.317***	1.288***
				(1.187)	(.346)	(.334)
1946 to 1955				1.292	.952**	1.010**
				(1.204)	(.349)	(.338)
1936 to 1945				.815	.500	.556
				(1.242)	(.376)	(.360)
Gap Between BA-Ph.D.						
Gap >10 years	-.096	-.037	-.050	-.155	-.072	-.092
	(.246)	(.007)	(.111)	(.239)	(.125)	(.111)
Marital Status						
Married	.419	.169	.181	.447	.168	.185
	(.285)	(.141)	(.123)	(.284)	(.142)	(.124)
Family Status						
Children in Home	.002	.263 *	.222*	-.098	.227 †	.174 †
	(.230)	(.112)	(.099)	(..239)	(.116)	(.103)
Publications	.014**	.019***	.019***	.013ns	.019***	.019***
	(.009)	(.005)	(.004)	(.008)	(.005)	(.004)
Length of Time in Survey						
Two Periods	-.937*	-.471*	-..587**	- .936*	-.261*	-.393*
	(.410)	(.214)	(.185)	(.402)	(.205)	(.178)
Three Periods	-.364	.322	.170	-.355 ↔	.449†	.276
	(.420)	(.221)	(.191)	(.417)	(.218)	(.188)
Four Periods	.526	.388†	.396*	.545	.446	.459*
	(.420)	(.230)	(.172)	(.418)	(.239)	(.197)
N (observations)	932	3,568	4,500	932	3,568	4,500
N (subjects)	337	1,261	1,598	337	1,261	1,598

Note: Numbers in parentheses are robust standard error estimates

†p<.10 *p<.05 **p<.01 ***p<.001

↔coefficients differ at p<.10

Table 17. Coefficients and Standard Errors for Promotion among *Engineering* Faculty in SDR 1993-2001

		Age Model		
Variables	Women		Men	Both
Gender (f)	--		--	.105 (0.093)
Age in years	.042 (.032)		-.048*** (.009)	-.047*** (.005)
Gap Between BA-Ph.D.				
Gap >10 years	.671 (.367)		.418** (.128)	.428*** (.074)
Marital Status				
Married	.791* (..357)	↔	.117 (.174)	.235 (.095)
Family Status				
Children in Home	.431 (.315)		.420** (.131)	.399*** (.073)
Publications	.039* (.018)		.030*** (.006)	.031*** (.003)
Length of Time in Survey				
Two Periods	-1.441* (.633)		-1.103*** (.240)	-1.057 *** (.123)
Three Periods	-.013 (.623)		-.173* (.240)	.-.052** (.120)
Four Periods	1.051 (.659)		.243 (.249)	.441✝ (.124)
N (observations)	434		2,896	3,330
N (subjects)	165		1,058	1,223

[1] The limited sample size for women engineers did not permit the grouping of meaningful birth cohorts.

Numbers in parentheses are robust standard error estimates

✝p<.10 *p<.05 **p<.01 ***p<.001

↔coefficients differ at p<.10

Table 18. Coefficients and Standard Errors for Promotion among *Off-Track Academic Scientists* in SDR 1993-2001

	Model 1 (Age)			Model 2 (Birth Cohort)		
Variables	Women	Men	Both	Women	Men	Both
Gender (f)			-.012			-.006
	--	--	(0.075	--	--	(.075)
Age in years	-.025**	-.046***	-.039***	--	--	--
	(.008)	(.007)	(.005)			
Birth Cohort						
1966 to 1976				1.512†	1.208***	1.023***
				(.809)	(.298)	(.273)
1956 to 1965				1.935*	.971***	.058***
				(.789)	(.274)	(.255)
1946 to 1955				1.594*	. 221	. 448 †
				(.792)	(.285)	(.262)
1936 to 1945				1.151	-.528	-.172
				(.816)	(.339)	(.294)
Gap Between BA-Ph.D.						
Gap > 10 years	-.082	.047	.017	-.144	.058	-.003
	(.136)	(.098)	(.079)	(.132)	(..098)	(.079)
Marital Status						
Married	-.036 ↔	.435***	.229*	-.048 ↔	.431***	.231*
	(.144)	(.120)	(.091)	(.147)	(.121)	(.092)
Family Status						
Children in Home	.014	.077	.067	-.059	.088	.041
	(.135)	(.097)	(.079)	(.139)	(.102)	(.082)
Academic Discipline						
Math /Comp Sci	.162	-.012	.055	.142	-.007	.069
	(.228)	(.157)	(.128)	(.230)	(.158)	(.129)
Engineering	-.241	-.541 ***	-.481***	-.219	-.507 **	-.466**
	(0.336)	(.1561)	(.142)	(.347)	(.158)	(.143)
Physical Sci	-.049	-.402 ***	-.339***	-.069	-.369***	-.325***
	(0.179)	(.103)	(.090)	(0.181)	(.104)	(.090)
Publications	.031**	.019 ***	.022***	.029 **	.021***	.023***
	(.011)	(.005)	(.005)	(.011)	(.005)	(.005)
Length of Time in Survey						
Two Periods	-.539* ↔	.207	.117	-.432† ↔	.357	.030
	(.256)	(.239)	(.176)	(.244)	(.232)	(.170)
Three Periods	-.041 ↔	.710 **	.374 *	.009 ↔	.792 **	.445 *
	(.264)	(.244)	(.180)	(.261)	(.244)	(.179)
Four Periods	-.123 ↔	.608*	.323 †	.095 ↔	.628*	.351 †
	(.285)	(.252)	(.189)	(.284)	(.253)	(.189)
N (observations)	2,696	5,153	7,849	2,696	5,153	7,849
N (subjects)	1,030	1,964	2,994	1,030	1,964	2,994

Note: Numbers in parentheses are robust standard error estimates

†*p*<.10 **p*<.05 ***p*<.01 ****p*<.001

↔coefficients differ at *p*<.10

Table 19. Coefficients and Standard Errors for Promotion among *Assistant Professors* in SDR 1993-2001

	Model 1 (Age)			Model 2 (Birth Cohort)		
Variables	Women	Men	Both	Women	Men	Both
Gender (f)			-.116			-.091
	--	--	(0.074)	--	--	(.074)
Age in years	.031*	.027**	.029***	--	--	--
	(.013)	(.009)	(.0087)			
Birth Cohort						
1966 to 1976				-.1.340 ↔	-.155	-.821
				(1.093)	(.862)	(.631)
1956 to 1965				-.350	.897	.240
				(1.031)	(.838)	(.605)
1946 to 1955				.042	1.193	.556
				(1.026)	(.838)	(.605)
1936 to 1945				-.452	.390	-.102
				(1.050)	(.868)	(.627)
Gap Between BA-Ph.D.						
Gap > 10 years	-.088	-.190 †	- .166†	-.034	- .161 †	- .126
	(.172)	(.101)	(.088)	(.156)	(.096)	(.082)
Marital Status						
Married	.350*	.112	.180†	.357*	.157	.206*
	(.173)	(.1123)	(.119)	(.169)	(.122)	(.098)
Family Status						
Children in Home	.285†	.285**	.271***	.188	.184*	.169*
	(.147)	(.093)	(.078)	(.148)	(.092)	(.078)
Academic Discipline						
Math /Comp Sci	.092 ↔	.549***	.416***	.114 ↔	.621***	.466***
	(.193)	(0.124)	(.104)	(.197)	(.123)	(.104)
Engineering	.627***	.647***	.614***	.701***	.689***	.655***
	(0.178)	(.099)	(0.087)	(.189)	(.098)	(.087)
Physical Sci	.081	.353**	.272**	.067	.411***	.297**
	(0.189)	(.111)	(.096)	(0.185)	(.113)	(.096)
Publications	.048***	.039***	.041***	.048***	.038***	.041***
	(.008)	(.006)	(.005)	(.008)	(.006)	(.005)
Length of Time in Survey						
Two Periods	-1.360***	-.959***	-1.115***	-1.549***	-1.182***	-1.342***
	(.279)	(.186)	(.154)	(.270)	(.183	(.150)
Three Periods	-.165	.166	.001	-.275	.041	-.139
	(.280)	(.188)	(.155)	(.278)	(.188)	(.154)
Four Periods	.510†	.503*	.424*	.458	.433*	.349*
	(.298)	(.201)	(0.166)	(.299)	(.200)	(.165)
N (observations)	2,127	5,156	7,283	2,127	5,156	7,283
N (subjects)	764	1,900	2,664	764	1,900	2,664

Note: Numbers in parentheses are robust standard error estimates

†p<.10 *p<.05 **p<.01 ***p<.001; ↔ coefficients differ at p<.10

Table 20. Coefficients and Standard Errors for Promotion *Associate Professors* in SDR 1993-2001 *(Age Model Only*)*

Variables	for Women	for Men	for Both
Gender (f)			.160
			(.108)
Age in years	-.011	-.034***	-.028***
	(.015)	(.007)	(.007)
Gap Between BA-Ph.D.			
Gap > 10 years	.070	.192 †	.167 †
	(.209)	(.107)	(.095)
Marital Status			
Married	.199	.304*	.235 *
	(.220)	(.141)	(.116)
Family Status			
Children in Home	-.016	.183 †	.145
	(.2118)	(.104)	(.092)
Academic Discipline			
Math /Comp Science	-.088	- .245 †	- .206 †
	(.238)	(.137)	(.118)
Engineering	- .637	-.170	-.177
	(.486)	(.119)	(.112)
Physical Science	.094	.074	.066
	(.249)	(.118)	(.106)
Publications	.031 ***	.040 ***	.039 ***
	(.009)	(.004)	(.004)
Length of Time in Survey			
Two Periods	-.818*	1.155 ***	-1.063 ***
	(.330)	(.169)	(.150)
Three Periods	-0.010	.048	.055
	(.333)	(.164)	(.147)
Four Periods	.235	.292 †	.265 †
	(.345)	(.168)	(.151)
N (observations)	1,162	5,193	6,355
N (subjects)	376	1,673	2,049

Note: The Birth cohort model for women and men could not be estimated due to an insufficient sample size.
Numbers in parentheses are robust standard error estimates
†p<.10 p<.06 *p<.05 **p<.01 ***p<.001
↔coefficients differ at p<.10

TABLE 21 – FREQUENCY AND PERCENT OF PROMOTIONS IN SDR 1993-2001

	Women		Men		Both	
PROMOTION	**0**	**1**	**0**	**1**	**0**	**1**
ALL RANKS	5,063 (84.59)	922 (15.41)	13,000 (83.86)	2,502 (16.14)	18,063 (84.06)	3,424 (15.94)
MATH/CS	706 (84.65)	128 (15.35)	1,818 (84.24)	340 (15.76)	2,524 (84.36)	458 (15.64)
LIFE SCIENCE	3,081 (84.81)	552 (15.19)	5,356 (83.78)	1,037 (16.22)	8,437 (84.15)	1,589 (15.85)
PHYSICAL SCI	800 (85.84)	132 (14.16)	3,033 (85.01)	535 (14.99)	3,833 (85.18)	667 (14.82)
ENGINEERING	360 (82.95)	74 (17.05)	2,398 (82.80)	498 (17.20)	2,758 (82.82)	572 (17.18)
OFF-TRACK	2,310 (85.68)	386 (14.32)	4,440 (86.16)	713 (13.84)	6,750 (86.00)	1,099 (14.00)
ASSISTANT	1,762 (82.84)	365 (17.16)	4,075 (79.03)	1,081 (20.97)	5,837 (80.15)	1,446 (19.85)
ASSOCIATE	991 (85.28)	171 (14.72)	4,485 (86.37)	708 (13.63)	5,476 (86.17)	879 (13.83)

TABLE 22. SELECTED BIVARIATE ANALYSES OF MOBILITY IN 1993-2001 SDR

	Women			Men		
PROMOTION	**0**	**1**	**TOTAL**	**0**	**1**	**TOTAL**
With Children	2,237 (82.70)	468 (17.30)	2,705 (100.00)	7,204 (81.75)	1,608 (18.25)	8,812 (100.00)
Without Children	2,826 (86.16)	454 (13.84)	3,280 (100.00)	5796 (86.64)	894 (13.36)	6,690 (100.00)
χ^2			$13.62_{df=1,\ p<000}$			$67.04_{df=1,\ p<000}$
Married	3,387 (83.69)	660 (16.31)	4,047 (100.00)	10,210 (82.85)	2,113 (17.15)	12,323 (100.00)
Single	1,676 (86.48)	262 (13.52)	1,938 (100.00)	2,790 (87.76)	389 (12.24)	3,179 (100.00)
χ^2			$7.82_{df=1,\ p<005}$			$45.02_{df=1,\ p<000}$

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