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Mothers of Invention? Gender, Motherhood, and New Dimensions of Productivity in the Science Profession

Kjersten Bunker Whittington[1]

Abstract

Gender and motherhood dynamics feature prominently in research that examines professional workplace inequities. The rise of patenting as an available form of academic productivity presents a fruitful site to revisit these in the science profession and to compare academic and industrial science contexts. I predict patenting involvement across disciplines, sectors, and time. Contrary to findings regarding publishing, academic mothers suffer a motherhood penalty not experienced by childless women or mothers in industry. Controls for past involvement remove the disparity, and a sex gap in industry. Work/family balance, sector-level incentives, and status expectations may explain these results, providing implications for future research on gender, motherhood, and work.

Keywords

gender and motherhood, science and innovation, productivity

[1]Reed College Portland, OR, USA

Corresponding Author:
Kjersten Bunker Whittington, 3203 SE Woodstock Ave, Reed College, Portland, OR 97202
Email: whittington@reed.edu

Introduction

Sex disparities in professional achievement have long been a focus of scholars of work and occupations. In recent work, motherhood, in particular, arises as a primary source of stratification between men and women workers in the contemporary workplace (Correll, Benard, & Paik, 2007; Crittendon, 2001; Cuddy, Fiske, & Glick, 2004; Glass, 2004). Employed mothers appear to constitute the majority of the sex gap in pay (Glass, 2004), and the overall pay gap between mothers and childless women is now estimated to be greater than the gap between men and women in the workplace (Crittendon, 2001). This article addresses gender and parenthood dynamics in the science profession. In research on workers in this field, productivity is a frequently studied disparity between men and women scientists. Studies have found that women are less likely to publish their research than men and that structural positioning and resources account for much of the sex gap in publishing productivity (see Long, 2001; Xie & Shauman, 2003 for reviews). However, previous studies of mothers and publishing productivity have found few disparities between this group and others (Cole & Zuckerman, 1987; Fox, 2005; Kyvik, 1990).

I focus on sex and motherhood disparities in *patenting* across academic and industrial domains. The rise of patenting activity in the academy over the past three decades reflects broad changes in the science profession more generally, as the logic of science and the logic of commerce increasingly overlap in the scientific work conducted in academia and industry. Aided by federal and state promotion as well as university infrastructure, academic scientists have become increasingly involved in a variety of commercial activities, including patenting, licensing, start-up incubation and firm founding, especially in the life sciences (Kleinman & Vallas, 2001; Owen-Smith & Powell, 2001; Rosenburg & Nelson, 1993). At the same time, in some sectors there is much greater involvement in basic research by industry (Powell, Koput, & Smith-Doerr, 1996). Whether this emerging hybrid logic reflects an “easy coexistence,” a “productive tension,” or a “hostile invasion” between the strategies of industrial and academic science (Murray, 2010), many agree that the traditional view of the scientist as a disinterested and communal searcher of “knowledge for knowledge’s sake” (Merton, 1942/1990) is being replaced by a new model of the scientist-entrepreneur—one who balances corporate responsibilities as well as academic activities.

University scientists now find it advantageous to become involved in both public and private domains (Owen-Smith & Powell, 2001); indeed, academic scientists face increasing pressure to commercialize in universities (Slaughter

& Rhoades, 2004). While research on patenting among scientists has grown prodigiously, studies that combine a concern with gender dynamics and an emphasis on commercial outcomes are rare (although see Ding, Murray, & Stuart, 2006; Murray & Graham, 2007; Whittington & Smith-Doerr, 2005, 2008). Publishing disparities in the academy may now represent just one dimension (and location) of productivity inequity in the science profession.

A focus on patenting allows for an examination of the ways in which men and women workers, especially parents, negotiate new dimensions of productivity amidst the existing demands of their professional work. Inventing is a largely "optional" activity for academics but can carry extensive monetary and reputational benefits for inventors. Yet patenting requires available time and resources and can hinge on the development of commercial relationships and invitations to participate. Although previous work on science professions suggests little differences in productivity exist between female parents and others, mothers' status may complicate opportunities to conduct research in new directions like commercial behavior.

I also address whether or not familiarity, or previous involvement with the patenting process, reduces sex or motherhood disparities. The influence of past exposure in predicting future involvement is not known and can reveal the extent to which particular types of constraints on academic scientists, such as time demands or existing commercial knowledge, may be important in producing observed sex disparities. This issue is particularly relevant for women scientists; at least in the academy, research has shown women to have less knowledge about inventing than their male counterparts (Murray & Graham, 2007).

Patents also provide a new coinage that can be drawn on in careers that span industrial and academic sectors. Although some research on women and mothers in science attends to institutional structure (Fox, 2001, 2005), the focus has been on conditions for academic scientists in research universities. Little is known about sex and motherhood disparities in industrial science, be it with a focus on productivity or toward other outcomes, such as management levels or promotion rates. Data have not been readily available on scientists who work outside of educational organizations although they constitute 49% of the doctoral scientists in the U.S. workforce (National Science Board, 2006, calculated from Appendix Tables 3-9). Sex differences at the sector level reveal the role of context in defining outcomes for women in the workplace and variations in productivity under different workplace norms, support, and circumstances.

My data source combines two waves of structural and locational variables with demographic and career-level data not present in other data sets. I focus on doctorate-level scientists working in academic and industrial domains. I investigate whether women scientists, and in particular, mothers, are less likely to be involved with, and produce less, commercial work than parent and nonparent men scientists. The results highlight the existence of important commercial tradeoffs in the academy and elsewhere. Women's participation rates as inventors vary from those of men and are partially related to sorting mechanisms across disciplines, job positions, and experience. Mothers emerge as a principally disadvantaged group although their involvement differs by sector and is related to prior commercial experience. The results provide insight into the ways in which gendered outcomes become more (or less) relevant with the introduction or expansion of new professional work activities. Furthermore, they highlight how motherhood effects can be situational or context-related and dependent on prior or existing knowledge or demands.

Patenting in Academic and Industrial Domains

Patenting is important behavior to study to understand career outcomes in both sectors (Kleinman & Vallas, 2006). Since the mid-1980s, there has been a dramatic upsurge in the amount of patenting in the United States and other countries (Kortum & Lerner, 1998). Growth in university patenting has eclipsed that of industry over the past 20 years; by 2002 the stock of academic patents had increased in volume nearly 8 times since 1980 (Owen-Smith & Powell, 2001). Academic scientists now make decisions in the face of university, department, and peer pressure about their level of involvement in commercial work. The unanimous 2006 decision by Texas A&M University to include patenting in tenure and promotion decisions is one example of changes occurring to the reward structure of the academy. Indeed, Owen-Smith and Powell (2003, p. 109) suggest that commercial involvement among academic scientists represents "the appearance of a new fault line" between those who participate and those who do not.

Unlike publishing, patenting in the academy is not a "required" activity for tenure and promotion and carries with it different incentives for participation. Although substantial benefits can accrue to those involved, many scientists (especially junior faculty) report an unwillingness to engage in commercial work at a time when "publishing is what counts" for tenure and promotion (Murray & Graham, 2007). Furthermore, fostering commercial networks, learning the process of disclosure in the university setting, and conducting patentable research requires effort, information, and often, experience. Interviews with academic scientists by Murray and Graham (2007) reveal that commercial opportunities come through a complex interaction between demand- (when firms or investors come to "buy" science) and supply-side (when scientists actively "sell" their science) mechanisms. On the demand-side, faculty are approached by a variety of outside sources that include "cold-calls" for expertise from previously unknown individuals, referrals from one's collaborative network, and personal invitations from colleagues or previous students. Scientists actively "sell" their science by filing invention disclosures, initiating formal patenting processes, and/or engaging in conversations about commercial opportunities with university technology transfer offices.

The nature of both demand- and supply-side commercial dynamics makes relevant the issue of women's differential access to support and information in the workplace. Whereas demand-side approaches reflect an implicit opportunity structure that shapes the commercial opportunities presented to academic faculty members, supply-side inputs rest on scientists' interests, expertise, and expectations regarding patenting. Furthermore, the available time, resources, and know-how needed for the commercial process does not always overlap with their knowledge of and capital for basic research activities.

The route to patenting for industry scientists is supported by alternative mechanisms. Commercial output is more of a typical outcome for industrial scientists and one way to display evidence of productivity. Involvement may be determined by one's job position (i.e., having a job description that develops commercial applications), or it may be influenced by technology management staff members who solicit commercial applications from their workers. Many companies offer lucrative bonuses for granted patents as added incentives for involvement. Furthermore, the invention process is often maintained through overt intellectual property arrangements that facilitate filing and support for patenting procedures. Thus the process governing industrial scientists' participation may look quite different from that of the academy, making the comparison of influences like sex and motherhood effects across sectors revealing.

Gender and Patenting

Women patent less than men, in both sectors, even after controlling for a handful of education- and career-history variables (Ding et al., 2006; Whittington & Smith-Doerr, 2008). Additional work on inventor citation rates shows no sex difference in the number of citations men and women receive on their patents, thus these differences may be less about whether women are capable of producing a similar level of patentable research and more about their opportunities or incentives to become involved (Whittington

& Smith-Doerr, 2005). Sex differences may stem from women's locations in particular job positions and disparities in research resources and/or women's differential responses to patenting and access to knowledge about the patenting process. The former references job characteristics that are influenced by sorting and distributional mechanisms such as rank, monetary resources, and type of workplace environment (teaching or research institution, etc.). These factors are largely measurable and many have been extensively documented as relevant to sex disparities in both publishing (Xie & Shauman, 1998) and patenting (Whittington, 2009) in studies of science professionals, at least in the academy. The latter—women's responses and access to commercial activity—references the gendered structure of scientific work and the embodied nature of job characteristics more generally. For example, it has been shown that academic women receive less support and research attention from their universities, departments, and scientific disciplines than their comparable male colleagues even when holding credentials, productivity levels, and job locations constant (Long & Fox, 1995).

Similar gendered processes may extend into the commercial realm. Murray and Graham's (2007) interviews reveal that women experience less exposure to the commercial process and fewer opportunities to disclose than men. While many nonpatenting academic men indicated turning down available opportunities, nonpatenting women were more likely to indicate a *lack* of opportunities and/or feelings of exclusion from the commercial process. Implicit bias may be influencing firms or investors from approaching female scientists, and discrepancies in familiarity with the patenting process may hinder more women from involvement than men. In academia, this may translate into less support for learning or engaging in a "new" or unfamiliar research direction like patenting.

Motherhood as an Empirical Focus

We know little about whether and how these experiences are concentrated in, or reflect the realities of, particular subgroups of women like mothers. Increased participation rates for women in the workforce have eroded some of the more explicit gender biases that traditionally governed women's occupational choice and evaluation. Indeed, childless women are realizing new equities in their achievement of job positions, wages, and labor market outcomes. There is growing evidence that women suffer additional disadvantages in the workplace when they give evidence of being a mother, however (Benard & Correll, 2010). The system is far from perfect for any women, but mothers appear to face particular challenges and hurdles in the workforce.

Given the demands associated with patenting in the academy, and its "optional" nature for promotion, certain groups of scientists may be more influenced to participate than others. Female parents may experience particular constraints regarding patenting in the academy. In contrast, the more "routine" nature of patenting in industrial science may reveal different trends for this group.

Motherhood in the academy. Parenthood has received a great deal of attention as a source of pressure for women scientists although the focus has been on academic scientists. Female parents typically act as primary caretaker for children in the home, are more likely to be married to other full-time workers (especially other scientists), and frequently experience dual-career and geographic mobility constraints in their careers (Preston, 2004). In addition, the concurrent timing of tenure with fertility can be particularly challenging for young women faculty. Many women scientists reference the decision to work in industry as one based on dual career geographic constraints and/or (the perception of) a more feasible balance of work and family obligations (Preston, 2004; Whittington, 2007). Women faculty with children do not, on average, publish less than women academics without children, however (Long, 1990; Reskin, 1978). While some authors find that women scientists raising preschool age children face significant career hurdles and decreased productivity (Xie & Shauman, 2003), others show increased publishing output when sufficient time is allocated to research activities during the childbearing years (Fox, 2005). Thus resources and time allocations are tantamount—sex disparities between women with children and peer scientists are not present between those in comparable situations.

Although commercial work can provide career benefits, it is a time luxury given tenure and promotion demands. Because academic women report responsibility for the heavy percentage of childrearing activities, the added time demands of commercial work may make it difficult to pursue (and gain knowledge about) activities that are not required for tenure and promotion. Indeed, one reason that marriage and the family are not particularly strong explanatory variables regarding publishing is that mothers appear to make "disciplined choices" (Cole & Zuckerman, 1987) and invoke selective "allocations of time" to preference research activities over other tasks such as committee work, instruction, and mentoring (Fox, 2005). Thus, time-compromised mothers may preference publishing activities and be less commercially involved.

Furthermore, implicit notions of availability or competence may influence the "demand" side of the commercial process that leads to invitations to participate. The fact that implicit assumptions about women permeate evaluation and rewards in the sciences is not new to research on the science profession

(Long & Fox, 1995). Yet recent research highlights how motherhood, in particular, operates as a distinct status characteristic that activates implicit stereotypes about mothers' perceived commitment and competence on the job, in ways childless women are able to overcome (Correll et al., 2007). In separate experiments, workers described as mothers are rated as less competent and committed when compared to similar childless women and men (Cuddy et al., 2004) and offered lower organizational rewards even when they are portrayed an unambiguously high performing (Benard & Correll, 2010). Given this, motherhood may be particularly important to consider in light of commercial involvement in the academy, where patenting activities are largely viewed as "special," "out-of-the-ordinary," or accessible only to scientists whose research and applications hold particular qualities. If women are less likely to be approached by outside firms and investors to "buy" their science, assumed notions of competency, commitment, and availability may make mothers particularly challenged in this regard. Furthermore, mothers' status and/or assumed (lack of) availability may mean that fewer are approached by colleagues or mentors with information on the commercial process or with invitations to collaborate in such endeavors.

Whether through the "discipline choices" of time demands, implicit assumptions that lead to commercial contacts and rewards, or interactions between the two, I expect the following:

Hypothesis 1: Mothers will be less likely to patent in the academy than men and childless women.

Motherhood in industry. It is less clear how sex and motherhood may influence patenting activity in industry. The literature on science professionals has largely avoided a focus on industry science—viewing work in this sector as too varied or different from academic science—and little is known about sex disparities in this sector. The structure of work in industrial organizations provides a strong contrast to that of the prestige hierarchy in academic science. While mothers in industry also wrestle with the competing demands of motherhood and work responsibilities, certain arrangements like part-time or flexible work schedules are more available for industrial workers and present work-life balance options not offered in the traditional academic setting (Preston, 2004). Furthermore, the prevalence of formal or bureaucratic policies in industry (especially in large organizations) are thought to assist women more generally by making performance standards more transparent and providing clearly defined benchmarks for promotion and productivity (McIlwee & Robinson, 1992; Reskin & McBrier, 2000). However, scientists, of any sector, must keep their skills current, and therefore time demands on mothers in industry—part-time or otherwise—are still present. The efficacy of flexible work arrangements also depends on adequate workplace structure. If not supported and funded appropriately, these work arrangements can lead to group backlash on the employees who take advantage of them or the managers who offer them. And while the availability of part-time or flexible work schedules may ease work for some women, it can also present more avenues of stifled career trajectories for "mommy-tracked" employees, or perpetuate the *perception* that mothers enjoy reduced work expectations.

Previous literature does not address whether there are productivity disparities between industry mothers and others. On one hand, industrial structure offers a distinctively different approach to productivity because industrial scientists work collectively to foster collaborative ties to other groups in their organization or outside of it. Industry settings may allow intermittent workers to do so with less compromise to their collaborative network than in academic settings (i.e., because by default, the research connections of the firm are maintained while they are away). Intermittency may not compromise productivity to the same degree in industry as in the academy. But there are plenty of industry women (and men) for whom intermittent work options are not offered and/or desired.

Furthermore, the different norms and incentives to patent in industry settings may reduce industrial motherhood disparities. At least in positions that emphasize research and development, commercialization is more of an expected and institutionally supported outcome. While the productivity of industrial mothers may still be subject to conflicting time demands of work-life balance, as in academic science, industrial women may make similar "disciplined choices" to preference these research activities over other workplace options (Cole & Zuckerman, 1987).

On the other hand, as in the academy, industry professionals are also subject to gendered evaluation processes, and their productivity is also likely linked to issues of status and legitimacy that privilege men over women workers, or nonmothers over others. However, while women parents in industry are almost certainly still subject to implicit assumptions of motherhood, the fact that industrial scientists do not have to actively "sell" their science to outside investors and firms may reduce motherhood disparities in commercial outcomes in comparison with that of academic workers.

It is possible that motherhood disparities in patenting may reveal alternative outcomes than in academia. Industrial mothers may not experience the same degree of disparity as academic mothers when considering patenting activity.

Given the dearth of previous research in this area, however, I do not formally hypothesize about this group but look to the data to shed light on these trends.

How Prior Involvement in Commercial Activity Reduces Sex and Motherhood Disparities

In the academy, aggregate sex and/or motherhood disparities may decline when considering whether or not scientists have previously initiated the patenting process. Scientists gain knowledge and familiarity with the patenting process by participating in it. If conflict between incentives and time demands leads academic mothers engage less in an unknown and ambiguous productivity activity like patenting, having previous experience should provide women (and men) knowledge and tools to facilitate future involvement in "selling science." Therefore the greatest disparity between mothers and others may be at the initial point of commercial involvement.

The visibility of previous commercial activity may also operate as a signal, drawing in firms or investors. While implicit beliefs are hard to curtail, evidence of prior commercial involvement may also provide disconfirming evidence that minimizes assumptions about a particular women's competency and legitimacy, thus facilitating future involvement.[1] Given these combined mechanisms, I expect the following:

> *Hypothesis 2:* In academy, accounting for scientists' prior experience with patenting activity will reduce (or diminish) motherhood disparities in patenting.

It is less clear how the experience of prior patenting involvement influences sex and motherhood disparities in the industrial sector. On one hand, the more routine status of patenting in industry should result in less of a disparity between industrial mothers and others to begin with. On the other hand, the increased firm-level support for the patenting process should facilitate women's (and men's) filing, for first-time inventers as well as others. I do not formally hypothesize about the experience of past patenting in industry but look to the results of the analysis to reveal the strength of these mechanisms in this sector.

Sorting and Distributional Mechanisms

In the academy, female scientists occupy fewer senior positions, receive fewer accepted grants, have less monetary research resources, and spend more time on teaching as opposed to research-related activities (Fox, 1995; Long, 2001;

Xie & Shauman, 2003). These factors relate both exogenously and endogenously to sex disparities in productivity. A job focus on research or teaching may have a reciprocal, causal relationship to sex or motherhood processes, for example, in contrast to the analytically prior consideration of the distribution of men and women across scientific disciplines. Whether through direct and/or indirect mechanisms, a significant portion of the publication gap is related to sorting and distributional factors (Long, 2001; Xie & Shauman, 2003), and may be related to academic patenting as well.

Industry workers also present variation in their job positions, opportunities, and resources, although it is not known how the distribution of positions and resources varies by sex in industry, or about their potential influence on patenting productivity. Given their importance in the academy, these may be correlated with sex discrepancies in productivity in this sector as well. If more men are senior in industry, for example, it is possible that a higher percentage of men will patent than women in this sector. This analysis includes sector-specific variables in the statistical models to gauge the extent to which sex and motherhood differences in patenting productivity are present in academia and industry among those with similar credentials, job locations, and resources. I return to the complex relationship between sorting and distribution factors and productivity assessments after presenting the results.

Research Method

Data

Data on scientists' patenting behavior is available from the April 1995 and April 2001 waves of the Survey of Doctorate Recipients (SDR), conducted by the National Science Foundation (National Science Foundation, 1995, 2001). The SDR is a longitudinal survey that follows recipients of research doctorates from U.S. institutions until age 76. Although SDR data is collected every other year, 1995 and 2001 are the only waves in which the survey asked respondents about their patenting behavior in consecutive and nonoverlapping time intervals.[2] These dates capture a highly relevant time for academic patenting, which began to take off in the mid-80s and gathered significant steam through the 90s. The SDR data are acquired through a complex survey design that stratifies respondents by scientific discipline, employment sector, receipt of a doctoral degree, and numerous demographics. When proportionally weighted, the SDR data characterize the nationally representative population of individuals trained and/or working as scientists or engineers in the United States in April of those years.[3]

The sampling process yields waves with a mix of both previous and new respondents, as each new sample from the population inevitably selects some individuals in back-to-back years (and post-1993 cohorts are sampled with slightly more weight). In this sample, 47% of the respondents were surveyed in both 1995 and 2001. This ad hoc panel allows for a unique opportunity to address changes over time within person as well as between survey years.

Scientists in the sample are classified by "major employment sector"—that is, 2-year colleges, 4-year colleges, government, or business/industry. I focus specifically on scientists in 4-year colleges and business/industry. Institutions designated as 4-year colleges include baccalaureate and masters institutions, and Research I and II universities. The industrial sector includes scientists in private, for-profit companies, and those who are self-employed. In addition, scientists are placed in one of six disciplines according to the type of science they perform in their current job, and I focus on those in the "hard" sciences—computer and mathematical sciences, life sciences, physical sciences, and engineering—for whom commercial activity is especially relevant.[4]

Respondents are asked to indicate the primary and secondary work activities on which they "spent the most hours during a typical work week."[5] I restrict the sample to those who list applied and basic research, development or design as their primary and/or secondary work activity. Doing so avoids confounding sex disparities with differential sorting into positions that carry sole teaching responsibilities or management levels with no research opportunities.

Last, I include only scientists who are working full time. Part-time scientists may not have the same opportunity to publish and patent as their full-time counterparts. These restrictions likely produce a lower bound on the level of sex differences between scientists, as more women than men are located in jobs that are part-time or contain job activities that focus less on research and development and more on teaching or other services.

Patenting Activity

Table 1 provides a list of all means and standard deviations, by sex and parental status (defined below), used in the analysis. The dependent variable is involvement in patenting activity. In both waves, respondents were asked whether or not they had been named as an inventor on a U.S. patent application in the past 5 or 6 years, respectively (e.g., for the 1995 survey, the question references patenting between April 1990—April 1995; for the 2001 survey, the period is April 1995-April 2001). Involvement is an indicator

Table 1. Weighted Means and Standard Errors for Demographic and Organizational Characteristics Used in the Analysis of Scientists' Propensity to Patent, 1990-1995; 1995-2001

	Female		Male	
Variables	Nonparent[b]	Parent	Nonparent	Parent
Dependent variable				
Patented (1990-1995) or (1995-2001)[a]	0.15	0.20	0.23	0.29
Control variables				
Research productivity and grant support				
Count of publications (academy only)	7.10 (.26)	8.61 (.33)	10.55 (.23)	11.44 (.20)
Did publish (industry only)[a]	0.67	0.66	0.60	0.59
Government grant support[a]	0.51	0.50	0.46	0.43
Primary job focus				
Research, primary focus (industry only)[a]	0.82	0.82	0.80	.0.80
Teaching, primary focus (academy only)[a]	0.28	0.24	0.35	0.34
Job rank				
Academic rank (academy only)				
Full professor	0.17	0.14	0.41	0.33
Associate professor	0.15	0.23	0.15	0.26
Assistant professor	0.28	0.28	0.16	0.21
"Other" ranking	0.41	0.35	0.28	0.20
Supervisor (industry only)[a]	0.52	0.54	0.50	0.57
Management, primary focus (industry only)	0.05	0.07	0.07	0.07
Salary (in US$10,000s)	5.85 (.07)	6.25 (.09)	7.40 (.05)	7.64 (.04)
Year of PhD	1988 (.21)	988 (.19)	1981 (.16)	1984 (.10)
Demographics				
Discipline				
Computer and mathematical sciences	0.14	0.12	0.15	0.15
Physical sciences	0.19	0.18	0.27	0.24
Life sciences	0.57	0.59	0.30	0.32
Engineering	0.10	0.11	0.28	0.29

(continued)

Table 1. (continued)

	Female		Male	
Variables	Nonparent[b]	Parent	Nonparent	Parent
Survey year = 2001[a]	0.55	0.59	0.52	0.52
PhD prestige	3.13 (.02)	3.22 (.02)	3.22 (.01)	3.15 (.01)
U.S. citizen[a]	0.85	0.79	0.86	0.82
Married[a]	0.51	0.93	0.66	0.97
Sample *N*	2,745	2,132	8,226	10,736
Weighted sample *N*	38,233	29,724	150,110	193,040

Source: NSF SESTAT Data, 1995 and 2001 Survey of Doctorate Recipients (SDR) (sestat.nsf.gov). Reference period of patenting question runs from April 1990 to April 1995 or April 1995 to April 2001.
Note: Valid *N* = 23,839. Means for continuous variables include standard deviations (in parentheses).
a. Omitted categories for the tables are did not patent, research not primary, teaching not primary, did not publish, did not receive government grant support, not a supervisor, not in management, survey year = 1995, not a U.S. citizen, and not married, respectively.
b. The term "parent" in this table specifically refers to individuals who have "children under the age of 18 living in the home," per the NSF SDR parlance.

variable where a value of 1 means that a scientist has patented at least once in the 5- or 6-year period.[6]

Sex and Parenthood Status

The primary analytical variables in the models are respondents' self-reported sex and parental status as well as the interaction between them. The operationalization of parenthood status is particularly important in defining the focus of the analysis. Parenthood effects can be conceptualized in a variety of ways, by using an indicator variable for whether the scientist has children, a continuous variable for the number of children, or categorically using particular age sets (infant, preschool, school age, out of the home, etc.). Models that include a continuous measure provide focus on the effect of each additional child on the odds of patenting. Categorical representations model variation across particular age groups (e.g., between those with young vs. older children).

Models that incorporate an indicator variable for parenthood set the lowest possible threshold for parental influences by combining the parental duties of those with multiple children or across ages and investigating aggregate differences between all parents and others. I operationalize parenthood using this approach (1 = *parent*), determined by a question on the survey that asks whether or not respondents currently have children under the age of 18 living in the home. While the parents of some age groups may be particularly sensitive to time demands (infants, for example), parental responsibilities for children of all ages can result in work/family conflict for professional scientists. In addition, as a status characteristic, motherhood influences should be present for women with one child as for those with more than one, and for any age, including for those with children older than preschool (Correll et al., 2007).[7] In this sample, 54% of the respondents have a child at home (56% men and 44% women) with little significant difference across sectors.

Sorting and Distributional Variables

To ensure comparisons between scientists with similar resources and standing, the models include sorting and distributional variables known to be related to patenting behavior (such as job position, resources, research involvement, and demographic characteristics), adjusted for relevance by sector.

Research productivity. In the academic models, I include a self-reported count of published research articles (in peer-reviewed journals) in the preceding 5- or 6-year period from the 1995 and 2001 survey date, respectively (logged to address skewness). Academic publishing has been shown to be positively related to patenting, and well-published scientists appear to have more opportunities to commercialize (Stephan, Gurmu, Sumell, & Black, 2007). The average academic scientist in this sample reports publishing 10.4 articles in the 5- or 6-year period.

In industry, authoring just one article in a 5-year period may indicate that the scientist is in a job position that is conducive to dissemination outcomes more generally, and thus she may be more likely to patent as well. For this reason, the industrial models contain an indicator variable (rather than a count, where value 1 indicates at least one publication in the preceding time period). Approximately 60% of the industry sample published at least once in the sample reference period.

Grant support. Research grants provide monetary and collaborative resources that can translate into dissemination outcomes. I include an indicator variable for presence of government-funded grants or support (value 1 = *presence of funding*), for both academic and industrial scientists.[8] Approximately 46% of the sample (65% and 25% of the academic and industrial scientific population, respectively) received government support during the survey period for their research program.

Primary job focus. Although the sample is restricted to those who report research or development as one of their first or second primary work activities, there is variation in the extent to which scientists choose research and development as their first primary work activity. Academic scientists who indicate that their first primary work activity is teaching, and industry scientists who indicate research and development (as opposed to management and administration, computer applications, or other tasks), are given an indicator variable value of 1 to account for the implications of the emphasis on their productivity.

Job rank. High ranking senior scientists may have more developed contacts and commercial networks and therefore may be more likely to patent. The academic models include indicator variables for scientists in full, associate, and assistant professor ranks. Academic scientists who do not fit into the tenure-track categories (i.e., research scientists, adjunct professors, postdoctoral workers, etc.) are designated to an "other" category.

In industry, senior scientists may be more involved in shaping the dissemination process than those who are early in their careers, and thus more likely to be listed as inventors on firm projects. Unlike academia, however, industry does not have the uniform status distinctions of rank across disciplines and industrial settings. Though not perfect, the SDR contains several measures that help delineate between various levels of experience in industrial science, and I include the following: whether or not the respondent is currently in a supervisory position (1/0), management as a primary work activity (1/0), salary (self-reported, in thousands), and the number of years since PhD grant date (to control for years of experience).

The academic models also include reported salary and years since PhD. Salary information helps adjudicate between the resources or status of scientists within (and across) ranks and may also be an indicator of the wealth of the academic institution. Years since PhD controls for any cohort effects in commercialization trends and for the amount of time scientists have had to patent since they completed graduate work. The average scientist in the sample received his or her PhD in 1984, with more women receiving their degree later, on average, then men (1988 for women vs. 1983 for men).

Demographics. The models include measures for scientific discipline (life sciences, physical sciences, computer and mathematical sciences, or engineering) to control for (a) disproportional rates of patenting across fields and (b) variation in the proportion of women across disciplines. Applied fields where research results translate into new medicines or tools more readily (e.g., the biomedical sciences or engineering) have higher rates of patenting. In 2006, women earned almost one half of the doctorates in the biological and agricultural sciences; around one third of the doctorates in chemistry and in mathematical sciences; and only about one fifth in computer science, engineering and physics (Hill, Corbett, & St. Rose, 2010, Figure 9). I also control for the year of the survey to account for changes in rates of commercialization in each sector and field over time and women's increasing presence in the labor market.

The models also account for the prestige of scientists' graduate training using the National Research Council's (NRC) 1995 ranking of graduate programs (National Research Council, 1995). The NRC ranks university programs on quality and effectiveness using a 5-point scale derived from institutional data and solicited opinions by the academic community . I construct a generalized score for each institution by taking the average of the institutional rating scores across all scientific disciplines. The measure varies from 0 (*Not sufficient for doctoral education*) to 5 (*Distinguished institution for doctorate education*), and is included in the models as a continuous variable.[9] The average NRC score for respondents in this sample is 3.18, and those who are involved in patenting behavior have a slightly higher score than those who do not patent ($p < .05$). Women in this sample do not differ statistically from men in their average PhD ranking, both across and within sectors ($p > .1$).

I include an indicator for U.S. citizens because they may be more inclined to file patents with the U.S. government than noncitizens (Stephan et al., 2007). Women in this sample are also slightly more likely to be citizens than men ($p > .05$). Last, I include an indicator for respondents' current marital status (1 = *married*) to isolate parenthood from marriage influences. The research on marriage and publishing productivity (in the academy) consistently finds that married scientists (both male and female) publish more than their single counterparts (Cole & Zuckerman, 1987; Xie & Shauman, 2003), and the aggregate data for this survey confirms this trend (Table 1, $p < .01$). The models also include interactions between sex and marital status to control for the potential of sex-specific interactions with marriage. Eighty-one percent of the respondents are married (83% men and 69% women, similar across sectors).

Method

I conduct two separate analyses to address the research questions of this study. In the first, I combine the two survey waves and use logistic regression to predict the likelihood of scientists' commercial involvement. I run separate regressions for industry and academic scientists to include structural and organizational variables that are within-group applicable.[10] The models control for survey year and incorporate robust standard errors to account for repeated measures across respondents.

In the second analysis, I address how prior patenting behavior predicts current involvement using the set of 1995 respondents who were resampled again in 2001. I use logistic regression to predict the likelihood of 2001 commercial involvement, and control for prior involvement reported in 1995 while also including the full set of 2001 variables from the first analysis.

Before conducting the second analysis, I present data and information on the patterns of attrition in the sample across waves.

After all variables and sample definitions are taken into account, the final sample contains 23,839 scientists (when weighted, 194,151 in 1995 and 216,956 in 2001). Female scientists make up 16.5% of the sample (19% in academia, 14% in industry). The percentage of missing data is low (N = 306 respondents, 1.2%).

Gender and the Patenting Population

Approximately 22% and 27% of the sample patented between 1990 and 1995, and between 1995 and 2001, respectively (Table 2). The proportion is skewed by the higher rates of industrial patenting; about 11% of university scientists patented in the period leading up to 1995, compared with 35% of industrial scientists. In the next 6 years, however, university growth eclipsed that of industry. By 2001, university involvement grew to 16% (a 45% increase) and industry to 40% (a 14% increase).

Figure 1 shows changes over time in the percent of men and women who patent, by sector. Approximately 14% of women and 24% of men had patented in the 1995 survey. By 2001, however, 20% of women scientists (a 43% increase) had patented compared to 29% men (a 21% increase). These percentages vary by employment sector. Whereas only 7% of women patented in the 1995 period within the university setting, the percentage of women who patented in industry in the same time period was 25%. Men and women across sectors have changed their participation over time, but the greatest change occurred for women scientists in the university, who increased their percent involvement by 86%. Men in academia and women and men in industry settings have also increased their involvement over time, just not as drastically (33%, 20% and 15%, respectively). Across all disciplines and sectors, however, women are involved in patenting activity at a lower rate than men.

Predicting Involvement in Commercial Behavior

Tables 3 and 4 present the results of logistic regression models for university and industrial workers, respectively. Unless noted below, all nested models improve in fit upon the previous models, and the tables show that most coefficients remain similar in sign and significance across models. The model order allows for comparisons to be drawn across models that include only the direct effect of sex (Models 1 and 2), versus those that include sex-specific interactions between parenthood and marriage (Models 3-5).

Table 2. Weighted Percentage of Male and Female Scientists Who Are Inventors by Year, Discipline, and Location

	Male inventors	Female inventors	Total
1995 Wave			
Employment sector			
University	.12	.07	.11
Business/industry	.36	.25	.35
Discipline			
Computer and mathematical sciences	.11	.04	.10
Life sciences	.18	.13	.17
Physical sciences	.30	.20	.29
Engineering	.30	.18	.29
Total	.24	.14	.22
2001 Wave			
Employment sector			
University	.16	.13	.16
Business/industry	.41	.30	.40
Discipline			
Computer and mathematical sciences	.17	.13	.16
Life sciences	.24	.17	.22
Physical sciences	.32	.23	.31
Engineering	.39	.35	.38
Total	.29	.20	.27
Total sample *N*, 1995	10,690	2,452	13,142
Weighted sample *N*, 1995	164,862	29,289	194,151
Total sample *N*, 2001	8,272	2,425	10,697
Weighted sample *N*, 2001	178,289	38,668	216,956

Source: NSF SESTAT Data, 1995 and 2001 Survey of Doctorate Recipients (SDR) (sestat.nsf.gov). Reference period of patenting question runs from April 1990 to April 1995 (1995 survey) and April 1995 to April 2001 (2001 survey).
Note: Valid *N* = 23,839

In both sectors, the odds of patenting grow across the survey waves and with increased doctorate prestige and publishing activity. As expected, scientists across disciplines display variation in their propensity to patent. In addition, scientists are more active in commercialization when in positions that

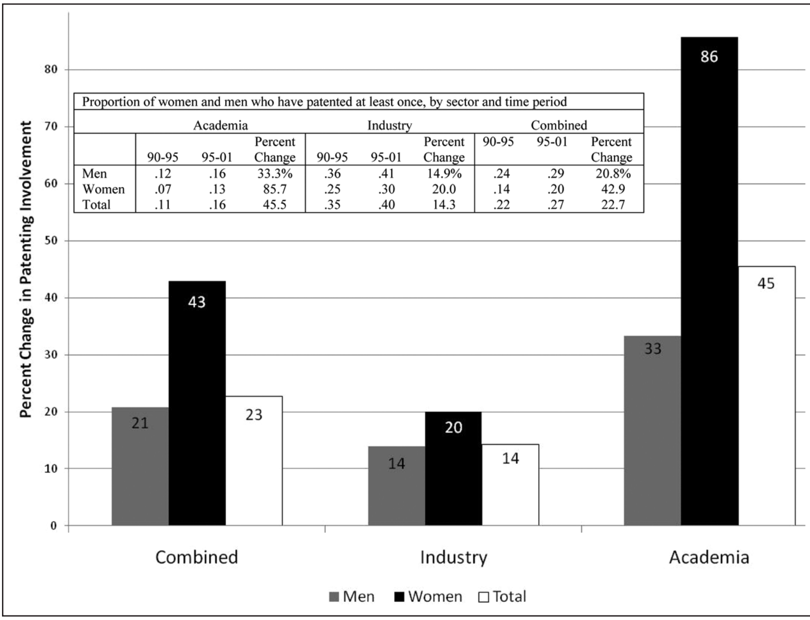

Figure 1. Percent change across survey waves in male and female scientists' involvement in patenting activity
Source: NSF SESTAT Data, 1995 and 2001 Survey of Doctorate Recipients (SDR; sestat .nsf.gov).

focus primarily on research activities (i.e., not on teaching, in academia, and on research, in industry).

Model 1 in Table 3 (academic sample) suggests that academic women patent at a lower rate than academic men. Model 2 suggests that observed sorting and distributional variables are responsible for a portion of the aggregate sex disparity in the academy. Though the gender coefficient remains negative and significant, factors related to research involvement, grant support, and job focus and job rank and experience significantly increase the model fit ($p < .01$) and reduce the magnitude of the coefficient for sex disparity. The sex coefficient in Model 2 corresponds to a 18% ($\exp^{(-.20)}$) reduction in the odds of academic women patenting as compared with men, other things equal.

Marital status does not have a significant effect on the predicted odds of patenting, and there are no differences in the odds of patenting between married men and women (Models 3 and 5). Parenthood, however, relates

Table 3. Maximum Likelihood Estimates and Robust Standard Errors From Logit Models Predicting the Probability of Patenting by University Scientists, 1990-1995; 1995-2001

Variables	Model 1	Model 2	Model 3	Model 4	Model 5
Sex					
Female[a]	−.45*** (.08)	−.20** (.08)	−.29* (.15)	−.17** (.08)	−.13 (.16)
Demographics					
Survey year = 2001[a]	.40*** (.05)	.23*** (.07)	.41*** (.05)	.26*** (.07)	.27*** (.07)
Computer and mathematical sciences[a]	−1.77*** (.14)	−1.56*** (.15)	−1.76*** (.14)	−1.56*** (.15)	−1.57*** (.15)
Physical sciences	−.80*** (.09)	−.90*** (.10)	−.78*** (.09)	−.90*** (.10)	−.90*** (.10)
Life sciences	−.48*** (.07)	−.70*** (.08)	−.48*** (.07)	−.71*** (.08)	−.72*** (.08)
U.S. citizen[a]	.23** (.09)	.16*** (.10)	.24** (.09)	.17* (.10)	.16 (.10)
PhD prestige	.25*** (.04)	.10*** (.04)	.26*** (.04)	.11*** (.04)	.11*** (.04)
Research involvement, grant support, and job focus					
Publication count (logged)		.46*** (.04)		.45*** (.04)	.45*** (.04)
Government grant funding[a]		.12* (.07)		.11 (.07)	.11 (.07)
Primary emphasis = teaching[a]		−.53*** (.09)		−.53*** (.09)	−.53*** (.09)
Job rank and experience					
Associate professor[a]		.10 (.09)		.08 (.09)	.08 (.09)
Assistant professor		.15 (.11)		.17 (.11)	.18 (.11)
"Other" ranking		.30*** (.12)		.34*** (.12)	.35*** (.12)
Salary (in thousands)		.10*** (.02)		.09*** (.02)	.09*** (.02)
Year of PhD		.0003 (.01)		−.003 (.01)	−.01 (.01)

(continued)

Table 3. (continued)

Variables	Model 1	Model 2	Model 3	Model 4	Model 5
Marital status and parenthood					
Married[a]			.16 (.10)	.06 (.09)	.001 (.10)
Female × Married			.11 (.20)		.26 (.20)
Children "in the Home"[a]			.33*** (.07)	.24*** (.07)	.33*** (.08)
Female × Children			−.38** (.17)		−.48*** (.17)
Constant	−2.52***	−2.85	−2.89***	2.58	5.36
Sample N	12,904	12,904	12,904	12,904	12,904
Wald χ^2	296.15	776.71	327.80	788.81	795.64
Degrees of Freedom	7	15	11	16	19

Source: NSF SESTAT Data, 1995 and 2001 Survey of Doctorate Recipients (SDR) (sestat.nsf.gov).
Note: Robust standard errors are in parentheses.
a. Omitted categories are male, survey year = 1995, engineering, not a U.S. citizen, no government grant support, primary emphasis is not teaching, full professor, not married, and does not have children under age 18 "in the home", respectively.
*$p < .1$. **$p < .05$. ***$p < .01$.

Table 4. Maximum Likelihood Estimates and Robust Standard Errors From Logit Models Predicting the Probability of Patenting by Industry Scientists, 1990-1995; 1995-2001

Variables	Model 1	Model 2	Model 3	Model 4	Model 5
Sex					
Female[a]	−.37*** (.06)	−.43*** (.06)	−.35*** (.12)	.30*** (.06)	−.38*** (.12)
Demographics					
Survey year = 2001[a]	.29*** (.04)	.17*** (.06)	.29*** (.04)	.18*** (.06)	.18*** (.06)
Computer and mathematical sciences[a]	−.82*** (.07)	−.68*** (.07)	−.82*** (.07)	−.68*** (.07)	−.68*** (.07)
Physical sciences	.28*** (.06)	.14** (.06)	.28*** (.06)	.14** (.06)	.14** (.06)
Life sciences	−.23*** (.06)	−.50*** (.06)	−.23*** (.06)	−.51*** (.06)	−.51*** (.06)
U.S. citizen[a]	.14** (.06)	.19*** (.06)	.16*** (.06)	.20*** (.06)	.20*** (.06)
PhD prestige	.15*** (.03)	.14*** (.03)	.16*** (.03)	.14*** (.03)	.14*** (.03)
Research involvement, grant support, and job focus					
Publishing activity[a]		.38*** (.05)		.39*** (.05)	.39***(.05)
Government funding[a]		−.88*** (.06)		−.87*** (.06)	−.87*** (.06)
Primary emphasis = research[a]		.73*** (.08)		.72*** (.08)	.72*** (.08)
Job rank and experience					
Salary (in thousands)		.07*** (.01)		.06*** (.01)	.06*** (.01)
Year of PhD		−.001 (.003)		−.002 (.003)	−.002 (.003)
Supervisory status[a]		.43*** (.05)		.42*** (.05)	.42*** (.05)
Primary emphasis = management[a]		.45*** (.11)		.45*** (.11)	.45*** (.11)

(continued)

Table 4. (continued)

Variables	Model 1	Model 2	Model 3	Model 4	Model 5
Marital Status and Parenthood					
Married[a]			.10 (.07)	.02 (.07)	.01 (.07)
Female × Married			−.04 (.15)		.03 (.16)
Children "in the home"[a]			.21*** (.05)	.20*** (.05)	.18*** (.06)
Female × Children			.12 (.13)		.13 (.14)
Constant	−1.11***	−1.66***	−1.37***	1.11	.88
Sample *N*	10,935	10,935	10,935	10,935	10,935
Wald χ^2	370.61	852.76	403.37	870.28	872.37
Degrees of Freedom	7	14	11	16	18

Source: NSF SESTAT Data, 1995 and 2001 Survey of Doctorate Recipients (SDR) (sestat.nsf.gov).
Note: Robust standard errors in parentheses.
a. Omitted categories are male, survey year = 1995, engineering, not a U.S. citizen, did not publish, no government support for research, primary emphasis is not research or management, is not a supervisor, not married, and does not have children under age 18 "in the home," respectively.
*$p < .1$. **$p < .05$. ***$p < .01$.

significantly to the propensity to patent. The inclusion of marital and parental status variables in the base model (Model 3) almost reduces the direct effect of sex to insignificance ($p < .1$). Close examination of the interaction effects suggest that while academic male parents experience a significant boost in their propensity to patent, female parents experience an additional decrease in their likelihood of patenting as compared with single, nonparent men. In the final Model 5, which includes the full set of sorting and distributional variables, accounting for marriage and parenthood variables removes the significance of the direct sex effect on patenting.[11] These results suggest support for Hypothesis 1, and imply that the most significant sex disparity in academic patenting relates to academic mothers.

In contrast to the academic models, Table 4 (industry sample) reveals that accounting for various sorting and distributional mechanisms (Model 2) does not substantively influence aggregate sex disparities in industry. Although the inclusion of the variables in Model 2 statistically improve the fit of the model, there is little change to the magnitude of the sex coefficient, which corresponds to 34% reduction in the odds of industrial women patenting as compared with men, ($\exp^{(-.43)}$). In addition, Models 3 and 5 demonstrate that the interaction between sex and parenthood is not significant (as are marriage influences and interactions). There is no statistical difference in the likelihood of male and female parents patenting.[12] In addition, there is little change in the direct effect of sex with the addition of these variables (Model 3) and with the full set of controls (Model 5). In industry, there is a lingering sex disparity in the likelihood of patenting after all variables are included in the models. In addition, while both women and men parents experience an increase in their propensity to patent, like childless women, the net likelihood of patenting by industry mothers is still less than that of men.

Predicted Probabilities of Patenting

Table 5 presents the predicted probabilities of patenting for men and women parents and nonparents, using the coefficient values from the final model of Table 3 (academic scientists) and Table 4 (industrial scientists).[13] In academia, parenthood delineations present the greatest difference between men and women scientists. Whereas the predicted probability of patenting by male and female academic scientists without children is .09 versus .08, respectively (a percent sex difference [F/M] of 89%, $p > .1$), the difference in predicted probability for men and women with children is much larger—from .12 to .07, respectively (a percent sex difference [F/M] of 57%, $p < .01$).

Table 5. Predicted Probabilities of Patenting by Sex, Parenthood Status, and Sector

	Female	Male	% Difference, row (F/M)
Industry			
Children	.31	.39	80.1%
No children	.25	.34	71.8%
% Difference, Column (no children/children)	80.7%	87.2%	
Academy			
Children	.07	.12	57.8%
No children	.08	.09	89.2%
% Difference, column (no children/children)	114.3%	75.0%	

Source: NSF SESTAT Data, 1995 and 2001 Survey of Doctorate Recipients (SDR) (sestat.nsf.gov).
Note: All predicted probabilities are calculated using Model 5 coefficient values from Table 3 (Academy) or Table 4 (Industry). The computed probabilities vary the model indicator values for female, parent, and Female × Parent while holding all other variable values at their mean. Percent difference is the ratio of the predicted probabilites of patenting, multiplied by 100.

Men with children have the highest probability of patenting in the academy, while women with children have the lowest.

While my theoretical motivation focuses on sex disparities between mothers and others, these findings demonstrate consistency with other research on sex disparities in the workplace that finds evidence of a “fatherhood premium” (Correll et al., 2007; Hersch & Stratton, 2000; Townsend, 2002). When gendered conceptions of the “ideal worker” mingle with that of the “ideal parent,” men and women parents can experience very different outcomes for evaluation and treatment. Whereas cultural conceptions of a “good mother” tend to exist in tension with that of the “ideal worker” (i.e., mothers are perceived as less committed or less available workers), traditional assumptions about what it means to be a “good father” are not seen as incompatible with that of an ideal worker. “Fatherhood premiums” often reflect the notion that male parents represent a “package deal” that simultaneously define both the ideal man and worker (Townsend, 2002). In the context of patenting, a fatherhood premium may arise through the contacts and invitations men receive from colleagues who believe them most capable and able to join in the commercial process. In addition, fathers may simply have more available time than mothers (Preston, 2004). Whether conceptualized as a fatherhood premium or a motherhood penalty, indeed, the results suggest that the largest difference in predicted probability between men and women across sectors occurs between men and women academics with children.

In comparison, the percent gender difference in the predicted probabilities of patenting between women and men with children in industry is much higher, at 80.1% (and, as the model statistics reveal, are not statistically significant).

Prior Involvement and the Panel Sample

Does evidence of past involvement in commercial activity reduce sex disparities between men and women, and/or mothers and others? The full sample includes 5,265 individuals who were randomly resampled twice by NSF in both survey waves and whose responses fit the criteria for inclusion in the two time periods. This subset, referred to here as "the panel" (as compared to "the full sample"), can be used to assess if prior involvement diminishes motherhood and sex disparities among scientists with similar job positions and resources.

It is of particular relevance to this study that an additional 1,856 scientists from the 1995 survey were also resurveyed but are not included in the second analysis because of changes in their employment circumstances in at least one of the following four criteria: work status (moving from full to part-time work, or to not working at all), employment sector (moving from academia or industry into other settings such as government or 2-year colleges), discipline (moving into the social sciences or nonscience and engineering fields), or work priorities (no longer listing R&D as a primary work activity).[14]

It is possible and likely that sex and other important characteristics are related to attrition from one wave to the next. Indeed, in this sample, women scientists are more likely to indicate moving on to either nonpaid work or work in other areas outside the sample domain, as indicated by the slightly lower percentage of women in the panel versus the full sample in 2001 (14% vs. 18%). In additional models, I used the full set of resampled respondents and conducted weighted logistic regression models to predict the probability of sample attrition using the same set of predictor variables incorporated in the final models (Model 5) of Tables 3 and 4. The results of the analysis indicate that *academic* parents—both mothers and fathers—are no more likely to change employment circumstances than others (and in addition, childless women are no more likely to leave the sample than childless men). In addition, *new* parents (those that report a change in parenthood status across sample waves) are no more likely to be in the attrition set than "incumbent" parents or childless scientists. In the *industry* models, however, mothers are more likely to leave the sample than fathers and childless men and women. Thus, any underlying sex disparity in the following industry models must be interpreted in light of the influences that already exist on industrial mothers to change employment circumstances in this sector. It is important to view the mothers in the 2001 panel as a particular group of women who have survived a winnowing process over time. I discuss this factor in tandem with the results of the final analysis in more detail below.

It is also important to consider the movement of scientists from academia to industry, and vice versa, across waves. Perhaps the higher percentage of academic female inventors in the second time period (Figure 1) is related to a growing proportion of women changing employment sectors, or otherwise transitioning from one locale to another? The data do not suggest that this is the case. Scientists' patenting statuses remain fairly static across time although in general those moving from academic to industry settings are more likely to be "new inventors." Men who switch employment sectors are more likely to be new inventors than those who have not switched (24% who switch are new inventors vs. 12% who have not switched, $p < .01$). In contrast, women who have switched are only marginally more likely to be new inventors than female scientists who have not switched (18% vs. 15%, respectively, $p < .01$). For female scientists, then, it would be difficult to attribute a switch toward or away from patenting to a change in employment sector, and the initiation of new female patenting is not simply a story of movement in and out of employment sectors.

The Influence of Previous Involvement

Table 6 presents the final Model 5 of Tables 3 and 4 again, this time using data from the panel respondents to predict 1995-2001 patenting involvement. I add three additional terms to the analysis: an indicator for past commercial involvement (as reported in the 1995 survey), whether the respondent reported a change of employment sector (industry to academia or vice versa) between 1995 and 2001, and whether the respondent reported a change in parenthood status across the two waves (1 = *new parent*).

The academic Model 1 predicts 1995-2001 patenting activity without the inclusion of variables that take into account 1990-1995 activity. As with the combined sample, this model suggests that academic mothers are less likely to patent compared to other scientists. Model 2 adds prior patenting involvement as well as controls for those moving from industry to academia and recent changes in parenthood. In support of Hypothesis 2, the inclusion of these variables reduces sex and motherhood disparities in patenting to insignificance.[15]

Table 6. Maximum Likelihood Estimates From Weighted Logistic Models Predicting the Probability of Involvement in Patenting Activity From 1995-2001[a]

	Academia		Industry	
Variables	Model 1	Model 2	Model 3	Model 4
Female	−0.04 (.91)	−0.04 (.39)	−0.28** (.12)	−0.05 (.12)
Discipline				
Computer and math. Sciences	−1.68*** (.34)	−1.47*** (.37)	−0.57*** (.17)	−0.16 (.18)
Physical sciences	−0.84*** (.18)	−0.78*** (.20)	0.29** (.12)	0.11 (.11)
Life sciences	−0.25* (.15)	−0.18 (.16)	−0.57*** (.17)	−0.49*** (.15)
U.S. citizen	0.38 (.25)	0.42 (.28)	0.10 (.18)	0.04 (.21)
PhD prestige	0.01 (.07)	0.01 (.08)	0.14** (.06)	0.09 (.06)
Publishing activity			0.44*** (.10)	0.42*** (.11)
Publication count (logged)	0.51*** (.08)	0.46*** (.08)		
Government funding	0.10 (.15)	0.10 (.16)	−1.00*** (.12)	−0.75*** (.13)
Primary emphasis = research			1.05*** (.19)	0.82*** (.21)
Primary emphasis = teaching	−0.13 (.15)	0.07 (.17)		
Salary (in thousands)	0.11*** (.03)	0.08*** (.03)	0.07*** (.02)	0.05** (.02)
Year of PhD	0.01 (.01)	0.02** (.01)	0.02*** (.01)	0.05*** (.01)
Academic rank				
Associate professor	0.12 (.17)	0.20 (.19)		
Assistant professor	0.19 (.22)	0.13 (.25)		
"Other" ranking	0.44** (.20)	0.42* (.22)		

(continued)

Table 6. (continued)

	Academia		Industry	
Variables	Model 1	Model 2	Model 3	Model 4
Supervisory status			0.32*** (.10)	0.28** (.12)
Primary emphasis = management			0.97*** (.23)	0.71*** (.26)
Marital status				
Married	0.25 (.23)	0.39 (.25)	0.10 (.10)	0.19 (.20)
Female × Married	0.63 (.43)	0.53 (.49)	−0.68* (.35)	−0.92** (.41)
Parental status				
Children "in the home"	0.32** (.15)	0.08 (.16)	0.07 (.12)	−0.02 (.14)
Female × Children	−0.80** (.32)	−0.49 (.35)	0.56* (.31)	0.68* (.37)
1995 variables				
Patented, 1990-1995		2.64*** (.16)		2.50*** (.13)
Change in employment sector		0.67*** (.22)		−0.11 (.16)
Change in parenthood status		0.18 (.20)		0.14 (.16)
Constant	−28.22	−49.18**	−45.19***	−97.90***
Sample *N*	2,760	2,760	2,413	2,412
Model *F*	10.64	18.35	12.92	25.35
Degrees of freedom	18	21	17	20

Source: NSF SESTAT Data, 1995 and 2001 Survey of Doctorate Recipients (SDR) (sestat.nsf.gov).
a.Omitted categories for the academic and industrial models follow those of Table 3 and 4, respectively.
*$p < .1$. **$p < .05$. ***$p < .01$.

In industry, Model 3 (Table 6) echoes the final model of Table 4 (Model 5) in revealing sex disparities among men and women although the panel results differ from that of the full sample. Among scientists in the panel in 2001, sex disparities in patenting involvement are present among childless scientists, and from marriage and family influences. In particular, married, childless women are even less likely to patent than childless women, while mothers display (marginally significant) increases in their likelihood of patenting. Given that industrial mothers are more likely to leave the panel sample across waves, these results suggest that mothers who have not left show improved rates of patenting. Although mothers show increases in their likelihood of patenting compared with childless men, the fact that the majority are married (87%) suggests that most experience a net negative likelihood of patenting as compared with men. The conclusion from Model 3 is that most women in industry show a decreased likelihood of patenting compared to men.

The addition of prior patenting performance in Model 4 renders the direct effect of sex insignificant although gendered marriage and (marginal) parenthood influences remain. Thus controlling for prior activity locates remaining residuals with those most vulnerable to attrition—married women and mothers. The industry results provide partial support for the idea that accounting for previous experience may reduce sex disparities for women in industry, specifically regarding childless women. When coupled with attrition influences, however, the industry set reveals specific implications about the influence of family status on women's patenting involvement in industry science. In both sectors, motherhood appears as an important delineator between those who participate in patenting and those who do not although the underlying mechanisms in the two sectors vary. I discuss the results for each sector in turn.

Discussion

Sex and Motherhood Influences on Academic Patenting

The conclusion of this study differs from those found for publishing in the academy, which find little statistically significant difference between mothers and others after controlling for positions and resources (Cole & Zuckerman, 1987; Fox, 2005; Kyvik, 1990). Among similarly situated scientists, academic mothers are less likely to patent. There are several reasons why family factors may play a more influential role for academic women's patenting than publishing. First, at this time, patenting is not a necessity for promotion like publishing, and therefore carries with it different incentives.

Although commercial behavior can provide positive outcomes for those who can balance their basic science with more applied applications, scientists must first have a research focus that lends itself to commercial applications and a desire to engage in the commercial process. In addition, commercial work requires time and additional work on the part of the academic, where networks of outside contacts and applied collaborators (which may not overlap with academic collaborators) are a necessity. Sex differences rooted specifically in the subpopulation of women with children may suggest that fewer mothers are interested in becoming inventors, or that fewer have the time or necessary support to become involved. The complex balancing act of parenthood and career responsibilities may turn not only on the choices parents make of where to focus their energies, but also on logistical issues like the amount of time or resources they have. The fact that patenting increases the time demand on productivity outcomes, while not being formally regarded, leads to yet another gendered element of the academic work structure. It builds on gender differences and reproduces them.

Differences between mothers and others may also be related to additional factors beyond resource allocation or time demands. If, as other studies suggest, parenthood is a particularly strong status delineator for women employees, the implicit evaluations of others may influence mothers' opportunities to participate. If patenting knowledge is partially dependent on interests from outside investors or firms, female parents may be less likely to be involved. Because women report less interaction with, and invitation to, the commercial process, the tangible challenges parenthood presents may interact with commercial demand-side processes to reinforce differential output. Though a nonrequired activity now, the growing importance of commercial activity in the academic realm leaves mothers' differential involvement an increasing concern.

Once accounting for differences in previous involvement, however, women scientists (mothers or not) are just as likely to patent as male scientists in the academy. One important difference between mothers and others, then, is that they do not appear to have as much previous involvement. Once the hurdle of knowledge acquisition is met, time demands may be lessened and mothers may not feel as though they have to make a "disciplined choice" away from patenting (Cole & Zuckerman, 1987). In addition, initial involvement may establish commercial networks that more easily promote future involvement, and may set in motion the necessary knowledge, support, and/or incentives for women (mothers or not) to patent to a similar degree to men.

Sex and Motherhood Influences on Industrial Patenting

Before taking into account prior activity, what is noticeable about the industrial models is the lingering sex difference that cannot be explained away by sorting and distributional variables. Furthermore, there is not a motherhood factor in the industrial sector regarding patenting involvement; rather, sex differences apply to all industry women. Although parents—both men and women—demonstrate an increased likelihood of patenting over childless men and women, the net influence on mothers remains negative compared to childless men.

Commercial work is often a more familiar outcome of scientists' research in industry, especially among the doctorate population. However, industrial women may be disproportionally located in positions that are not delineated by the models here (into jobs *within* research and development that provide less incentive to commercialize, for example). Perhaps more women are working in research than development, or more men occupy positions with direct lines to the commercial process. One limitation of studying scientists in industry is that, unlike academia, rank/position is not uniformly classified across industrial settings, and contains more inherent variability. Although this research includes a suite of variables intended to measure work responsibility, job position, training and experience, the lingering sex disparity among men and women in industry could be attributed to further sorting mechanisms in industrial positions. This sample is by necessity relatively homogenous in that all scientists have doctorate degrees and a similar emphasis on research and development, however. Thus companion explanations are foreseeable. One possibility for the persistent and uniform disparity is that, like industrial mothers, *childless* women in industry may also sort into (or experience discrimination regarding) job characteristics in relation to their *potential* to become mothers.[16] Indeed the models show that, over time, women with children are more likely to change their employment criteria by leaving full-time work in industry or by moving away from an R&D focus. This may contribute to views in the workforce that mothers (or those likely to become mothers), are (or will be) more variable or intermittent workers. Thus, similar to mothers, nonmothers (who may become pregnant down the road) may also experience status delineations of the signaling sort as coworkers assess their perceived commitment and skill. Alternatively, this group of scientists may anticipate future marital or motherhood status events in their careers and sort themselves into job positions like mothers. In either case, motherhood disparities could be similarly relevant to childless women.

The final panel sample suggests steep decreases in the odds of patenting of married, childless women, providing some support for this mechanism. Although the models control for cohort effects from year of degree, age is perhaps a more direct reference to scientists' fertility in the workplace. If nonmothers are, on average, significantly younger than mothers, it may be possible to argue that nonmothers are seen against a backdrop of their future motherhood potential. Mothers in industry are, however, only 1 year older that nonmothers in industry ($p < .05$), on average, and there is no difference between mothers and nonmothers in academia ($p > .1$).

On the other hand, it could be argued that rather than industry, it is the academy that produces unique influences regarding motherhood. Do childless women in the academy engage in "discrimination avoidance behavior," where they disproportionally avoid becoming mothers in order to not be disadvantaged (or have conflicts between research and family)? Among tenured women and men in the sciences, for example, 70% of men but only 50% of women reported having children in the home (Mason & Goulden, 2002), and more women scientists than men in the academy indicate that they had fewer children than they wanted (Mason & Goulden, 2004). However, a comparison study of women in industry also finds women more likely than men to report foregoing or delaying parenthood and marriage (Simard, Henderson, Gilmartin, Schiebinger, & Whitney, 2008). Indeed, there are similar percentages of women with children in both the academy and industry in this sample (44% of women, in both sectors). On the surface, academia does not seem to be supporting larger proportions of childless women (i.e., "avoiding" motherhood to a greater extent) than in industry, at least among doctorate-level science professionals.

The second analysis of industry workers sheds light on how sorting and attrition may work in tandem with the idea that childless women in industry may anticipate or are expected to perform differently down the road. Controlling for those with past commercial involvement removes sex disparities between childless men and women although the majority of mothers and married women are less likely to patent. When scientists are 5 years farther along in their careers, delineations between those married and/or with children and those without are much more prevalent. Furthermore, the fact that there are more uniform sex disparities between men and women *before* controlling for prior performance, and particular sex disparities *after* doing so, may be an indication that mothers (and perhaps those who anticipate being mothers) are located in job positions that do not commercialize. Childless, unmarried women may hold more prior patenting knowledge due to the jobs they are in, for example. Like the academy, motherhood effects in industry may be particularly influential, contributing not only to attrition along the way but also to involvement among those on the job.

Without further data it is difficult to know what specific influence marriage and parenthood have on the work choices or placements of industrial women in science. We do not have extensive data on the distribution of men and women science professionals across industry positions. In addition, we do not know to what extent status penalties for characteristics like motherhood apply to those who *might* be likely to make that choice in the future. Future qualitative or experimental data on scientists and engineers across sectors could provide detail about how these mechanisms inform work outcomes for scientists.

In addition, any analysis of gender differences among those employed in science must reference the unique standpoint of the women in the sample. As doctorate holders, they have already overcome barriers of sample selection by obtaining advanced degrees in science and continuing to postgraduate employment in academic or industrial science (Fox, 2001). All sex disparities in this sample are above and beyond those in a gendered attrition process that persist across the scientific career trajectory, and thus may represent a low estimate of actual sex differences. Furthermore, the *types* of scientists that work in each sector may also be relevant. Although the percentage of women with children is similar in each sector, the backgrounds, decisions, and focus of industry versus academic scientists may stem from different employment drives and motivations.

At the heart of this research is the goal of gaining a better understanding of how work environments and changes in the context of the profession of science may influence the known sex disparities between scientists. The study findings reinforce the notion that the structure of science remains a gendered structure, wherein the formal and informal advantages and disadvantages in the profession run along gender lines. And as the job activities of academic and industrial science increasingly overlap, it becomes relevant to consider both sectors when studying sex disparities among science professionals. As commercialization becomes more common, these trends have considerable implications not only for science as a profession, but the wider pursuit of knowledge as well.

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Notes

1. Status expectation theories would suggest that mothers would continue to be held to higher standards than others despite the presence of disconfirming evidence, however (Correll & Ridgeway, 2003). In this case, mothers may still be "running faster to stay in place."
2. Patenting questions were also asked in 2003, but the reference period of the question does not align with that of the 1995 and 2001 data.
3. Proportional weights refer to sampling weights, and the inclusion of weights in the analysis corrects for the sampling design of the survey. All conclusions drawn from weighted models are substantively similar to those found when calculating unweighted models.
4. The SDR also contains data on social scientists and those in "nonscientific" occupations.
5. Scientists could choose from the following work activities: (a) accounting, (b) applied research, (c) basic research, (d) computer applications, programming, or system development, (e) development, (f) design of equipment, processes, or models, (g) employee relations including recruitment, training, or personal development, (h) managing and supervising, (i) production or operations, (j) professional services, (k) sales, purchasing, marketing, customer service, or public relations, (l) quality assurance, (m) teaching, or (n) other.
6. While the reference periods differ by 1 year, my use of the variable as an indicator likely introduces less bias to model interpretations across waves than other configurations, such as a count measure.

7. I find similar substantive results in models that contain a continuous variable for the number of children in the home. In addition, models with age sets reveal consistency between categorical groups of parents versus nonparents.
8. Although government grants represent the majority of academic scientists' (and many industrial R&D labs') outside funding, information on any additional, non-governmental, funding is not available in this data set.
9. Although the NRC reported ratings in 1982, 1995, and 2009, the 1995 ranking is the only crosswalk available to pair with the SDR data. Regarding measure construction, there is remarkable coherence across programs within institutions. In tables not reported here, I also examined models that included this measure as a categorical variable ("top tier," "middle tier," and "lower tier") to address whether basic classifications subsume continuous variation. All substantive and statistical implications remain the same.
10. Models of the combined sample of university and industry scientists (which contain only common overlapping variables) that include three-way effects between sex, parenthood, and sector reveal significant interaction effects ($p < .01$). In addition, results reveal significant differences between the direct sex effect across sectors ($p < .05$) as well as for sector and parenthood ($p < .01$).
11. Similar results are achieved when the interaction between sex and parenthood is added to the models individually and in different sequence from that presented here.
12. Indeed, there is no significant improvement to the fit of the model between Models 4 and 5 ($p > .1$).
13. Calculations were conducted using the "prvalue" procedure in the statistical analysis program, Stata. Prvalue computes the predicted outcome of designated indicator variables and interactions for men and women parents and nonparents while holding constant all other model values at their mean.
14. About a third (N = 533) left the workforce entirely and about 50% (N = 926) changed work priorities. A further site of attrition may come from those who were surveyed in 1995 but did not respond after being resampled in 2001.The precise amount of this type of attrition—while likely small given typical SDR response rates (>78%)—is unknown.
15. Models that include prior patenting behavior by itself render sex disparities insignificant as well and those that include a control for interactions between sex and prior performance show the same results and implications but with an insignificant interaction effect.
16. I am appreciative of the anonymous reviewer who brought this point to my attention.

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Bio

Kjersten Bunker Whittington is assistant professor of sociology at Reed College. Her research focuses on the intersection of science and innovation, the scientific labor market, and the dynamics of regional economies. Additional work on this topic examines sex differences in productivity in light of the network structure of collaborations across organizational forms.