GENDER DIFFERENCES IN PRODUCTIVITY
Research Specialization as a Missing Link

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Since 1984, when Cole and Zuckerman referred to gender differences in productivity among academic scientists as a puzzle, sociologists have sought to explain these differences by incorporating primarily institutional-level factors. In addition to these factors, the author contends that an undertheorized and heretofore unmeasured concept—the extent of research specialization—can also help explain the process by which gender affects research productivity. Although some researchers have examined areas of specialization, the extent of research specialization has been completely neglected in studies of academic careers. Using a probability sample of academics in two disciplines (sociology and linguistics), primary data collection, and simultaneous equation modeling, the author finds that the extent of research specialization is a critical intervening variable: Women specialize less than men and thereby lose out on an important means of increasing their productivity.

Keywords: *gender; academic science; research productivity; specialization*

Although scientists consistently receive among the highest of occupational prestige ratings, large disparities in career attainment are apparent, especially between men and women. And while gender differences in salary, receipt of grants, and promotion can be explained largely by research productivity, researchers have had a much harder time explaining

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the large gender difference in research productivity itself. Only 20 years ago, Cole and Zuckerman (1984) referred to gender differences in research productivity as the "productivity puzzle" because efforts to account for the differences were at that time unsuccessful. Since then, scholars such as Keith et al. (2002), Fox (1983, 1985), Ward and Grant (1995), and others have identified individual- and institutional-level factors that help explain variation in productivity, and Xie and Shauman (1998) were able to explain almost all variation. But the direct effects typically explored in regression models can hide important indirect effects, or mechanisms, which are an important part of a complete understanding of a phenomenon. Elucidating the process by which gender affects productivity requires measuring relevant but previously unmeasured attributes—such as the nature of scholars' research programs—and correctly specifying their mediating effects in statistical models.

I contend that the nature of scholars' research programs, specifically the extent to which they are specialized (that is, focused on one or a few subfields rather than spanning many), is a relevant but heretofore unmeasured characteristic that can elucidate how gender affects research productivity. It is likely that men and women scientists specialize to different degrees, and the extent to which one's research program is specialized affects productivity rates. Although some researchers have examined areas of specialization (Barbezat 1987a; Haberfeld and Shenhav 1990; Ward and Grant 1995), the extent of research specialization has been completely neglected in studies of academic careers and research productivity in particular. Two academics could work in the same specialty area but differ dramatically in the extent to which their successive papers and projects are related to their previous work: One could contribute repeatedly to the same subfield, whereas another could produce articles on other topics as well.

This neglect is surprising given the widespread anecdotal evidence that specialization matters. The productivity gains realized from specializing seem intuitive. Specializing allows one to master a literature in a subfield, including the relevant debates and research methods, thereby making successive and related research undertakings easier. Specializing allows a scholar to know, and come to be known by, other scholars in the specialty area, which improves opportunities for advancement and publication, especially given that double-blind peer review is not always blind in practice. These benefits from specializing may serve as further incentive to capitalize on investments and continue working in the same subfield(s), reproducing a cycle of specialization and productivity. The Center for Advanced Study in the Behavioral Sciences recognizes the link between specialization and productivity, at least at early career stages, by recruiting promising young

scholars who have "worked *narrowly* for 6-8 years to get tenure, [and] are now in a position to think more ambitiously about their work and to take greater intellectual risks" (http://www.casbs.org/programs.php?snav=programs_fellows.html).

While specialization has been explored at the organizational level (Blau 1994; Carroll 1985), it has not been integrated into studies of academics' career outcomes. To fill this void, I theoretically motivate, develop, and measure the extent of individuals' research specialization and incorporate it into statistical models to help explain how it is that men have large and consistently higher rates of productivity relative to women. The goal of this investigation is to help further delineate the processes producing gender differentials in publication rates and to better understand the productivity puzzle. Toward this end, I begin by discussing the significance of productivity and reviewing literature on the gender gap. I then turn to my key theoretical construct—the extent of research specialization—and develop the two critical links in my theoretical argument: (1) how gender affects the extent of research specialization and (2) how the extent of research specialization affects research productivity.

LITERATURE REVIEW

Gender and Research Productivity

Even though scholarly publishing is central to academic success, it is relatively understudied (Ward and Grant 1995), even by scholars interested in the status of women in colleges and universities. But rates of academic publication, and especially the large and persistent gender differences in such rates, are important to study. Publication "makes or breaks individual academic careers" (Ward and Grant 1995, 202); performance evaluations, funding decisions, promotions, and salary raises are based on the quality and quantity of publications (Dean 1989; Ferree and McQuillan 1998). Women's lower productivity relative to men's is critical to study not only because of the size and the persistence of the gap but also because other forms of gender inequality are perpetuated by it (Fox 2001; Fox and Stephan 2001). The large gender difference in productivity documented by Cole and Zuckerman (1984) has not disappeared in recent years (Fox 2005; Long 1992; Long, Allison, and McGinnis 1993; Prpic 2002; Xie and Shauman 1998), and it continues to contribute to women's disadvantage in terms of salary and promotion to higher academic ranks.

Because "explaining the immense variation in the productivity of scientists is a major research objective in the sociology of science" (Long

1992, 159), social scientists have responded to Cole and Zuckerman's (1984) call to explain the productivity puzzle. They have incorporated individual factors such as age, marital and parental status, cohort, rank, and receipt of research funding as well as more structural factors such as prestige of PhD-granting department and current department, time available for research, and disciplinary integration (Fox 2005; Keith et al. 2002; Prpic 2002; Xie and Shauman 1998). These factors were largely successful in explaining gender differences in productivity levels (Xie and Shauman 2003). However, these structural characteristics could be reflecting typically unmeasured characteristics such as encouragement, expectations, motivation, satisfaction with work, or—most relevant to my investigation—a commitment to either the breadth or the depth of research. Perhaps the extent of research specialization can contribute to our understanding of gender differences in productivity.

The Extent of Research Specialization

Whereas most previous work on specialization focused on the content of specialization, that is, the specialty areas scholars engage in, I highlight the form that specialization takes by examining each scholar's distribution of specialty areas. To what extent do they specialize, regardless of their area(s) of specialization? I conceive of the extent of research specialization as a continuum along which scholars—or rather their research programs–are located. It assesses the extent to which an individual's body of work is internally homogeneous or diverse. It is easy to imagine a categorical distribution of each scholar's various subfields, with some scholars' research spanning several subfields and others' being confined to one or two. Some scholars repeatedly engage with the same research topic(s) and tend to write multiple papers on that topic for several years if not their entire careers. I refer to such scholars as specialists. At the other end of the continuum lie scholars with very diverse research interests: those who write papers on a wide variety of topics and rarely publish on the same topic more than once.

Although there are likely several dimensions of the extent of research specialization, I focus on the extent to which a scholar repeatedly engages in research on the same substantive topic, for it is the communities surrounding such substantive research areas that may be critical to producing specialization's benefits. Certainly, other dimensions of specialization are possible: The extent of teaching specialization could assess whether faculty members teach the same course(s) repeatedly; the extent of service specialization might capture whether a scholar engages in the same kinds

of department service year after year. Even within the realm of scholarship, different kinds of specialization are possible. For example, one could specialize to a great extent by method (e.g., by engaging in only experimental work) or by theory (e.g., by employing the same theoretical framework to studying various topics). I investigate the extent of specialization in substantive research areas because they correspond best to accepted areas of expertise as delineated by the American Sociological Association[1]—few of which embody a single method or a single theoretical perspective. Moreover, it is the invisible colleges and communication networks surrounding substantive research topics—rather than methods or theories—that should be most relevant to scholars' productivity and the gendered patterns of publishing.

Gender and Specialization

Previous research has found that men and women specialize in different areas of research (Grant and Ward 1991), and I also expect them to specialize to different degrees. I consider specializing to be a form of professional capital that begets all sorts of valued outcomes, including productivity and visibility. Because previous studies have found that women are disadvantaged with respect to other forms of capital (Lin, Ensel, and Vaughn 1981; Paglin and Rufolo 1990; Tam 1997; Weeden 2002), I also expect women to be disadvantaged in terms of professional capital–that is, to specialize less than men. Like human, social, and cultural capital, the professional form of capital that specialization represents is likely more available to men than to women.

Specialization and Productivity

Because I conceive of specialization as a resource—essentially a form of professional capital—I expect scholars to reap benefits from specializing. Specifically, I expect specializing to promote research productivity. Specializing allows a scholar to gain in-depth knowledge of a body of literature—including its central debates, theories, methods, and key players—and thus should make successive papers on that topic easier and more efficient to write, thereby increasing the quantity of research produced. Moreover, by fostering professional networks within a subfield, specializing may increase the chance of getting papers accepted at peer-reviewed journals, given that double-blind peer review is not always blind in practice and reviewers may be biased in favor of those they know. These benefits from specializing may serve as further incentive to capitalize on investments and continue

working in the same subfield(s), reproducing a cycle of specialization and productivity.

The effects of research specialization on productivity may vary by discipline. Previous research has found that status attainment patterns are associated with disciplinary consensus, which is known to be higher in the natural sciences (Hargens and Hagstrom 1982). However, even across the social sciences and humanities, which have been typically understudied (Guetzkow, Lamont, and Mallard 2004), the processes whereby resources are transformed into scholarly productivity are likely to vary (Wanner, Lewis, and Gregorio 1981). One discipline in the humanities, linguistics, has a very strong core (Dogan and Pahre 1989b) from which scholars choose a subfield without losing touch with the others (phonetics, phonemics, morphology, syntax, pragmatics). In this field, specialization may have a particularly strong effect on productivity. In contrast, sociology has expanded the definition of its subject matter and fragmented into a large number of poorly connected, and mostly hybrid, subfields (Dogan and Pahre 1989b). Specialization may be less valued in this field and less determinant of productivity.

Overall, my investigation yields two primary contributions to our understanding of gender inequality in academic work. First, I conceptualize and develop a way to measure an important but heretofore neglected construct: the extent of research specialization. Second, I incorporate this construct into a model of gender inequality in academic productivity, focusing on its role as an intervening mechanism. Understanding the processes by which inequality arises and is maintained is critical for policy purposes and has been highlighted by a recent American Sociological Association president (Reskin 2003) as well as researchers studying stratification in science (Grant and Ward 1991; Long and Fox 1995). To accomplish these goals, I collect extensive data on a probability sample of academics from two fields, develop a way to empirically measure the extent of research specialization, and specify a process-oriented simultaneous equation model to assess the mediating effects of this new construct.

DATA AND METHOD

Sample

Like most research on academics, I begin with a cross section of individuals currently in academe (Bayer and Astin 1975) and then collect

retrospective data on publications. The sample I have selected for this study—a 20 percent sample of tenured and tenure-track sociology and linguistics faculty members at extensive[2] research universities—makes my test of gender and research specialization effects particularly stringent. Thus, the population from which I drew my sample is rather selective, and this is particularly true of the women, who are more likely than men to withdraw from science at various stages leading up to academic employment (National Research Council 2001; Preston 2004; Rosser 2004; Sonnert and Holton 1995) and to work at less prestigious institutions, such as teaching colleges (Grant and Ward 1991). Because the women in my sample have career patterns that most closely mirror men's, testing for remaining gender differences is challenging. Moreover, by selecting only extensive research universities, I control for many resource-based influences on productivity, including not only expectations, research funding, and travel expenses but also time available to devote to research relative to teaching, which has been shown to affect productivity (Fox 1992). Because the vast majority of research takes place at extensive research universities (Levin and Stephan 1989) and the quantity, quality, and form that research takes is rather consistent across these settings (Xie and Shauman 1998), they serve as an appropriate context for investigating the impact of research specialization.

I focus my investigation on two disciplines: sociology (n = 196) and linguistics (n = 222). While many previous studies of gender stratification in academe have focused on a single discipline (Keith et al. 2002; Long 1992; Reskin 1977), I examined two disciplines because processes of gender stratification have been found to differ across disciplines (Fox and Stephan 2001; Levin and Stephan 1989; Prpic 2002). In addition, most previous studies of productivity have examined the natural and life sciences (Levin and Stephan 1989; Long, Allison, and McGinnis 1993; Prpic 2002; Reskin 1978), and I am eager to see if the findings are generalizable to the social sciences and the humanities, which have generally been neglected by the sociology of science and knowledge (Guetzkow, Lamont, and Mallard 2004). In these fields, more than in the natural sciences, women have been incorporated to a greater extent.[3] Compared to other fields such as engineering, sociology and linguistics are less sex segregated (Etzkowitz et al. 1994) and therefore provide subsample sizes large enough to obtain a high level of statistical power for examining gender differences. Although the two disciplines also differ in age (sociology is older) and size (sociology is bigger in terms of membership), they both sit at the crossroads of several different disciplines and are inherently integrative, making an investigation of research specialization in these two fields particularly informative.

Data Sources

Most of the data used for my analyses are culled from secondary sources. To construct the sampling frame, take the sample, and contact people, I obtained faculty members' names and contact information from university and department Web sites and also from disciplinary guides to graduate programs and membership directories. I also used this information to obtain information about where and when the academics earned their doctoral degrees and used first names and various Internet searches, when necessary, to determine each individual's gender. To handle unmeasured heterogeneity that remains even among the rather homogeneous sample of extensive research universities, I control for department prestige of current and PhD-granting institutions, obtained from the National Research Council (Goldberger, Maher, and Flattau 1995).

Most of the data needed to construct measures of research specialization and research productivity (described in the next section) were collected from discipline-specific electronic databases: Sociological Abstracts and Linguistics and Language Behavior Abstracts. By entering academics' names, I accessed all of their refereed journal articles. For each article, I collected the keywords used to describe the research, including both the more general classification codes (up to two per publication, selected from a total of about 130) and the more detailed major descriptors (up to nine per publication, selected from almost 10,000), both of which are assigned by trained staff at Cambridge Scientific Abstracts, the umbrella organization that manages both databases. Because of the extensiveness of Sociological Abstracts' and Linguistics and Language Behavior Abstracts' coverage (they index articles from 1,246 and 1,809 periodicals, respectively, during a period of more than 30 years), they are better than other databases such as the Social Science Citation Index and the Arts and Humanities Citation Index, which cover only 140 sociology journals since 1970 and 1,138 arts and humanities journals since 1990.[4]

Information needed to construct various control variables (e.g., marital and parent status and receipt of external funding) was obtained from academic CVs and a Web-based survey. During spring 2004, I invited all sampled academics to take a short Web-based survey and submit a copy of their CV. The response rate was 50 percent, but I was able to obtain CVs via the Internet for a majority of nonresponders. Importantly, CVs obtained directly from individuals and indirectly from the Internet are comparable to each other and also provide data comparable to other sources of career histories such as disciplinary association publications (Dietz et al. 2000; Heinsler and Rosenfeld 1987).

Key Measures

I assess the extent of specialization, which taps differentiation in a scholar's research program, using keyword descriptors. From the discipline-specific databases (Sociological Abstracts or Linguistics and Language Behavior Abstracts), I compiled keywords for every faculty member's multiple journal articles[5] to identify the specialty areas that each paper covers (and as noted earlier, the list of specialty areas is different for sociology and linguistics). To construct a measure of the extent of research specialization, I compare the cumulative number of publications with the cumulative number of unique keyword descriptors. Specifically, to differentiate scholars who specialize (i.e., devote a large portion of their research program to a small set of specialty areas) from those who branch out (i.e., write successive papers on new topics), I use the ratio of the cumulative number of unique keyword descriptors to the cumulative number of publications (1-[# of unique keywords / # of publications]).

I demonstrate how I construct the extent of specialization measure using data for three hypothetical sociologists (see Table 1). Underlined keyword descriptors are those that are new to each scholar's research program (as defined by a history of journal publications). Sociologist 1, who first began publishing in 1996, has the most diverse research program, covering seven unique subfields within sociology over the course of nine publications. Sociologist 3, who entered the field in 1984, has the most specialized research program, covering only two subfields (group processes and social network analysis) in his 12 publications since that time. Similarly, sociologist 2 has only published in two subfields (1020: occupations and professions, and 2983: sociology of gender) but is professionally younger and has fewer publications, and thus he has a lower specialization score than sociologist 3. Because articles receive at the most two classification codes that describe their content, the measure has a minimum value of "–1" for scholars who pursue new areas with each publication (e.g., [1-(2/1)] = –1) and a maximum value close to "1" for scholars who publish repeatedly on the same topic (e.g., [1-(1/12)] = 0.92 for a scholar with 12 publications and [1-(1/10)] = 0.90 for a scholar with 10 publications). To account for the fact that the theoretical maximum value of specialization depends on number of cumulative publications, I assess the robustness of my results to a relative measure of specialization that indicates the percentile location of one's specialization score, given his or her productivity level.

Specialization scores also depend on how detailed the keyword descriptors are (Blau 1977), and for this reason, I construct the measure using keywords at three levels of specificity. In addition to using the classification

TABLE 1: Construction of the Extent of Specialization Measure

Panel A: Publication-Level Information Used To Construct the Measure

Year	*Publication Outlet*	*Classification Code 1*	*Classification Code 2*
Sociologist 1			
1996	*Journal of Marriage and the Family*	1941: sociology of the family	1636: sociology of law
1997	*Social Science Research*	1941: sociology of the family	
1997	*Sociological Forum*	1636: sociology of law	
1998	*Deviant Behavior*	2151: juvenile delinquency	
1999	*Social Forces*	2151: juvenile delinquency	
2000	*Law and Society*	1636: sociology of law	
2001	*American Journal of Sociology*	2148: social work	2190: family violence
2001	*Sociological Inquiry*	2151: juvenile delinquency	
2002	*Gender and Society*	2983: sociology of gender	
2003	*Journal of Marriage and the Family*	1941: sociology of the family	
2003	*Law and Society*	1636: sociology of law	
2004	*American Sociological Review*	1636: sociology of law	1939: adolescence and youth
Sociologist 2			
2001	*Research in Stratification and Mobility*	1020: occupations and professions	
2002	*Sociology*	1020: occupations and professions	
2003	*Work and Occupations*	1020: occupations and professions	
2003	*Gender and Society*	1020: occupations and professions	2983: sociology of gender
2004	*Social Forces*	2983: sociology of gender	
Sociologist 3			
1984	*Advances in Group Processes*	0309: group processes	
1985	*Social Psychology Quarterly*	0309: group processes	

TABLE 1: (continued)

Panel A: Publication-Level Information Used To Construct the Measure

Year	*Publication Outlet*	*Classification Code 1*	*Classification Code 2*
1986	*Sociological Perspectives*	0309: group processes	
1986	*Social Forces*	0309: group processes	0665: social network analysis
1987	*American Sociological Review*	0309: group processes	
1988	*Social Networks*	0665: social network analysis	
1990	*Social Networks*	0665: social network analysis	
1991	*Social Psychology Quarterly*	0309: group processes	
1994	*Annual Review of Sociology*	0309: group processes	0665: social network analysis
1995	*Sociological Methodology*	0665: social network analysis	
1998	*American Journal of Sociology*	0665: social network analysis	0309: group processes
2001	*Sociological Methods and Research*	0665: social network analysis	

Panel B: Measure Used in Analyses

	Cumulative Number of Unique Classification Codes (CCs)	*Cumulative Number of Publications (Pubs)*	*Extent of Specialization Measure (1– [# CCs / # Pubs])*
Sociologist 1	7	9	0.22
Sociologist 2	2	5	0.60
Sociologist 3	2	12	0.83

NOTE: Classification codes that are new to this scholar's research program are underlined in panel A.

codes used in the example above, I also calculate the extent of specialization using the very detailed major descriptors and also using the broadest classification code families, which encompass a parent classification code and several subcodes (e.g., a "social control" family includes the subcodes "sociology of law" and "penology"). Note that because up to nine major descriptors can be applied to an article, the specialization score derived from these keywords takes a minimum value of –8 (i.e., 1-[9/1]); the maximum value still approaches 1. Importantly, constructing the specialization score using each scholar's distribution of classification code families allows me to account for the possibility that men and women are unevenly distributed across subfields. This is critical if female-dominated areas of specialization have fewer possible codes than male-dominated areas, thereby making female scholars appear artificially specialized.[6]

To tap research productivity and to achieve comparability with previous studies, I rely on a count of journal articles, arguably the most important form of scholarly communication at extensive universities. Publication is not equivalent to research productivity but rather a strong indicator of it (Fox 1989). Although no single measure of productivity is adequate or universally accepted (Fox 1983; Long 1992), quantity of refereed journal articles, perhaps standardized by time, is used most often in the literature (Allison and Long 1987; Ferber and Loeb 1973; Fox and Faver 1985; McBrier 2003; Prpic 2002; Reskin 1977, 1978; Wanner, Lewis, and Gregorio 1981; Ward and Grant 1995; Xie and Shauman 1998). This measure also taps the most fundamental dimension of publication: frequency (Long 1992). Moreover, raw article counts are highly correlated with counts weighted by coauthorship status (Levin and Stephan 1989; Long 1992) or by journal quality (Keith et al. 2002; Levin and Stephan 1989; Long 1992; McBrier 2003). Rather than rely on self-reports as others have (Fox and Faver 1985; Prpic 2002; Wanner, Lewis, and Gregorio 1981; Xie and Shauman 1998), I obtain article counts from publicly available electronic databases. To limit right skewness, I take the natural log of raw publication counts (Reskin 1977).

Importantly, my measures of both research specialization and research productivity do not include books. This is largely because books are rarely indexed in Cambridge Scientific Abstracts' databases. However, even if book counts could be obtained from CVs or from the Library of Congress, lists of keyword descriptors would be different from Cambridge Scientific Abstracts' (making a uniform measure of specialization impossible), and it would be unclear how to make a book count commensurate with an article count. Because method and evidence, not subject matter (embodied by

the keywords used here), distinguish books from articles (Clemens et al. 1995), the exclusion of books should not bias the measure of research specialization; however, the same cannot be said for the measure of research productivity. Qualitatively oriented scholars—a large percentage of whom are women—tend to publish their work in book form; thus, my measure undercounts their true productivity. To ensure that my results are comparable to previous work on this topic, I restrict my measure of research productivity to articles; however, the bias in this measure should be considered when interpreting results.

Modeling Strategy

To test my hypotheses about the impact of research specialization on productivity, especially how it may mediate the effect of gender, I use simultaneous equation modeling, also known as path analysis. This statistical method is ideal given that (1) the endogenous variables of interest (specialization and ultimately article counts) are continuous and (2) I am interested in not only the direct effects of gender on productivity but the indirect effects that gender might have through specialization (Bollen 1989). The ultimate, best-fitting model I estimate is depicted in Figure 1 (presented without error terms and intercorrelated exogenous variables for aesthetic purposes). I use the statistical package AMOS and its full information maximum likelihood estimation procedure because, when some data are missing, this strategy permits the inclusion of all available data (Anderson 1957) rather than deleting data in a listwise fashion, which is the default strategy in most statistical packages. It also bypasses the need to impute data, which is ideal given that sophisticated multiple-imputation procedures are difficult to combine with simultaneous equation modeling.

RESULTS

Descriptive statistics for my sample confirm findings from previous studies, which document stark gender differences in productivity (see Table 2, panel A). Among tenured and tenure-track sociologists and linguists at extensive universities, the mean number of cumulative articles is 15.5 for men and 9.5 for women. In addition, men have a much larger standard deviation: 13.5 to women's 8.1, indicating greater variability among men. Even after removing 18 individuals (8 men and 10 women) who are statistical outliers in terms of article counts, the stark gender difference remains: Men's mean is 16 and women's is 10. This gender difference is large and statistically significant according to a *t*-test for differences in group means. Although disciplinary differences in these

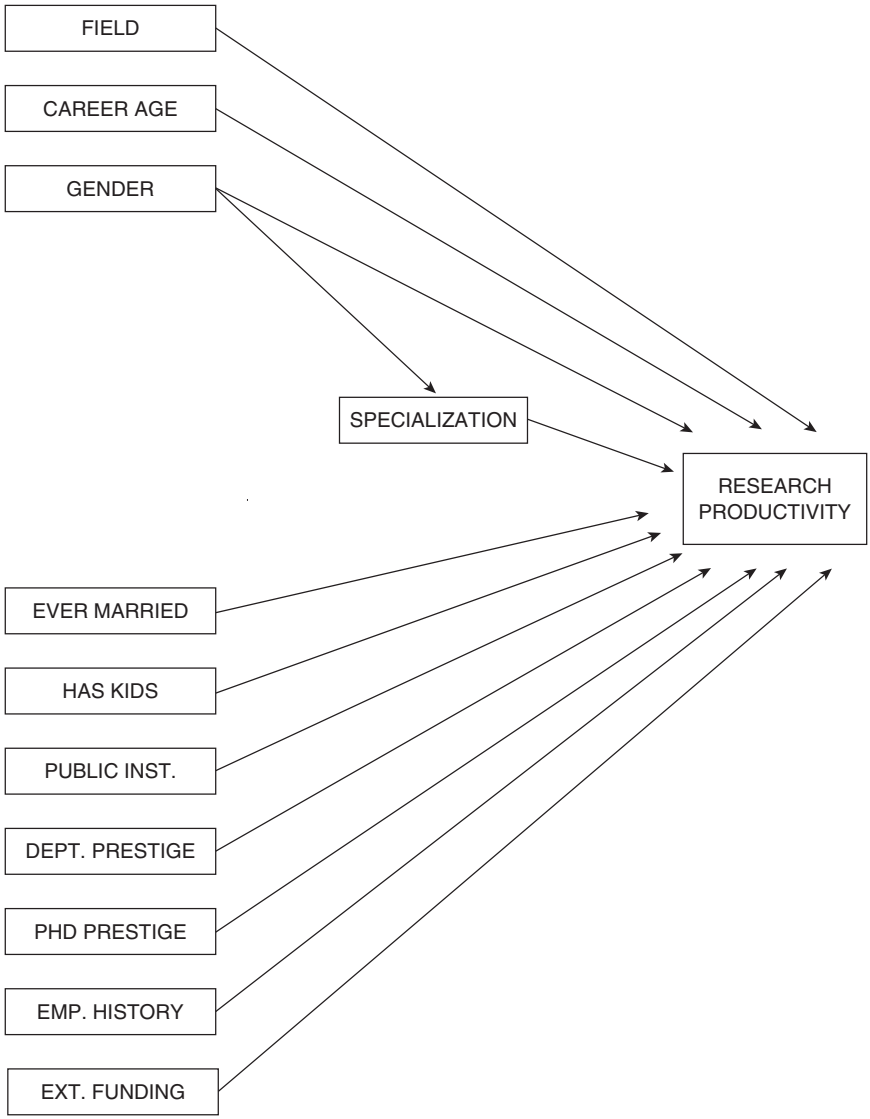

Figure 1: Final Model Specification

relationships will be examined in the multivariate analyses that follow, I note here that these relationships remain for both sociology and linguistics but are slightly stronger in sociology.

TABLE 2: Gender Differences in Publication and Specialization

	Males		*Females*
Panel A: Cumulative number of publications			
Mean	14.60	†	9.10
Median	11.00		7.00
Standard deviation	13.30		8.20
Panel B: Extent of specialization			
Using detailed major descriptors			
Mean	–2.40	†	–2.87
Median	–2.20		–0.60
Standard deviation	1.31		1.36
Using classification codes			
Mean	0.40	*	0.35
Median	0.50		0.43
Standard deviation	0.34		0.34
Using broad classification code families			
Mean	0.49	**	0.43
Median	0.58		0.50
Standard deviation	0.33		0.34
Subsample size	255		162

NOTE: Significant group differences using one-tailed tests are indicated by *$p \leq .10$. **$p \leq .05$. †$p \leq .001$.

There is also a strong bivariate relationship between gender and specialization in the expected direction. Using the specialization score constructed with the broad classification codes, I find that women in the sample tend to specialize less than men (see Table 2, panel B). Women's mean score (0.35) is lower than men's (0.40), and this difference is statistically significant, suggesting that men's cumulative research programs have tended to be more focused on a restricted number of subfields, whereas women's research programs are characterized by more breadth. This result holds—and actually becomes larger and more statistically significant—when the other two kinds of keyword descriptors (the detailed major descriptors and the broadest classification code families) are used to construct the specialization score.

The relationship between gender and productivity, adjusted for both field (sociology or linguistics) and experience (career age), serves as a baseline model for the multivariate analyses (see Table 3, model 1). It demonstrates what I found descriptively: Women tend to publish fewer articles than men—even men in the same field with similar years of experience. Because I use the natural log of article counts, the gender coefficient of –0.15

TABLE 3: The Mediating Effect of Specialization on the Relationship between Gender and Productivity: Unstandardized Regression Coefficients and Standard Errors

	Model 1		*Model 2*		*Model 3*	
	Coefficient	*Standard Error*	*Coefficient*	*Standard Error*	*Coefficient*	*Standard Error*
Effects on productivity						
Gender[a]						
Female (1 if female)	–0.15*	0.08	–0.09	0.07	–0.05	0.07
Specialization[a]						
Extent of specialization, logged	—	—	0.37†	0.026	0.35†	0.02
Field						
Sociology (1 if sociology)	0.07	0.07	0.50†	0.07	0.51†	0.08
Career age						
Years since PhD	0.44†	0.003	0.021†	0.003	0.01**	0.00
Family status						
Ever married (1 if yes)	—	—	—	—	0.22*	0.12
Has kids (1 if yes)	—	—	—	—	0.06	0.05
Institutional affiliation						
Public institution (1 if yes)	—	—	—	—	0.15**	0.07
NRC rank of department prestige	—	—	—	—	–0.003*	0.001
PhD-granting institution						
NRC rank of department prestige	—	—	—	—	–0.001	0.002
Employment history						
Number of institutions	—	—	—	—	0.15***	0.03
Receipt of research funding						
External funds (1 if yes)	—	—	—	—	0.27***	0.08
Constant	1.41†	0.1	2.56†	0.11	1.80†	0.17
R^2	0.32		0.46		0.52	

TABLE 3: (continued)

	Model 1		*Model 2*		*Model 3*	
	Coefficient	*Standard Error*	*Coefficient*	*Standard Error*	*Coefficient*	*Standard Error*
Effects on specialization						
Gender[a]						
Female (1 if female)	—	—	–0.45***	0.14	–0.44***	0.14
Constant	—	—	–2.40†	0.09	–2.40†	0.09
R^2	—		0.03		0.03	
N	418		418		418	
Chi-square (*df*)	971.6 (19)		278.4 (16)		245.4 (9)	
Comparative fit index	0.83		0.95		0.96	
Incremental fit index	0.83		0.94		0.96	
Browne-Cudeck criterion	1118.1		431.1		412.6	
Akaike's information criterion	1113.6		426.4		407.4	

NOTE: Dashes indicate that the variable was not included in the model; no parameter estimate was obtained. NRC = National Research Council.
a. One-tailed tests.
*$p \leq .10$. **$p \leq .05$. ***$p \leq .01$. †$p \leq .001$.

suggests that women academics publish only about 86 percent ($e^{-0.15}$) of the articles that similarly situated men do. Gender, field, and career age combined explain almost 33 percent of the variation in article counts.

Adding the extent of research specialization as an intervening variable to this model demonstrates its relevance (see Table 3, model 2). In this better-fitting model, I find that men specialize more than women, and that specialization increases productivity: Each of these links is statistically significant at the .001 level and in the expected direction. Specialization alone also helps explain an additional 14 percent of the variance in research productivity (i.e., $R^2_{\text{model 2}}$ [0.46] – $R^2_{\text{model 1}}$ [0.32] = 0.14). Adding specialization to this process also reduces the gender's direct effect on productivity by 36 percent (from –0.146 to –0.093) and renders it statistically insignificant. In fact, gender's indirect effect on productivity, through specialization (standardized at –0.08) is almost three times larger than gender's direct effect on productivity (standardized at –0.03). Clearly, the extent of research specialization is critical to the gendered process of publishing papers: By failing to specialize as much as men, women are missing out on an important route to increased productivity.

These results hold, and results from previous studies are replicated, when I control for other relevant factors (see Table 3, model 3). Employment history, marital and family status, receipt of external funding, institutional type (public or private), and prestige of current and PhD-granting departments together explain an additional 6 percent of the variance in productivity, above and beyond specialization, career age, gender, and field. Being married, being older professionally, receiving research funding, and employment at other institutions prior to one's current job all promote productivity levels. As other studies have found (Barbezat 1987a, 1987b; Cole and Zuckerman 1984), there is no child penalty on productivity, although my measures may not be refined enough to capture this effect; see Fox (2005) for more ideal measures.[7] These results are also not sensitive to the exclusion of 18 outliers that were identified in the descriptive analyses.

Results obtained from this final model do not depend on the measure of research specialization used. Recall that the value that specialization takes depends on the specificity of the keyword descriptor. Calculating the specialization score using the classification codes or the broad classification code families, rather than the specific major descriptors presented in Table 3 does not change the direction or the significance of the coefficients of interest. Moreover, even when I calculate a relative measure of specialization (in which each scholar's specialization score is compared to the theoretically

possible values of specialization for his or her productivity level and the resultant percentile value is used), the results for links between gender, specialization, and productivity remain (results not shown).

The results are also robust to other measures of research productivity (albeit still article based) and to alternative model specifications. When I adjust cumulative publication counts to account for coauthorship status (weighting articles by 1/n, where n = total number of authors), the relationships among gender, specialization, and productivity presented in Table 3 remain. When I weight publications by the Institute for Scientific Information's journal impact factor (a measure of visibility or quality of the journal), all results remain except that in model 3, gender's direct effect on productivity maintains its marginal significance, and the indicator for employment at a public institution becomes significant and negative. Specialization and other explanatory variables are better able to explain gender differences in raw productivity counts, perhaps because publishing in high-impact journals depends on additional factors yet to be measured, such as creativity and writing style. When I limit publications to a particular time period (2000-2004)—which may be critical when comparing men and women, given women's typically shorter careers and thus lower productivity records—the key relationships between gender, specialization, and productivity remain. Using this last alternative measure of productivity in combination with a revised specialization measure that only relies on keywords from articles published before the year 2000 also lends support to the directionality of effects that I theorized. In other words, it is unlikely that productivity affects specialization. Even when I allow for a reciprocal effect between specialization and productivity (which is possible in path analysis), the direction and significance of the specialization effect do not change.

These results also hold for both disciplines under study: sociology and linguistics. In addition to simply controlling for discipline in the models presented in Table 3, I also specified a multiple group analysis to see whether the processes of interest differed between the fields, as previous research suggests (Fox and Stephan 2001; Levin and Stephan 1989; Liebert 1976; Prpic 2002; Wanner, Lewis, and Gregorio 1981). Although the direction and significance of the coefficients linking gender, specialization, and productivity are the same for both fields, there are some differences in the magnitude of effects. Gender has a stronger effect on the extent of specialization in sociology (–0.62) than in linguistics (–0.36). However, in linguistics, specialization has a slightly larger impact on productivity, as indicated by both the relative size of the standardized coefficients and the R^2 values, which are .46 for sociology and .56 for linguistics.

The goal of this analysis was to introduce a distinct dimension of specialization—its extent. However, an examination of gender differences in areas of specialization might add to this analysis, especially with respect to disciplinary differences. Do men and women specialize in different areas, and could this affect the extent to which they specialize and/or their productivity? This could be the case if some areas (like comparative-historical work) require intensive historical knowledge and language skills or other areas lend themselves well to extensive and time-consuming field research. In sociology, we know that women have tended to rely on qualitative methods (Grant, Ward, and Rong 1987) and write on gender issues (Grant, Ward, and Bottenfield 1993; Lutz 1990) more often than men, and perhaps these differences in primary areas of substantive interest contribute to both their low degrees of specialization and their reduced productivity. Examining the distribution of academics' modal specialty areas by gender and discipline reveals interesting disciplinary differences. In linguistics, women's two most popular modal areas (phonology and syntax) are the same as men's. In sociology, women are likely to specialize in sociology of the family, marriage, and divorce (code 1941) and sociology of education (code 1432), whereas men tend to specialize in social group identity and intergroup relations (code 0410) and sociology of religion (code 1535). Thus, in sociology, women are not only specializing less than men (which is also the case in linguistics) but also specializing in different areas of study.

However, even as men and women sociologists gravitate toward different specialty areas, these areas do not differ in terms of their prestige. From the individual distributions of keywords, I determined each academic's modal subfield(s) and also constructed a measure of subfield prestige by counting the number of times each classification code appeared in the disciplines' top journals (*ASR* and *AJS* for sociology, and *Language* for linguistics) in the year 2003. Results from a *t*-test suggest that there is no statistically significant difference between the prestige of men's and women's typical areas of research. In addition, when I add this variable to the final model presented in Table 3, it fails to reach statistical significance and does not alter other findings. Because about 35 percent of subfields did not appear in the top journals at all (and thus values of subfield prestige are not distributed normally), I created a dichotomous variable that indicates whether a scholar's modal area appeared in a top journal in 2003. A chi-square test of independence between this dichotomous variable and gender confirm that men and women have equally prestigious areas of specialization ($p = .174$), and this finding remains when I conduct the test separately for each discipline.

DISCUSSION

In this article, I have found that a heretofore neglected aspect of scholars' research programs—the extent to which they are specialized—plays a critical role in not only explaining variation in productivity levels but also helping us understand why women have consistently lower rates of productivity than men. Having a specialized research program (i.e., writing papers in the same specialty area repeatedly) promotes productivity, but women tend to have less specialized research programs, thereby missing out on a means of achieving higher productivity. This mediating effect is large (especially relative to effects of more typical explanatory variables used to account for gender differentials in productivity), statistically significant, and robust to alternative measures of specialization and productivity.

Further decomposition of this process will be necessary to understand why women tend to specialize less than men even when they conduct research in the same areas, as was the case in linguistics. Perhaps the phenomenon at work in the film industry (Zuckerman et al. 2003) operates here, but only for men: While attempting to demonstrate expertise, men specialize because they think a diversified research program indicates a failure to excel in any one area, whereas women diversify because they think it indicates scholarly breadth. In other words, women may think that diversification will broaden their professional identity, whereas men may fear it will sully theirs. Men's and women's different professional networks and collaboration strategies may also be relevant. Men's wider and more diverse professional networks (Burt 1998; Kanter 1977) may allow them to find collaborators whose interests overlap their own, allowing their research collaborations to reinforce their expertise in one or a few specialty areas, whereas women's smaller and more homogeneous professional networks (Grant and Ward 1991; Renzulli, Aldrich, and Moody 2000) require them to branch out to other substantive areas if they want to collaborate, resulting in more diversified research programs.

I found the processes by which specialization mediates gender differences in productivity to be roughly the same in two fields typically neglected by the sociology of science: sociology and linguistics (Guetzkow, Lamont, and Mallard 2004). However, gender effects were more pronounced in sociology—a field with many ill-defined core areas (Dogan and Pahre 1989a)—than in linguistics. Linguistics has only a few core areas (semantics, syntax, morphology, phonology, and phonetics), each of which requires a very different knowledge base (e.g., anatomy, biology, sociology, psychology, neurology, grammar, and/or experimental design), and this likely encourages a great degree of specialization for men and women alike.[8] This normatively high degree of specialization in

the field of linguistics has a larger effect on productivity than comparable amounts of specialization in the field of sociology, where there is more cross-fertilization among subfields (Leahey 2006).

To shed more light on the processes of specialization and research productivity, future scholars might consider examining other domains of specialization. I focused on the extent of specialization in terms of subject matter (Turner and Turner 1990), not in terms of methodological or theoretical approach, even though we know that academics typically specialize by theory and method as well as substantive topic (Burt 2004). Even though women are less specialized substantively, perhaps they specialize more in terms of methodological and theoretical approach. While it is certainly the case that both kinds of keywords (the major descriptors and the classification codes) include terms that pertain to methodology (e.g., log-linear modeling) and theoretical perspective (e.g., symbolic interactionism), these dimensions are not distinguished in the current analysis.

I found that specialization aids productivity, but its effect on other career outcomes remains to be seen. For example, it may be breadth rather than depth of research that promotes visibility in the field, external job offers, job satisfaction, and salary levels. Responses to open-ended questions from the Web-based survey suggest that specialization's effects may vary depending on the career outcome under study. It may, for example, have negative effects on institutional mobility: "I think that specialization was detrimental to some extent, and may have kept me from moving to another department. Departments may have perceived me as being too narrow in focus and even a large department might not have wanted me if they already had someone working in the field" (woman sociologist). Specialization may also limit the "broad appeal" of one's work and subsequent visibility: "The particular areas that I have chosen to work on have helped me reach my current position, in the sense that the questions I ask in my research seem to speak to interests of a relatively broad sociological audience. For example, when I was on the job market my PhD seemed to interest people with different subspecialties for different reasons. I believe the fact that I have done work in more than one area has also been an advantage up to this point" (woman sociologist). Whether specializing in research—or any kind of work—promotes valued outcomes such as mobility, visibility, and even job satisfaction is a question that the current study poses and future studies will ideally address.

The strong, significant, and robust results of this study—that women specialize less than men and that specialization enhances productivity—are just a beginning. Before these empirical results can contribute to a theory of specialization in work and to more practical endeavors, such as policy

making and career planning, they must be replicated on other samples from other fields, at different times, with different outcome variables—including more encompassing measures of research productivity than the ones I used here. Does specialization also affect research productivity as defined by books, and if so, is the relationship positive, as we found here? Are women's levels of specialization more akin to men's levels when books are used to assess specialization? Do the current results hold up when the analysis shifts to other disciplines or even other professions? These kinds of questions will ideally motivate future research and contribute to the development of a broad theory of how specialization affects gendered career patterns.

NOTES

1. See the list of sections (http://www.asanet.org/page.ww?section=Sections&name=Overview) and the newly devised list of specialty areas (http://www2.asanet.org/footnotes/septoct05/fn7.html).

2. "Extensive" is the term that the Carnegie Foundation currently uses to refer to Research I universities: those that award 50 or more doctoral degrees per year in at least 15 disciplines.

3. This is evident in an increasingly equitable gender distribution of recent PhDs over time: In 1973, less than 15 percent of the professionally young (PhD within the past 10 years), full-time, academic labor force in the social and behavioral sciences was women; this increased to 45 percent by 1995. This contrasts with much lower levels of integration in the natural sciences and engineering, where in 1995, women constituted only 20 percent and 11 percent, respectively (National Research Council 2001).

4. Serial lists and classification schemes can be found at http://www.csa.com/factsheets/socioabs-set-c.php (for Sociological Abstracts) and http://www.csa.com/factsheets/llba-set-c.php (for Linguistics and Language Behavior Abstracts).

5. I do not distinguish between coauthored and single-authored pieces, as Wagner-Dobler (1997) and others have, because whether one worked on a piece alone or in collaboration with others should not diminish or enhance the prominence of that subfield in one's research program.

6. On the surface, this does not appear to be the case. Sociological areas in which women are disproportionately represented include 2900 (gender), with two child codes, but also 1900 (family), which has six child codes. Sociological areas in which men are disproportionately represented include 1200 (urban sociology), with just one child code, but also 0100 (methods), which has five child codes.

7. Tests to examine whether gender interacted with marital or parental status did not reach statistical significance.

8. In addition, linguists receive their doctoral training in disciplines as diverse as philosophy, psychology, English or another language, and cognitive science, and this, too, may discourage diversification.

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