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Parenting and research productivity: New evidence and methods

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Abstract

To date, studies on how having children affects the research productivity of academics, and whether the effects differ by gender, have had inconsistent findings. Using nuanced measures of parental obligations and linear growth modeling, we analyzed the effects of children on the entire careers of academics in two disciplines – linguistics and sociology – and tested for differential effects by gender. In addition, we modeled not only productivity, but also visibility, another component of scholarly success. Our findings suggest that after the birth a child, productivity growth declines, but more so for women. Thus, children account for part of the gender gap in rates of productivity over time. Children also have an impact on the research visibility of academics, but cannot account for gender differences in visibility.

Keywords

academic careers, children, gender, research productivity, research visibility

Why do female academics continue to publish less than their male counterparts? Sociological research has provided some compelling and consistent answers to this question. For example, we know that gender differences in academic rank (Xie and Shauman, 1998), organizational aspects of work (Fox and Mohapatra, 2007; Sonnert and Holton, 1995), subfields (Grant and Ward, 1991), and extent of specialization (Leahey, 2006, 2007) account for much of the gender disparity. Moreover, women's over-representation in less prestigious research universities, which have fewer resources and greater teaching and service requirements, contributes to their lower productivity relative to men (Xie and Shauman, 1998).

However, regarding one of the most intuitive explanations for a gender gap in research productivity – differential family responsibilities – research findings are inconsistent. Given the typical gendered division of childcare in the home (Hochschild, 1989; Wrigley, 1999), the presence of one or more children should have more detrimental effects on

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women's productivity than men's. But some researchers have found that children have no effect on productivity (for example, Cole and Zuckerman, 1987; Leahey, 2006), others have found negative effects (for example, Hargens et al., 1978; Long, 1990), and still others have found positive effects (for example, Fox and Faver, 1985; Nakhaie, 2002).

A number of factors may account for these inconsistent findings. First, measures of parenting vary across studies. Many studies employ a static binary indicator for presence of children (for example, Xie and Shauman, 1998), whereas more recent studies use a more nuanced measure that accounts for shifts in parental status and age of children (Fox, 2005; Stack, 2004). Second, results are also sensitive to the time frame under study. Much research to date has looked at the impact of children on productivity in relatively short time spans, such as 2 or 3 years (for example, Fox, 2005; Fox and Faver, 1985; Kyvik, 1990; Long, 1990; Sax et al., 2002). This neglects the longer-term effect of childrearing on academics' careers, and disregards the typical lag between conducting research, journal submission, and final publication.[1] Finally, the disciplines studied may influence results, because fields vary in their modes of research (for example, some are lab- or field-based) and their rates of collaboration, which may make the effects of children differ across fields. Some studies focus on one field (for example, Long, 1992), whereas others cover all academic fields (for example, Nakhaie, 2002).

Our research overcomes many of these limitations. Regarding measurement, we used Mary Frank Fox's (2005) nuanced and time-sensitive measure of parenthood, which accounts for not only the number but also the age of children. Regarding the time frame of the study, we collected retrospective data on scholars' entire careers, rather than examine a small subset of career years. Scholars have called for investigations into the impact of children on entire careers (for example: Fox, 2005; Kyvik, 1990), and this is the first study to heed this call with a time-sensitive measure of children.[2] We also sought to advance research on the subject by moving beyond the typical focus on productivity and including two measures of research *visibility.* Although productivity has been studied more often, research visibility is another critical component of scholarly success along which gender differences arise (Leahey et al., 2008). Our study is the first on this topic to use Linear Growth Modeling, a statistical method that can easily handle time-sensitive measures and longitudinal data on entire careers (during which children can affect not only the level of productivity and visibility, but also their rate of growth). Because we examine only two fields (sociology and linguistics), we cannot address inconsistencies that may result from differences in fields studied.

How children matter

Children are likely to have an adverse effect on both productivity and visibility. Compared with most workers, academics have considerable control over the number of hours they work, often working evenings and weekends. Rearing children takes a considerable amount of time and effort, potentially reducing the amount of time and energy devoted to scholarship, and this could diminish professional performance in terms of productivity or visibility (Hargens et al., 1978).

However, children of different ages demand different amounts of time and energy from their parents. Only a few previous studies have accounted for the age of children, and their results are not consistent. In a sample of PhD recipients in science (including social science) and engineering, Stack (2004) found that female scientists with only preschool children publish less than other scientists, even women with multiple children in other age ranges. Fox (2005), on the other hand, found that women engineers and scientists with preschool children are *more* productive than their childless counterparts or women with school-age children. To explain this, Fox suggests that academic women with young children are a very selective group, and that women with young children also tend to have fewer children. In a sample from all academic fields, Kyvik (1990) found that women with children are more productive than women without children, but the age of the children matters for comparisons with men: women with young children are less productive than their male counterparts, but women whose children are aged 10 years or older are just as productive as men in the same family situation and academic position (Kyvik, 1990; Kyvik and Teigen, 1996).

Qualitative data supplement these quantitative findings by highlighting scholars' perceptions of how children affect their productivity and strategies for managing work and family obligations. Many scientists say that having children has been harmful to their productivity levels (Sonnert and Holton, 1995), and that it is extremely difficult to juggle a scientific career and children (Grant et al., 2000). Academic scientists in natural, physical, and social sciences – particularly women – engage in elaborate and complex strategies to avoid productivity lags after having children (Grant et al., 2000). For instance, they collaborate more often, avoid having as many children as they may have preferred, and limit activities unrelated to work or family. Qualitative data suggest that academics believe that children matter for attaining career goals or at least the ease with which such goals can be attained.

Having children may also be more taxing for women than for men in academia. Drawing from Coser (1974), Grant et al. (2000) claim that science is a 'greedy institution' that makes total claims on scientists' membership and attempts to encompass the whole personality. They also argue that the family is also a greedy institution, especially for women. Indeed, the literature shows that women, even high-status professional women (Wrigley, 1999), still perform more housework and childcare than their male counterparts (Hochschild, 1989). Physical differences may also matter as only (biological) mothers can experience physical changes associated with pregnancy that could make conducting research more difficult, such as sickness and time spent breastfeeding. Given the gendered division of labor within the home, and the fact that academia is not particularly family-friendly, children may hinder the productivity of women academics more so than for men. For these reasons, we expected that productivity would decline after the birth of a child, and that this negative effect would be larger for women.

While productivity measured in terms of quantity of publications is perhaps the main criterion for scholarly success, the quality and visibility of such publications also may be critical for success (Whitley, 1984), as scholars are judged on their research visibility when it comes to distributing valued resources such as salaries, grants, awards, and research assistance (Reskin, 1977; Ward et al., 1992). To our knowledge, only one study to date has investigated the effect of children on scholarly visibility, as assessed by the number of citations in a 2-year period, and the effect was statistically insignificant (Hargens et al., 1978). However, the time and energy required to have and raise children may affect the quality as well as the quantity of an academic's scholarly output. Scholarly visibility is heightened by publishing (Leahey, 2007), but it is also dependent upon disciplinary and subdisciplinary networks, which may be harder to develop and maintain while raising children. And if scholars try to maintain their productivity after having children, time constraints may require them to sacrifice quality – perhaps by publishing in lower ranked journals. These effects may be particularly pronounced for women, who (as mentioned earlier) are typically responsible for a greater share of child-rearing and housework. For these reasons, having children might be assumed to dampen research visibility, especially for women. However, we also consider the possibility that with less time to devote to research, parents may dedicate themselves only to projects with a potentially high pay-off, which may lead to fewer (but more visible) publications. For these reasons – and because visibility has rarely been studied in the literature – our hypothesis for children's effect on visibility was non-directional; but we did expect that the effect would differ for men and women.

Data and methods

To assess whether and how children affect academics' career trajectories in terms of productivity and visibility, we analyzed a subset of the 20% probability sample of tenure-track and tenured linguists and sociologists that we collected in 2004. The sample was taken from the population of academics based in Research I universities in the USA, thereby partially controlling for access to some resources related to productivity and visibility. Our decision to study tenured and tenure-track scholars made the test of our hypotheses particularly conservative, for Mason and Goulden (2004) found that having young children affected the likelihood of PhD recipients securing tenure-track positions in US universities and that this effect was different for women and men PhDs. We analyzed the career trajectories of two-thirds of the original sample – the 150 individuals who completed the web-based survey, which asked about the presence and age(s) of children. A majority of our sample was male (63%) and from the field of sociology (58%). A comparison of the responders to our survey with the non-responders suggested that the latter were professionally older, as well as more productive and visible, but their gender distribution was equivalent to that of the non-responders.

Linguistics and sociology were chosen because the relatively low levels of sex segregation in those fields (Etzkowitz et al., 1994) provided subsample sizes large enough to obtain statistically significant comparisons. Because we were investigating the impact of children across the course of careers, it was necessary to have a sufficient number of women with lengthier careers to adequately test our hypotheses. While women are now relatively integrated in some natural science fields, such as biology, this was not the case two or three decades ago. In contrast, behavioral science fields such as sociology and linguistics experienced earlier gender integration, thereby making them particularly well suited for our goals. Indeed, in 1983, women accounted for 45% of the PhD recipients in sociology, 56% of the PhD students in linguistics, but only 34% of PhD recipients in biology (Nelson, 2007; www.lsadc.org/info/coswl/wm-in-ling-survey.pdf). We urge scholars to analyze career trajectories in other fields, such as biology, but different sampling procedures (or increasing the sample size) are likely to be necessary to get enough women with adequate career lengths.

We also chose to study these fields because the social sciences are under-studied compared with the natural sciences (Guetzkow et al., 2004), and because these fields are likely to provide a conservative test of our hypotheses. While sociology and linguistics share important characteristics with other fields (such as demanding hours), there are differences that may lessen the impact of children on productivity and visibility compared with physical and life science fields. First, work is more often portable in sociology and linguistics (for example, analyzing survey data, transcription), potentially allowing researchers to work from home or even while traveling, whereas in the physical and life sciences, much work is restricted to the lab and requires regular presence there. Second, compared with life and physical scientists, sociologists and linguists collaborate less (Babchuk et al., 1999), providing them a greater degree of independence and flexibility to attain some work–family balance. If children matter in the behavioral sciences, we speculate that they probably matter even more in the natural sciences.

Of course, our focus on these two fields must be taken into consideration when interpreting our results. Our results are not generalizable to academics in other fields – such as natural, biological, and physical scientists – which have different sizes of gender gaps in productivity (Nakhaie, 2002) and different modes of research and publication (for example, greater collaboration). If our approach proves fruitful, we hope future scholars will employ similar methods – analyzing entire careers with appropriate statistical models, using time-sensitive measures of parenthood and productivity, and incorporating visibility – to understand the effects of children on men's and women's academic careers in other fields better.

Key measures

Time: Career year

Because our study utilized a longitudinal design to analyze career trajectories, and because research productivity has a distinct career-cycle profile (Xie and Shauman, 2003), we used career year to measure time. We followed previous studies (Leahey et al., 2008; Toren and Moore, 1998) by using the attainment of a certain threshold as a starting point for each career trajectory. Each individual's trajectory begins when two conditions are met: when he or she obtains a tenure-track academic position and publishes at least two journal papers.[3]

Gender

Gender is a dichotomous variable (female = 1; male = 0) constructed from a self-reported question on the survey.

Children

In the survey, respondents reported the number of their children, along with the ages of the eldest and youngest.[4] Using this, we followed Fox (2005) and accounted for both the number of children and their age categories. This is a time-sensitive measure of number of children that changes with each additional birth. Like Fox (2005), we constructed variables for the presence of a preschool child (1 if any; 0 if none) and the presence of school-age children (1 if they have children of school age; 0 if none). These are not mutually exclusive: both can equal 1 when the parent has two children, with one in each category. These variables are all lagged by 1 year given the time-lag between producing and publishing research. To capture the effect of children on the *growth* of productivity and visibility, we created a time-varying variable to capture the interaction of the number of child with time. To ascertain whether children matter differently for women and men, we constructed interaction terms by multiplying gender by number of children.

Productivity

To measure productivity, we used the indicator that is most common in the literature: a publication count (Allison and Long, 1987; Fox and Faver, 1985; Prpic, 2002; Reskin, 1977, 1978; Ward and Grant, 1995; Xie and Shauman, 1998). In addition, following previous research, we include only peer-reviewed journal articles, which previous studies have found to be highly correlated with total productivity; these can include books and contributions to edited volumes (Reskin, 1977, 1978). We did not base our measures of research productivity on self-reports as several others have done (Fox and Faver, 1985; Prpic, 2002; Xie and Shauman, 1998); instead, we obtained this information from publicly available electronic databases to reduce any systematic and random measurement error (Long, 1992; Reskin, 1977). We collected scholars' publication histories from discipline-specific electronic databases – *Sociological Abstracts* and *Linguistics and Language Behavior Abstracts* – both of which are managed by Cambridge Scientific Abstracts. By entering authors' names, we accessed their entire publication histories. Because we were interested in trajectories, we used the cumulative count of publications in our analyses. Thus, the publication count was time-varying, with the value in the year 2004 representing the cumulative number of publications in an author's career up to that point.

Visibility

We used two measures of research visibility proposed in the literature – journal impact score-weighted publications and citation counts – both of which are time-varying cumulative sums. The first measure relies on the impact factor that ISI's Journal Citation Reports provides for each journal, which for any given year is the average number of citations to items in the journal published in the previous 2 years. Like Levin and Stephan (1989), we measure visibility by counting publications after they had been weighted by their respective journal impact factor scores. Consequently, papers published in high-impact journals, such as the *American Sociological Review* and *Language*, counted more in our measure of visibility than papers published in journals with lower scores.[5]

Members of academic fields perhaps rely more on citation counts than journal reputations to gauge an author's visibility (Diamond, 1986). To measure this, we followed Long (1992) by collecting citation rates for the papers published per year by each individual in our sample. Citation data for sociologists were obtained from the Social Science Citation Index, and data for linguists were obtained from the Arts and Humanities Index.

Control variables

Because institutional context may matter for productivity (Allison and Long, 1990) and research visibility, we statistically controlled for prestige of the PhD-granting and employing departments using rankings obtained from the National Research Council (Goldberger et al., 1995). With survey data on academics' institutional mobility, we were able to control for changes in the departmental prestige when they moved from one department to another.

We also controlled for important individual-level factors, such as field (sociology = 1, linguistics = 0), time between PhD receipt and the start of their career trajectory, marital status, and biological age at trajectory start. We also controlled for academic rank because productivity and visibility may depend not only on career year but career stage (Wagner-Dobler, 1997), and the two are not necessarily correlated perfectly: women tend to remain at each rank longer than men (Ward et al., 1992). The extent of research specialization has been found to affect career trajectories for both productivity and visibility; and because men and women differ in the extent to which they specialize, we also accounted for this variable in our analysis (Leahey, 2006, 2007).

We accounted for the inter-relationship between visibility and productivity by incorporating lagged measures of one construct when attempting to explain variation in the other construct. Because the sheer quantity of publications fosters recognition by others in the scholarly community (Cole and Zuckerman, 1984: 231), we controlled for productivity when modeling visibility. Perhaps less intuitively, heightened visibility may also promote productivity through a reinforcement process (Cole and Cole, 1973; Leahey et al., 2008). Visibility is a criterion for academic merit for promotions, grants, research assistance, and other rewards (Reskin, 1977). Accordingly, it reinforces past productivity and facilitates future productivity as well. To reduce concerns of reverse causality, we took Singer and Willett's (2003) advice to use lagged versions of the predictor variable in each model.

Statistical model

Given our interest in children's impact on career trajectories, we employ hierarchical linear modeling (HLM) for longitudinal data analysis. This allows key explanatory variables, such as gender and parental status to affect both the *level* (that is, intercept) and rate of *growth* (that is, slope) of such key career outcomes as productivity and visibility. While most sociological applications of HLM focus on contextual effects, this method can also be adapted to study individual change over time, typically referred to as linear growth modeling (LGM). This allowed us to model scholars' yearly productivity (or research visibility) over their careers, rather than rely on a cumulative, static measure of these outcomes. LGM can handle unbalanced datasets in which the number of time points in a trajectory varies across individuals. In other words, this method can handle careers of varying lengths. In fact, this method is ideal because it allowed us to examine career processes without resorting to categorizing that process into discrete time periods – which was more typical before the advent of HLM (Fox and Faver, 1985; Reskin, 1978).

Unlike most applications of LGM, most of our predictors were time-varying, rather than static, individual-level predictors. A coefficient associated with time-varying predictors does not indicate the predictor's effect on the intercept (here, the origin of the trajectory). Instead, a time-varying predictor can shift the entire trajectory – either up (if the coefficient if positive) or down (if the coefficient is negative) – holding the slope of it (that is, the rate of growth) constant. Thus, main effects of time-varying predictors suggest shifts among parallel trajectories across time, but no change in the rate of growth. The 'intercept' then, for a time-varying binary indicator for presence of children is the population average difference in the outcome (for example, productivity) between people with and without children over time (Singer and Willett, 2003:164). Thus, having a child creates a discontinuous trajectory, in which a 'jump' or 'dip' can occur, and this change only occurs in the year that the independent variable changes (or the year after if independent variables are lagged 1 year – see Singer and Willett [2003: 165]).

Whereas changes in intercepts (as described above) reflect *parallel* shifts, the effect of such time-varying independent variables on the slope, or trajectory of interest, indicates the *change* in productivity growth after the birth of a child; in other words, the angle of the slope can change. Therefore, the slope can be altered by children.

In LGM, career years (level I) are nested within persons (level II), so we specify models at each level and estimate a combined model. We modeled our dependent variables of interest (cumulative productivity and cumulative visibility), here symbolized by Y, for person i at time t for level I as:

$$Y_{ti} = \pi_{0i} + \pi_{1i}TIME_{ti} + \pi_{2i}TIME_{ti}^{\;2} + \pi_{3i}CHILD_{ti} + \pi_{4I}\,CHILD_{ti} \times TIME_{ti} + \ldots + \pi_{qi}\,X_{qti} + e_{ti}$$

Thus, Y is a function of an intercept (π_{0i}, the grand mean of publications across academics when all predictors, including time, equal zero), TIME (π_{1i} and π_{2i}), number of children (CHILD) at time t (π_{3i}), the interaction of number of children (CHILD) and TIME (π_{4i}), while controlling for other relevant variables (π_{qi}). We centered $TIME_{ti}$ (career year) so that the intercept parameter π_{0i} can be interpreted as the number of publications at the start of the trajectory. In the level II models, we modeled the person-specific intercepts (π_{0i}) and slope (π_{1i} and $\pi_{2i,}$ which define the curvilinear trajectory), using only time-invariant predictors, such as gender:

$$\begin{aligned}
\pi_{0i} &= \beta_{00} + \beta_{01}\,FEMALE_{1i} + \ldots + \beta_{0q}\,X_{qi} + r_{0i}\\
\pi_{1i} &= \beta_{10} + \beta_{11}\,FEMALE_{1i} + r_{1i}\\
\pi_{2i} &= \beta_{20} + r_{2i}
\end{aligned}$$

A preliminary analysis indicated that no predictor affected the rate of acceleration or deceleration, π_{2i}, and so we did not include such interactions, although we did allow a random component (r_{2i}) to be associated with this quadratic term. The random components of the Level II models (essentially the error terms r_{0i}, r_{1i}, and r_{2i}) contain the effect of unmeasured individual characteristics that do not change over time.

Results

Descriptive results

Table 1 displays the descriptive results by gender, and shows that men, on average, had significantly higher productivity (as measured by the number of papers published) and greater visibility (as measured by the number of papers weighted by journal impact factor and number of citations). Unlike Long (1992), who found that women biochemists garnered more citations per publication, we found that men had slightly more citations per publication than women in our sample. Men were also significantly older and had been in their careers significantly longer. Men had significantly more children than women, which has also been documented in previous research (for example, Fox, 2005), and may suggest that women, more so than men, believe that children are incompatible with their academic careers (Grant et al., 2000).

Multivariate results

In order to systematically examine the effects of having children on career trajectories, we specified a series of hierarchical linear models wherein productivity and visibility trajectories are the outcome variables of interest. We present results for each outcome variable in Table 2. For each outcome, we ran two models with all control variables and predictors of interest, adding interaction terms to the second model to ascertain whether children matter differently for women and men. To assess the value added of these interaction terms, we looked at the individual significance tests for the respective coefficients, and compared deviance statistics (for which lower values indicate a better fitting model) using the deviance likelihood ratio test.[6] Because of space constraints, we limit our discussion to the variables of interest.

Productivity

Our findings suggest that the number of children significantly affects both the *level* and *growth rates* of productivity, although the direction of the effect differs (see Table 2, Model 1a). Because number of children is time-varying and significant, this suggests that children's impact on productivity levels is discontinuous. The data indicate a significant one-time jump in productivity levels in the year after the birth of a child. This pattern is compatible with previous research that showed that having young children increased productivity (for example, Fox, 2005). However, this may be an artifact of planning for

Table 1. Descriptive statistics

Variable	Women	Men
	Mean	Mean
Cumulative articles	10.85***	18.26***
Cumulative impact score-weighted articles	7.06**	14.13**
Cumulative citations	96.70**	247.17**
Citations per publication	7.98*	10.85*
Number of children	0.94***	1.54***
Age (years)	45.77***	52.00***
Career age (years)	11.96***	20.43***

Note: the level of significance is indicated by t-tests. All statistics are cumulative up to 2004, the final year included in the dataset. *p<.05, **p<.01, ***p<.001.

Table 2. Effects on publications, weighted publications, and citations (coefficients and standard errors)

Variable	Publications				Weighted publications				Citations			
	Model 1a		Model 1b		Model 2a		Model 2b		Model 3a		Model 3b	
	Coefficient	SE	Coefficient	SE	Coefficient	SE	Coefficient	SE	Coefficient	SE	Coefficient	SE
Time in career years (slope)	0.76***	0.06	0.74***	0.06	0.32***	0.08	0.33***	0.08	5.03*	1.97	4.41*	1.93
Time^2 (acceleration)	–0.003+	0.00	–0.003+	0.00	0.002	0.002	0.002	0.002	0.02	0.05	0.02	0.05
Key explanatory variables: effect on level												
Female	0.16	0.37	–0.11	0.40	–0.05	0.45	–0.13	0.48	–0.03	11.42	–14.34	12.23
Number of children[abc]	0.29*	0.12	0.20	0.14	–0.004	0.15	–0.06	0.15	–20.04***	3.88	–25.63***	4.26
Preschool children (yes=1, otherwise=0)[ab]	0.12	0.09	0.12	0.09	0.06	0.10	0.07	0.10	0.18	2.98	0.20	2.98
School age children (yes=1, otherwise=0)[ab]	0.20*	0.09	0.20*	0.09	0.05	0.10	0.05	0.10	–8.16**	3.07	–7.61*	3.07
Female × number of children[abc]	–	–	0.39	0.25	–	–	0.18	0.28	–	–	23.69**	7.62
Key explanatory variables: effect on slope (time)												
Female × Time	–0.16*	0.07	–0.09	0.08	–0.17+	0.09	–0.22*	0.10	–7.50***	2.13	–5.72*	2.50
Number of children[ab] × Time	–0.06***	0.01	–0.04**	0.02	–0.04***	0.02	–0.05***	0.02	1.49***	0.44	1.84***	0.49
Female × Number of children[ab] × Time	–	–	–0.07*	0.04	–	–	0.02	0.04	–	–	–1.83*	1.06

Table 2. *(Continued)*

Variable	Publications				Weighted publications				Citations			
	Model 1a		Model 1b		Model 2a		Model 2b		Model 3a		Model 3b	
	Coefficient	SE	Coefficient	SE	Coefficient	SE	Coefficient	SE	Coefficient	SE	Coefficient	SE
Control variables: effect on level												
Age at beginning of trajectory	–0.05	0.04	–0.05	0.04	–0.09+	0.05	–0.09+	0.05	0.61	1.26	0.35	1.25
Married	–0.52	0.73	–0.58	0.72	0.61	0.89	0.62	0.89	29.87	22.16	27.97	21.91
Divorced	–1.15	0.87	–1.19	0.87	0.08	1.07	0.11	1.06	30.95	26.61	31.43	26.31
Single [reference category]	–	–	–	–	–	–	–	–	–	–	–	–
Field (Sociology=1, Linguistics=0)	–0.3	0.36	–0.29	0.36	1.90***	0.44	1.91***	0.44	2.97	11.04	4.17	10.93
Years from PhD to start of trajectory	0.00	0.06	0.00	0.06	0.06	0.07	0.06	0.07	3.44*	1.77	3.43*	1.75
Department prestige of PhD institution	–0.08	0.06	–0.08	0.06	0.05	0.07	0.06	0.07	2.34	1.73	2.51	1.71
Full professor[ab] (yes=1, otherwise=0)	0.31*	0.15	0.32*	0.15	0.21	0.16	0.20	0.16	–8.43+	4.90	–7.97+	4.90
Associate professor[ab] (yes=1, otherwise=0)	0.28**	0.10	0.29**	0.10	0.04	0.11	0.03	0.11	–6.21*	3.21	–5.88+	3.23
Assistant professor [reference category]	–	–	–	–	–	–	–	–	–	–	–	–
Department prestige[ab]	0.02	0.03	0.02	0.03	–0.03	0.03	–0.03	0.03	2.93***	0.81	3.00***	0.81

(Continued)

Table 2. *(Continued)*

Variable	Publications				Weighted publications				Citations			
	Model 1a		Model 1b		Model 2a		Model 2b		Model 3a		Model 3b	
	Coefficient	SE	Coefficient	SE	Coefficient	SE	Coefficient	SE	Coefficient	SE	Coefficient	SE
Cumulative citations[ab]	0.007***	0.0008	0.007***	0.0008	–	–	–	–	–	–	–	–
Cumulative publications[ab]	–	–	–	–	0.55***	0.01	0.55***	0.03	14.66***	0.88	14.61***	0.88
Specialization[ab]	0.96***	0.26	0.99***	0.26	–0.39	0.29	–0.4	0.29	–34.28***	8.48	–33.47***	8.48
Control variables: effect on slope (time)												
Cumulative citations[ab] × Time	0.00	0.00	0.00	0.00	–	–	–	–	–	–	–	–
Cumulative publications[ab] × Time	–	–	–	–	–0.006***	0.00	–0.006***	0.00	–0.49***	0.05	–0.49***	0.05
Specialization[ab] × Time	0.12***	0.04	0.12***	0.04	–0.03	0.05	–0.03	0.05	4.73***	1.36	4.72***	1.36
Intercept	5.57***	1.57	5.73***	1.57	1.73	1.92	1.85	1.92	–73.56	47.92	–61.44	47.55
Number of observations	2664		2664		2664		2664		2664		2664	
Deviance (–2 log likelihood)	8810.38		8806.68		9330.66		9328.38		27435.52		27425.96	

Note:+ p<.10, *p<.05, **p<.01, ***p<.001.
[a]Variable has been lagged by 1 year.
[b]Variable is time-varying.
[c]One-tailed test in Model 1.

a child: when an academic expects a child, he or she may work diligently to finish research while anticipating less time in the future. In our data, this significant gain in the level of productivity occurs in the first year only, and does not continue throughout children's preschool years. Similarly, having children enter school has a positive effect on the level of productivity, most likely because this transition leaves parents with more time for research.

Perhaps more importantly, our results suggest that having children has a significant and negative effect on the rate of productivity *growth*: the rate of increase in the number of publications for individuals who have children was lower than that of their childless peers in our sample. In other words, the slope of productivity growth became less steep following the birth of a child. Therefore, any initial rise in productivity following the birth of a child eventually turns into a cumulative disadvantage, perhaps because caring for children limits the time available for scholarship (Kyvik, 1990). While this effect is fairly small – parents' rate of growth in productivity is 92% of their childless peers' growth rate – it would result in fairly large disparities over time. Moreover, the cumulative effect may not be large enough to exhibit significant productivity differences within the 2- or 3-year periods often analyzed by other researchers (for example, Sax et al., 2002).

While women and men start their academic careers with similar publication records, women experience slower productivity growth over time (see Model 1a), but the differential effect from having children accounts for part of this disparity. We assessed whether the effects of children were significantly different for women and men by incorporating a two-way interaction between gender and children, and a three-way interaction between gender, time, and children (see Model 1b). The correlation between the latter variable and productivity was statistically significant, and the lower deviance statistic suggests that Model 1b is superior to Model 1a. Although the deviance likelihood ratio chi-square statistic did not quite reach statistical significance, we maintain that the theoretically motivated variables (with one significant coefficient) should remain in the model. Thus, while men's productivity growth is significantly reduced after having a child, women's productivity growth is reduced even more (the interaction term is –0.07 ($p<.05$) in Model 1b). Female parents' growth rate was 85% of their childless peers, and gender's main effect on the slope (that is, productivity growth) was no longer significant, suggesting that the differential effects of having children contributed to the gender productivity gap, as Stack (2004) also suggested. Given the typical division of labor in the home, it is not surprising that children have a more negative effect for women's rate of publication growth. And although the interaction of gender and number of children had no significant effect on the *level* of productivity (0.39), the main effect of children became insignificant once it was introduced (from 0.29 ($p<.05$) in Model 1a to 0.20 in Model 1b), perhaps indicating that, compared with men, women experienced a slightly (but not significantly) greater increase in the level of productivity after the birth of a child.

As an illustrative example, the combined effects of children, gender, and time (holding all other variables constant) indicated that 18 years after having a child, a woman has an expected total of 11.54 publications, whereas her childless counterpart (man or woman) has an expected 13.32 publications. Given that publications are expected to increase by 0.74 per year (holding all other factors constant), the 1.78 expected difference in publications between a female parent and her childless counterparts indicates that her productivity was more than 2 years behind, on average, when her one child reaches the age of 18 years.

Visibility

The number or ages of children had no effect on the level of weighted publications (a measure of research visibility), but children did seem to hinder the growth rate of publishing papers in high-impact journals (see Table 2, Models 2a and 2b). Specifically, parents' rate of growth in weighted publications was 88% of that of their childless peers. Notably, this statistical method controls for career year, so parents had lower growth rates than non-parents independent of career stage. And as we found for productivity, the main effect of gender on weighted publication growth was pronounced: when we controlled for productivity, women's growth rate of high-impact papers was significantly lower than men's.

Unlike our results for productivity, these main effects of gender and parental status do not interact: it seems that having children has a similar effect for men and women on their weighted publication growth (0.02 in Model 2b). Indeed, the significant gender difference in rate of growth of visibility (0.17+) in Model 2a remains even when interaction terms are introduced. The coefficients and the deviance likelihood ratio chi-square statistic failed to reach statistical significance, indicating that the inclusion of interactions does not improve model fit. Thus, children cannot account for gender differences in visibility trajectories as defined by weighted publications. This disparity may reflect women's lower propensity to submit their papers to high-impact journals – perhaps because of lower confidence in their professional abilities and lower sense of entitlement (Babcock and Laschever, 2003) – given the lack of evidence for gender differences in acceptance rates at prestigious journals such as the *American Sociological Review* (Bakanic et al., 1987).

For our alternative measure of scholars' research visibility – cumulative citation counts – we found that the effects of gender and children were statistically significant (see Table 2, Model 3a). Men's citation growth rate – when controlling for productivity – was higher than women's, resulting in large gender differences as careers progressed. While the number of children was inversely related to the level of citations, it had a small direct relation to the rate of growth in citations. Having school-age children also reduces citations. While this may seem counterintuitive, it is important to remember that productivity increases after children enter school (see Table 2, Models 1a and 1b). Because we controlled for productivity, this may indicate that while parents are able to increase their productivity when children enter school, each of these publications is cited less often on average. Although an earlier study of chemists (Hargens et al., 1978) found no significant effects of having children on citations over a 2-year period, our results for sociologists and linguists suggest children do matter for citations.

The effect of gender on the rate of citation growth remained significant in Model 3b, suggesting that having children did not account for gender differences in citation growth, but it did have different effects on women's and men's citation patterns. According to both individual significance tests for coefficients and the deviance likelihood ratio test, Model 3b – which incorporates these key interaction terms – is superior to Model 3a. At least initially, having children diminished the citation advantage of men over women: it decreased men's level by 25.6 citations, but increased their growth rate by 1.84 citations per year (see Table 2, Model 3b). Even though men's growth rate of productivity declined after children (as Model 1b showed), and their citation counts took an initial hit, their rate of citations actually increased over time. The same processes are not at work for women and this gender difference cannot be attributed to differences in the timing of children: descriptive analyses demonstrated no significant gender differences in career year or biological age at first child.

Discussion

Previous research findings on the effects of children on productivity have been inconsistent (Fox and Faver, 1985; Long, 1990; Leahey, 2006), and our findings suggest possible reasons for such inconsistency. In our sample of sociologists and linguists, we found that children had a differential impact on productivity levels and productivity growth rates: they had an initial, one-time, *positive* effect on levels of productivity (which may be an artifact of planning for a child) and a *negative* effect on productivity growth over time. Second, the negative effects of children on productivity appeared to unfold and accumulate *over time*, highlighting the importance of examining academics' entire careers for understanding the cumulative effect of children in other fields. Consequently, we urge future researchers interested in the effects of children on academic career outcomes to use longitudinal data with time-sensitive measures of children.

Our findings suggest that children account for part of the productivity gender gap in sociology and linguistics. Significant gender differences in productivity growth were eliminated once we controlled for differential effects of children by gender. Given the gendered division of labor in the household, it is not surprising that women suffer greater penalties than men. Moreover, the demanding family–work balancing acts that academics, particularly women, feel necessary to perform (Grant et al., 2000) may grow more challenging to sustain and less effective as a career progresses, contributing to women's stagnating productivity growth rates. While our results may not be generalizable across fields, we hope our findings and methods will motivate studies of other fields to understand the effects of children on productivity and their likely impact on the gender productivity gap better.

Our study is the first to investigate whether children affect two measures of research visibility – weighted publications and citations – and our results reveal a complicated story that subsequent research can help clarify. In our sample of sociologists and linguists, both men and women tended to publish in less prestigious journals after the birth of a child, and men in particular also experienced a drop in their level of citations. However, men's citation *growth rate* actually increased after having children. These seemingly contradictory findings for men – that growth in publications in prestigious journals declined at the same time that growth in citations occurred – may be because citations are related to networks and disciplinary alliances (Stinchcombe, 1982). Perhaps fathers become more enmeshed in networks or more comfortable with promoting their own work. We hope future research will be able capture these diverse aspects of visibility and assess children's potential effects on them.

In our sample, we find that women were disadvantaged in terms of their research visibility, even after controlling for children. Contrary to our results, research on biochemists (Long, 1992), biologists (Sonnert, 1995), and sociologists (Ward et al., 1992) found that women received more citations per paper than did men. Thus, more research on gender differences in research visibility is needed, and there is ample room for future research to operationalize and incorporate other potential mechanisms for gender differences. We found gender differences in weighted publication and citation growth, but previous research has found no gender differences in acceptance rates at prestigious sociology journals such as the *American Sociological Review* (Bakanic et al., 1987), perhaps indicating that women are less likely to submit their work to highly visible journals that generally garner more citations in other fields. Or perhaps gender differences in reference patterns are relevant: scholars are more likely to cite the work of someone of the same sex (Ferber, 1986), and even after controlling for topic, male scholars cite women less often than female scholars do (McElhinny et al., 2003). These possibilities lend themselves nicely to a reunion of data and theorizing on individual career outcomes, professional networks, and reference patterns.

Notes

1. Recent studies account for this lag better by including both published papers and accepted papers in their measure of productivity (for example: Fox, 2005; Fox and Mohapatra, 2007).
2. Nakhaie (2002) modeled cumulative publications at the time of the survey. However, this analysis was not longitudinal and controlled for the number of children, but not when they born. Thus, when modeling life-time publications, an academic with a child born in the previous year received the same number of children as an academic who had a child 10 years ago.
3. Publishing two or more papers is vital because we controlled for extent of specialization (a measure that depends on potential repetition of research areas with subsequent publications), because our previous work has found that specialization affects productivity and visibility trajectories (Leahey et al., 2008).
4. Only asking the ages of the oldest and youngest children was problematic for knowing the ages of children when there were more than two. However, only 20 of the academics had more than two children, and they were spaced closely enough that we could always know whether or not there were preschool or school-age children in the house.
5. For the lowest-tier journals that were not rated in the Journal Citation Reports, we assigned a value (0.05) that lies just below the lowest impact factor but is greater than zero.
6. The difference in the deviance statistics for a full and reduced model was compared with a chi-square distribution and the degrees of freedom was equivalent to the difference in the number of parameters.

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