Productivity and Reproductivity: Fertility and Professional Achievement among Research Scientists*

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ABSTRACT

Data for a group of research chemists are examined to test the hypothesis that marital fertility is associated with lower levels of research productivity and to assess the extent to which the fertility–productivity relationship varies by sex. The results show a negative relationship between fertility and productivity among the scientists; the relationships for the sexes are similar in direction and magnitude. We argue that previous studies of the impact of marital fertility on career attainments have failed to find the expected negative association because they have dealt with workers who cannot freely invest extra time and energy in work efforts and because they have used inadequate measures of attainment such as occupational mobility rather than more direct measures of job performance.

The idea that occupational success is negatively associated with fertility is a classical hypothesis in social demography. Ambition for social achievement, it is reasoned, motivates couples to limit the number of their children in order to free the time, energy, and money which are usually required to rear a large family, for economic and occupational pursuits (Berant; Westoff et al.). Investing these resources in occupational activities should result in superior economic or occupational performance, which should in turn be reflected by later career success. The hypothesized negative association between career success and fertility should be due in part to deliberate attempts by ambitious couples to limit their fertility and in part to the advantages which extra resources confer on couples who have fewer children, regardless of the reasons for their lower fertility.

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A number of studies have investigated the relationship between fertility and career success, where career success has been measured by either inter- or intragenerational mobility. Those studies considering *inter*-generational mobility have shown no effects at all or none that can be unambiguously attributed to fertility (Blau and Duncan; Perrucci). Intergenerational mobility is largely a function of educational attainment and the status of one's first job, and most workers begin their first jobs before marrying or very early in the course of marriage. Thus, low marital fertility is not necessarily causally prior to intergenerational mobility. One might expect less ambiguous results when career success is defined as *intra*-generational mobility. Intragenerational mobility generally occurs during marriage and, often, during the reproductive years. If a large family encumbers mobility, then those with smaller families ought to exhibit intragenerational mobility. Empirical research has not supported this prediction. Featherman reports that fertility has a small *positive* relationship to occupational attainment when prior occupational status is controlled. Perucci found no relationship between the fertility of engineers and their job status controlling for duration of marriage and for educational attainment. Other research, generally with weaker study designs, has also failed to find a significant association between fertility and intragenerational mobility (for a review, see Boyd; Westoff et al.).

Since the expected negative relationship between fertility and career success has not been empirically supported, we may ask where the reasoning behind the prediction is in error. The prediction rests on the following assumptions:

1. People with few children devote fewer resources such as time, energy, and money to their families.
2. Such individuals can invest some of the surplus resources in their occupations, leading to better job performance.
3. This performance leads in turn to occupational success.

When the steps in the argument are detailed, it is not difficult to see why researchers have found little evidence for a relationship between fertility and mobility. First, the studies reviewed above focus only on the relationship for men, and it is not at all clear that additional children require men to expend more time and energy on their families. Under the traditional sexual division of labor, husbands may be exempt from the burdens associated with additional children, especially as far as their time and energy are concerned. Indeed, the effect might be that men will devote more resources to their work to meet the material demands of large families. Second, even if people of either sex with small families do have more free time or energy, they may not be able to apply surpluses to their work. Most people work fixed hours at the direction of others. Such circumstances make it difficult to apply extra time or energy to any effective occupational

advantage. Moreover, people's educational level or talents frequently limit their advancement regardless of the scale of their efforts. Finally, even when investments do lead to improved performance, the relationship between performance and career success is less than perfect for a variety of reasons. To the extent that the relationship between job performance and career success is weak, the latter will serve as an inefficient indicator for studies of the impact of marital fertility on job performance.[1]

However, the hypothesis linking fertility and success may be more plausible for some groups than it is for the population as a whole. This paper tests the hypothesis by examining the relationship between these variables in a sample of male and female Ph.D. chemists who work in settings which emphasize the performance and publication of research. These workers provide a strategic group for testing the hypothesis that marital fertility inhibits job performance for the following reasons.

First, since they are generally expected to publish research findings and are rewarded for such accomplishments, it is possible to measure aspects of their performance by examining their publication records. Focusing on performance offers a considerable advantage over studies which operationalize career success as inter- or intragenerational mobility. Second, compared to most workers, research scientists have considerable discretion in allocating their time and energy to research, and often work during evenings and weekends. Thus, additional investments of time and energy should lead to improved professional performance (Hargens). Third, since research scientists do not differ greatly in their educational achievements or in the day-to-day demands of their job, the influence of differential fertility on job performance will be less confounded with these other variables than is the case in more heterogeneous populations.

Since we include both male and female chemists, we can determine whether previous studies' focus on men accounts for their failure to observe the expected negative association between marital fertility and career success. If this accounts for the previous failures to find the expected association, we should observe it only among the female chemists.

Data and Methods

Our study is based on biographical data for members of several cohorts of chemists who obtained Ph.D. degrees at U.S. universities during the period from 1955 to 1961. The names of all women (N = 231) and a systematic random sample of men (N = 222) were obtained from the American Chemical Society's biennial publication, *Directory of Graduate Research*. Biographical data for these scientists were sought in *American Men and Women of Science* and, for those not included in this source, were solicited from the individuals by a mailed questionnaire.[2] By these methods we obtained

data for 90 percent of the scientists (86 percent of the women and 94 percent of the men).[3] The data include information about career histories, marital status and year of marriage, and number of children.

Notions about the relationship between fertility and occupational success have typically focused on married couples' fertility decisions, both because most fertility decisions are made by married couples and because most of the individuals whose performance was being examined were married. Although the probability of being married for male scientists is not unlike that for the general population, women scientists are substantially less likely to marry.[4] In order to test the reasoning underlying previous studies of marital fertility, we restricted our analyses to married scientists, thereby excluding about 9 percent of the men and 36 percent of the women in the original survey.

The sample includes chemists in a variety of occupational settings. For the present study we had to select those who were employed at the time of the survey in settings that encouraged the performance and publication of research. Two such groups were chosen for analysis: those with positions in universities (institutions granting advanced degrees in chemistry) and those with positions in federal or state government research laboratories.[5] There were 96 such married individuals, 39 men and 57 women.[6]

Data on the publication records for the scientists in our study were obtained from the 1969 and 1970 editions of *Science Citation Index*.[7] This source provided data on the number of research articles published during 1969 and 1970 and on the number of times a scientist's work was cited by others during this two-year period. These two types of data are commonly used as measures of the quantity and quality of scientists' scholarly contributions (Cole and Cole). The number of references made to a scientist's work during a given period is in part a function of the number of papers that scientist has previously published, and as a result there is a substantial correlation between measures of quality and quantity of publications. In order to obtain a measure of the quality of scientists' published work which is independent of their volume of publications, we regressed the scientists' 1969–70 citation rates on the total number of papers they ever published and were thus subject to citation.[8] We use the residuals of the observed from the predicted citation rates (standardized to have a unit variance) to measure the quality of scientists' published work.[9]

American Men and Women of Science, our primary biographical data source, provides data on scientists' number of children but not their birth dates. Ideally, we would prefer the latter as well as the former information, since the amount of time spent on childrearing and related activities varies by children's ages (Turchi). We assess the probable effect of our ignorance of the children's ages by examining the association of duration of marriage and our measures of productivity, net of other variables.

We experimented with three different representations of the number-of-children variable in our analysis: (1) the number of children expressed as a simple metric variable, (2) a dummy variable distinguishing the childless from those with children, and (3) a series of three dummy variables contrasting those with one, two, or three or more children with the childless (the reference category). We found that the simple metric representation yields smaller coefficients of determination than the two different dummy-variable representations. Given the economies of scale present in childrearing,[10] this is not surprising. Although analyses employing the three-dummy-variables representation show slightly larger coefficients of determination than those employing the single dummy variable, correcting these coefficients for degrees of freedom favors the single-dummy-variable representation.[11] Thus, we use the latter dichotomous representation in the analyses reported below, and, as a result, assess the effects of childlessness on professional productivity.

Results

Table 1 shows the means for our two measures of scholarly productivity by sample members' sex and parental status. In general, the male research chemists published more than the females and also published articles of slightly higher average quality. Those with children published fewer articles and articles of slightly lower average quality than the childless. In order to determine if these differences are statistically reliable, we used multiple regression analysis with dummy variables to represent sex (men coded 0, women coded 1), the presence of children (none coded 0, any coded 1) and a sex-by-children interaction (women and children coded 1, all others coded 0). The results are shown in Table 2.

Table 1. MEAN NUMBER OF PUBLISHED PAPERS AND RESIDUAL CITATION SCORES,* BY SEX AND PRESENCE OF CHILDREN

	Women		Men	
	Children	No Children	Children	No Children
Mean number of published papers	1.51	3.06	3.91	5.43
Mean residual-citation score	-.112	-.036	.117	.207
N	(41)	(16)	(32)	(7)

*See text for a description of the construction of this measure.

Table 2. RESULTS OF REGRESSIONS OF NUMBER OF PUBLISHED PAPERS AND RESIDUAL-CITATION SCORES ON SEX AND PRESENCE OF CHILDREN, WITHOUT AND WITH A SEX-BY-PRESENCE-OF-CHILDREN INTERACTION TERM (N = 96)

Independent Variables	Metric Coefficients for Number of Publications		Metric Coefficients for Residual-Citation Score	
Sex (female = 1)	-2.42*	-2.52*	-.23	-.24
Presence of children	-1.54*	-1.63*	-.08	-.09
Sex-by-children interaction	--	.13	--	.02
Intercept	5.45*	5.51*	.25	.26
R^2	.151*	.151*	.014	.014

*Coefficient significantly different from zero, $\alpha = .05$.

Although the directions of the effects of the independent variables were the same for both number of published papers and their quality, their coefficients were statistically significant only for the former productivity measure. When we regressed number of published papers on all three independent variables, the interaction term was not statistically significant (see column 2) and had a sign opposite that expected under the argument that women assume more of the childrearing duties than do men. In light of our knowledge about the sexual division of labor with regard to child care, this result is surprising. While most married women scientists employ domestic helpers (Astin), they also report spending about as much time on child care and household tasks as estimates for American women in general. Moreover, the married women chemists are virtually all in two-career households, whereas only a small proportion of the male sample members are in such households (Centra) and are thus presumably able to minimize their contributions to childrearing. Of course, female scientists are a highly selected group, and those who choose to raise families while practicing their profession are probably very highly motivated. In addition, it is obvious from the distribution of cases in Table 1 that a much higher proportion of these women are childless than is the case for other married women in their age cohort.[12]

In any event, the simple additive model, whose coefficients are shown in the first column of Table 2, is the more appropriate model. It reveals that having any children cost scientists of both sexes about one and one-half published papers over the two-year period examined. The results in Tables 1 and 2 are consistent with the argument that when one examines an occupation in which workers control the allocation of their time and energy, and in which additional expenditures of these resources should enhance performance, marital fertility does have a negative impact on job performance and presumably, in turn, on occupational success.[13] Of course, one might ask whether the causal models implied by the regressions in Table 2 are correctly specified, since other variables, especially those re-

flecting a scientist's training and early career activities, also might affect measures of job performance. In order to assess the extent to which the results presented above depend on the omission of such variables, we included a set of such factors which have been shown elsewhere (Reskin, b) to affect scientists' productivity. These variables are the calibre of the scientists' Ph.D.-granting department, the prestige of any postdoctoral award, and the type of position scientists obtained after completing their doctoral (or postdoctoral) training.[14]

In order to test for sex differences in the impact of the three control variables, we included both the variables and their respective interactions with sex in the regression analyses for both of the dependent variables. None of the interaction terms was statistically significant, so the results for the equations with interaction terms are not shown. We present the main effects of the five independent variables in Table 3. These results are similar to those in Table 2. Once again none of the independent variables significantly affects the residual-citation scores. Including the three control variables in the equation for the number of articles had little effect on the coefficients for sex and the presence of children, both of which remained statistically significant. Neither the calibre of the Ph.D. department, the prestige of any postdoctoral fellowship, nor the setting of the first post-Ph.D. job significantly affected the number of publications. Thus, the effect of the presence of children on scholarly productivity does not result from its associations with our measures of the quality of scientists' training, their access to prestigious postdoctoral study, or the institutional sector in which they began their careers. It follows that the estimates of the effect of children on the number of published papers are relatively stable across the two tables. On the basis of the more completely specified model, the presence of children cost the research chemists a little more than .8 articles per year ($b = 1.67$ for articles published over a two-year period).

Table 3. RESULTS OF REGRESSIONS OF NUMBER OF PUBLISHED PAPERS AND RESIDUAL-CITATION SCORES ON SEX, PRESENCE OF CHILDREN, CALIBRE OF THE PH.D. DEPARTMENT, PRESTIGE OF POSTDOCTORAL FELLOWSHIP AND TYPE OF FIRST JOB (N = 96)

	Number of Publications		Residual-Citation Score	
Independent Variables	Metric Coeff.	Standardized Coeff.	Metric Coeff.	Standardized Coeff.
Sex	-2.337*	-.35*	-.227	-.11
Presence of children	-1.668*	-.21*	-.091	-.04
Calibre of Ph.D. department	.004	.13	.002	.17
Postdoctoral fellowship prestige	.110	.12	-.009	-.04
Type of first job	.905	.13	-.093	-.05
Intercept	3.434*	--	.185	--
R^2	.195*		.048	

*Coefficient significantly different from zero, $\alpha = .05$.

We included a presence-of-children-by-sex interaction term in the equations shown in Table 3 to retest for significant sex differences in the more fully specified models. For neither dependent variable was the coefficient statistically reliable (or in the expected direction), and we do not report these results in the table.

Finally, the effect of children on scientists' productivity may plausibly vary by the children's ages. Lacking data on the birth dates of any children, we treated the duration of marriage at the point we observed productivity as a crude proxy for the ages of any children. To the extent that younger children make greater demands on scientists' time and energies, one would expect an interaction between duration of marriage and presence of children to occur in our data. Although we do not report the results of this analysis in the table, neither the main effect of duration of marriage nor its interaction with the presence of children was statistically significant. (The coefficient for the interaction term was negative, and *within our sample* more recently married scientists with children actually published more papers, net of the effects of other variables, than the scientists with children who had been married longer.) These results suggest that our estimate of the effect of children on productivity is probably not seriously biased by our lack of knowledge of the children's ages.[15]

Conclusions

In this paper we have shown that the presence of children in the families of a sample of research scientists is associated with lower levels of scientific productivity, when this is measured in terms of the rate of publication of research papers: the childless outpublished those with children by about one and one-half articles over the two-year period we observed. This result, robust across regression analyses employing a variety of additional independent variables, is at odds with those of studies based on samples of the general population which have consistently found little or no association between marital fertility and job success. This difference may stem in part from the fact that previous studies have inferred performance differentials from occupational outcomes, while we employed a direct measure of job performance. Also, not all workers have jobs that permit investing those extra resources freed by low fertility or childlessness in job performance. Thus, the hypothesis that marital fertility has a negative impact on career success probably holds true only for those occupations which allow the free investment of time, energy, and money into job performance, but in which children themselves are not economic assets. Although these conditions may prevail for many self-employed persons and for those with professional occupations, most occupations in modern societies do not have these characteristics, and job performance in them is neither helped nor hindered by workers' fertility patterns.

Notes

1. Occupational mobility is a poor measure of career success insofar as advancement within occupations is a prominent mode of social mobility. This is probably a greater problem for studies of intra- than intergenerational mobility. Boyd discusses problems of measurement imprecision, ambiguous time ordering of variables, etc., encountered by studies which measure career success in terms of inter- and/or intragenerational mobility.
2. The questionnaires were mailed and returned during the Summer and Fall of 1971, a period contemporaneous with that during which data for *American Men and Women of Science* were collected. For further sampling details, see Reskin (a).
3. Reskin (a) presents evidence for the representativeness of the 408 chemists for whom career data were obtained.
4. Thirty-six percent of the women in our sample have never been married, a figure consistent with the results of previous studies of female doctorates in several academic disciplines (Astin). This stands in marked contrast to the marital statuses of the general population of American women; only five percent of those in age cohorts equivalent to those of our female sample members were single in 1969 (U.S. Bureau of Census).
5. The other major settings in which the chemists found employment are industrial firms and colleges. Chemists employed in these settings published substantially less on the average than those included in this study. During 1969–70, for example, the former group published an average of 1.18 articles, compared to 2.85 for the latter group.
6. The proportion of female doctoral chemists who are employed in universities and government research laboratories is greater than the proportion of males. While most doctoral chemists work in private industry, females are greatly underrepresented in that sector. This pattern holds for other scientific disciplines as well, and possible reasons for it are discussed by Reskin (a).
7. Although this period slightly predates the period during which data on marital fertility were gathered for sample members, it is unlikely that many experienced first births during the intervening year because they were all over 35 years old in 1970.
8. This information was obtained from the *Science Citation Index* for the period 1965 to 1970 and from *Chemical Abstracts* for the period from 1955 to 1964. Available evidence (Hargens et al.) indicates that both of these are highly reliable sources of data on publication counts.
9. We experimented with two other operationalizations of this measure: (1) a ratio of citation counts over total publications (see Allison, 73–74), and (2) the number of citations the chemists received in 1969 and 1970, with their total number of publications included in the regression equation as an independent variable. The results of these analyses are not reported below because they are substantially the same as those reported for our residual measure.
10. Turchi (83–95) gives estimates of these "economies of scale" for women in the general U.S. population and points out that they may result in part from limitations on resources available for investment in childrearing.
11. The R's for the two different representations rarely differ by more than .02. For a discussion of correcting the coefficient of determination for degrees of freedom, see Bohrnstedt and Carter.
12. Nearly 30 percent of the women we studied are childless, while the percentage for women in the U.S. population of the same ages is about 9 percent (U.S. Bureau of the Census). The absence of a sex difference in the impact of fertility on our scientists' performance does not preclude a sex interaction in the larger population, since female scientists who successfully combine marriage and careers differ dramatically from most working women in their professional commitment, the availability of financial resources to purchase domestic assistance, and their greater likelihood of their husbands' helping with childrearing.
13. After this paper was accepted for publication, we learned of Hamovitch and Morgenstern's results, which show no effect of number of children on the number of articles published by female college and university faculty from major academic disciplines. Including college faculty, who seldom publish (see note 5), probably accounts for the failure of number of children to be significantly related to publications.
14. We measured the calibre of the Ph.D. department by scores reported by Cartter. The prestige of postdoctoral fellowships was measured in terms of scores reported by Cole and Cole (270–75), with scores of zero assigned to chemists with no postdoctoral fellowship. The

type of first job was represented as a dummy variable with those with first positions in universities and governmental research laboratories coded as 1 and all others 0.
15. This probably results from the fact that very few of our chemists had preschool children in 1970 (as implied in note 7), and it is this group of children that makes the heaviest demands on their parents' time and energy (Turchi).

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