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WOMEN IN SCIENCE. LESSONS FROM THE BABY BOOM

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This paper investigates how children affect women in science, using biographies in the American Men of Science (MoS 1956), linked with publications. First, we show that mothers have a unique life cycle pattern of productivity: While other scientists peak in their mid-30s, mothers become less productive at that age and reach peak productivity in their early-40s. Next, we estimate event studies of marriage, comparing mothers and fathers with other married scientists. Event study estimates show that the productivity of mothers declines until children reach school age, while fathers experience no change. These differences have important implications for tenure and participation: Just 27% of mothers achieve tenure, compared with 48% of fathers and 46% of other women. When women carried the full burden of childcare, the time costs of raising the baby boom led to a great loss of female scientists.

KEYWORDS: Gender, children, science, innovation.

1. INTRODUCTION

WOMEN CONTINUE to be severely underrepresented in science, especially at the top ranks of tenured faculty. In the United States, just 34% of full professors are women; this share is even lower in Canada (28%), the UK (26%), and Germany 19% (Catalyst (2020)). This persistent scarcity of women at the top level of academic science may be due to structural impediments, including discrimination at hire, glass ceilings in promotion, inequities in credit for academic work (Sarsons, Gërxhani, Reuben, and Schram (2021)), salary and support (Altonji and Blank (1999)), and a lack of role models among faculty (Carrell, Page, and West (2010), Porter and Serra (2020)).

Children are another possible cause. According to the American Time Use Survey, the average mother spends more than twice as much time caring for children than the average father (IPUMS Time Use Survey (2023)). During the Covid pandemic, female scientists with young children were most affected by school closures and most likely to cut back on research (Deryugina, Shurchkov, and Stearns (2021), Myers et al. (2020)). Understanding the long-run effects of this increased child-care burden requires long-run data on publications and promotions; such data, however, will only become available when it is too late to design policies. Existing research on the gender gap has documented child penalties in earnings (e.g., Lundberg and Rose (2000), Bertrand, Goldin, and Katz (2010), Miller (2011), Adda, Dustmann, and Stevens (2017), Kleven, Landais, and Søgaard (2019)), while the effects of children on academic productivity remain poorly understood.

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This paper investigates how children change the academic productivity of women in science. Understanding this issue is critical because advances in the allocation of talent are a major source of economic growth (Hsieh, Jones, Hurst, and Klenow (2019)). Science is an ideal setting for examining the productivity effects of children because changes in scientific productivity are readily observable through publications. Our empirical setting is the baby boom (1946–1964), a time of exceptionally high birth rates, when the burden of raising children fell entirely on women. If the baby boom made it harder for women to succeed in science, it may have created a historical setback for women in science.

The main data for our analysis are nearly 50,000 biographies of male and female scientists in the *American Men of Science* (MoS (1956)), linked with publications. First collected by the long-time editor of *Science*, James McKeeen Cattell, the MoS offers a uniquely comprehensive and rich data set on American scientists. Entries include information on the scientist's birth date, marriage status, and children, along with their university education, employment history, and research topics. Linking these biographies with publications in Microsoft Academic Graph (MAG, Sinha et al. (2015)), we analyze differences in the timing and in the quality of publications between mothers and other demographic groups. Precise data on scientists' home addresses, years of marriage, and full names allow us to identify couples of married scientists.

First, we show that mothers have a unique life cycle pattern of productivity. Until their early-30s, publications by mothers increase at the same rate as other scientists. Around age 32, however, publications by mothers decline and remain low for roughly seven years. After that time, mothers recover and reach peak productivity in their early-40s. This transient decline in productivity begins when the first child of the median scientist would have been one year old, and recovery starts when the child would have reached school age.

Next, we estimate event studies of changes in publications after marriage for parents compared with other married scientists. Methodologically, the event study approach exploits the fact that changes in productivity due to the birth of a child occur sharply, while other determinants of productivity, such as a person's preference for leisure, influence the time path of productivity more smoothly. Since we do not observe the precise birth year of children, we use the year of marriage to capture a discrete change in the likelihood of having children.[1] Matching scientists with their census records, we find that the median scientist in our sample has their first child after four years of marriage.

Event study estimates indicate that children reduce the productivity of mothers relative to other married women. Leading up to marriage, mothers and other married women publish at comparable rates. After five years of marriage, however, publications by mothers decline significantly relative to other married women. This decline occurs one year after the median scientist had their first child and intensifies until children reach school age. The gap between mothers and other married women is largest after 7–8 years of marriage, when the first child would have been 3–4 years old. After that time, the research output of mothers recovers; after 13–14 years of marriage, the output gap has nearly closed. By comparison, publications by fathers experience no decline after marriage and are never statistically different from those of other married men.

To control for differences in income, access to childcare, and other forces that vary across families, we estimate regressions with couple fixed effects for married couples of

[1]Collecting years of birth for scientists' children would require matching children with their census data. Such data, however, miss children born after 1950 (the most recent available census wave), and they are difficult to collect algorithmically because women change their names upon marriage. To address this issue, we hand-match 1119 male and 269 female scientists with their census records and use these data to estimate the year when the median scientist had their first child.

academic scientists. Academic couples differ from other scientists on several dimensions. First, both partners have flexible schedules, leaving them less exposed to "greedy work," which tends to be particularly difficult for mothers (e.g., Goldin (2021, 2014)). Second, if women get less credit for the same research output (Sarsons et al. (2021), Card, Della Vigna, Funk, and Iriberri (2022, 2023)),[2] individuals in academic couples may decide to specialize and focus their joint production on the research of the male partner, leaving women more exposed to the career costs of children.

Event studies for academic couples reveal an even larger decline in productivity for mothers in academic couples. Consistent with specialization, publications by mothers in academic couples decline significantly relative to other women, while fathers publish more. Controlling for couple fixed effects, the publication gap between mothers and fathers doubles after 5–6 years of marriage, when the median child is 1–2 years old. Compared with fathers, mothers in academic couples never recover to their pre-marriage productivity. These results are robust to alternative specifications, including controlling for quality and accounting for co-authored publications.

Decomposing changes at the extensive and intensive margins, we find that the intensity and the timing of the productivity decline for mothers is driven by a temporary decline in participation for mothers. Mothers are least likely to publish after 7–8 years of marriage, when the median first child would have been 3–4 years old, and recover after children reach school age.

These differences in the timing of productivity create important implications for tenure and participation: Just 27% of mothers who are academic scientists achieve tenure, compared with 48% of fathers and 46% of other women. Mothers and other scientists have comparable tenure rates for the first six years after starting an assistant professor job. After six years, however, mothers fall behind, suggesting that mothers either get tenure early or not at all. Notably, publications by mothers increase after tenure, while publications by other scientists peak around the tenure year.

Examining selection, we find that mothers who survive in science are extremely positively selected. Compared with other women, mothers publish 12% more than other women before the median age of marriage at 28, and their pre-marriage publications are extremely well-cited, receiving 75% additional citations. Female scientists are also more likely to have a PhD, but just one-third as likely to have children and half as likely to marry. Matching faculty rosters with individual records in the U.S. census and with the MoS, we find that mothers are substantially less likely to survive in science than fathers or women without children. Investigating selection into fields, we find mothers were more likely to pursue research in psychology, a field with opportunities for flexible work. By comparison, other women and men were most likely to work in chemistry, a field in which research requires long hours of laboratory work.

In a final section, we investigate the long-run costs of the baby boom on science. Comparing changes in the number of male and female scientists across birth cohorts, we estimate that more than 600 female scientists are missing in the generation of baby boom parents. Compared to the actual number of female scientists, this implies a loss of 22%. Equivalent estimates for a 5% random sample of the 1960 census imply an even larger

[2]Examining tenure decisions at the top 35 economics departments, Sarsons et al. (2021) show that women receive less credit for co-authored work. Investigating the selection of Fellows of the Economic Society, Card et al. (2022, 2023) show that women were less likely to be chosen between 1933 and 1987, conditional on the same publications and citations. Between 1980 and 2010, women in the top 10% of female economists were more likely to be selected, with no effect for the bottom 90%.

loss: Had the number of female professors continued to grow at the same rate as that of male professors, an additional 20,327 female professors would have taught at U.S. universities by 1960. Relative to the actual number of female professors, this implies a 47% loss.

These findings indicate that the baby boom was an important driver of the underrepresentation of women that affects science to this day. Even though reduced barriers for women and minorities have contributed greatly to economic growth since the 1960s (Hsieh et al. (2019)), women continue to face poor odds in many fields of science and invention (e.g., Bayer and Rouse (2016), Jensen, Kovács, and Sorenson (2018), Bell, Chetty, Jaravel, Petkova, and van Reenen (2019)). In the 20th century, female participation in academia was low in almost all countries (Iaria, Schwarz, and Waldinger (2022)). Analyses of publications across 83 countries and 13 disciplines between 1955 and 2010 show that the increase in the share of female authors over the past 60 years was accompanied by a growing gender gap in publications, driven by differences in drop-out rates and productivity (Huang, Gates, Sinatra, and Barabási (2020)). In STEM, female postdoctoral scholars publish less and are 20% less likely to advance to principal investigator (Lerchenmueller and Sorenson (2018)). Text analyses of scientific publications indicate that fields such as surgery, computer science, physics, and mathematics will not approach gender parity in this century (Holman, Stuart-Fox, and Hauser (2018)). We complement this literature by investigating children as a possible cause of gender differences in productivity and by exploring the historical roots of underrepresentation.

Underrepresentation may affect the direction of innovation, away from innovations that benefit underrepresented groups. For example, an analysis of U.S. biomedical patents finds that patents with all-female inventors are 35% more likely than patents of all-male inventors to focus on women's health (Koning, Samila, and Ferguson (2021)), and research teams that include women are more likely to pursue research than benefits women, especially when women are lead authors (Koning, Samila, and Ferguson (2020)). Thus, the loss of female scientists during the baby boom may have changed the direction of innovation away from advances that benefit women.

More generally, our findings contribute to research on parenting as a source of gender gaps in labor market outcomes (e.g., Bertrand, Goldin, and Katz (2010), Cortés and Pan (2023)). Methodologically, our paper is most closely related to event-study analyses that investigate the role of children in the evolution of earnings and other labor market outcomes in the years before and after the birth of a couple's first child (e.g., Kleven, Landais, and Søgaard (2019)). Comparing outcomes for women and men in the same family, these papers document a persistent divergence in labor market trajectories between mothers and fathers. To this literature, we add an analysis of divergence in productivity, measured by publications.

Building on the literature on gender wage gaps and labor misallocation by gender (e.g., Mulligan and Rubinstein (2008), Hsieh et al. (2019), Ashraf et al. (2023)), we use data on publications before marriage to investigate selection. Applying a Heckman two-step estimator to a repeated cross section of the Current Population Survey, Mulligan and Rubinstein (2008) find that selection into female full-time full-year employment shifted from negative in the 1970s to positive in the 1990s. Examining the personnel records of a multinational firm, Ashraf, Bandiera, Minni, and Quintas-Martínez (2023) show that the performance of female employees is higher in countries and cohorts where fewer women work outside the home, consistent with gender barriers creating positive selection. To these findings, we add an analysis of an extremely high-skilled population of women in science, and show that, for this population, selection was positive already in the early 1900s.

2. HISTORICAL BACKGROUND

The empirical setting for our analyses is the American baby boom, a period in which many children were born, and the burden of childcare fell almost entirely on women. After World War II, more Americans than ever married, had children, and stayed married. In 1930, the median woman had first married at age 21.3; by 1950, the median age of marriage had dropped by a full year to 20.3 (U.S. Census Bureau (n.d.)). In 1960, only 27.4% of women between the ages of 20 and 24 were single. Divorce rates slowed to a low of 8.9 per 1000 women aged 15 and older in 1958, relative to 10.3 and 14.4 per 1000 women in 1950 and 1945, respectively (U.S. Department of Health, Education, and Welfare (1958)). The combination of these factors led to a dramatic increase in births from 1946 to 1964, during the "baby boom."[3] Between 1940 and 1947, annual births increased from just 19.4 per 1000 people in 1940 to 26.6 in 1947. Ten years later, in 1957, 25.3 children per 1000 people were born in the United States (U.S. Department of Health, Education, and Welfare (1958)). Couples also had children more quickly and spaced their children closely together (Weiss (2000), p. 4). These forces created a "collapsed period of intensive child rearing" and a "relative freedom from such demands" when mothers reached their late-30s and early-40s (Weiss (2000), p. 8).

"Family values" placed the burden of childcare entirely on mothers, who were expected to focus their attention on the home. In his history of American physics, Kevles (1995, 1st ed. 1971, p. 371) attributes the underrepresentation of women to such preferences: "Women generally preferred to find their own primary fulfillment as mothers of accomplished children and wives of prominent husbands. On the whole, women of the postwar era went to work to help raise the family standard of living; they had jobs, not careers."[4]

3. DATA

Our main data cover the lives and careers of 82,094 scientists who were active in American science in 1956, collected from the *American Men of Science* (MoS (1956)), including 52,946 academic scientists with known birth years and gender. To measure variation in academic output across the life cycle and over time, we match scientists with their publications in Microsoft Academic Graph (MAG). Estimates exploit a balanced sample of 49,243 academic scientists with known birth year and gender whose publications we observe between the ages of 18 and 45 (Table I).

3.1. *Academic Appointments and Promotions*

To collect biographical data, we have digitized the text of all 82,094 unique biographies in the *American Men of Science* (MoS (1956)). A comprehensive database of scientists,

[3]There are many competing explanations for the causes of the baby boom. For example, Doepke, Hazan, and Maoz (2015) argue that competition with women who entered the labor force during WWII and stayed in the labor force after the war made it harder for younger women to get jobs, encouraging them to exit the labor market and have children. There is, however, an active debate on whether women who entered the labor force during the war remained in the labor force after the war (e.g., Goldin (1991) and Rose (2018)).

[4]While such preferences are persistent (Alesina, Giuliano, and Nunn (2013)), they are not immutable. Bursztyn, Gonzalez, and Yangizawa-Drott (2020), for instance, show that most young married men in Saudia Arabia privately support women working outside the home and underestimate support by other men like them. Correcting these beliefs increases men's willingness to help their wives looking for jobs.

TABLE I

SUMMARY STATISTICS: PUBLICATIONS BY ACADEMIC SCIENTISTS.

	All	Mothers	Other Women	Fathers	Other Men
Publications per year	0.278	0.161	0.171	0.291	0.271
	(0.874)	(0.576)	(0.614)	(0.880)	(0.917)
Citations per publication	20.68 | 7.50	21.43 | 9.00	16.27 | 7.00	20.94 | 7.86	20.70 | 6.63
(mean | median)	(193.18)	(40.90)	(30.94)	(217.60)	(123.50)
N all scientists	65,337	867	2893	46,621	14,956
N academic scientists	49,243	736	2567	34,320	11,620
% academic	75.4%	84.9%	88.7%	73.6%	77.7%

Note: Publications and citations for a balanced sample of 49,243 scientists born between 1882 and 1925 who held a university appointment (e.g., as a professor or lecturer) at least once, and whose publications we observe between the ages of 18 and 45. Both the mean and median citations per publication are reported, with standard errors in the parentheses. The median publications per year for all scientists was 0. Data include 383,666 publications between 1900 and 1970 by academic scientists and 9,294,360 citations between 1900 and 2020 to these publications.

these data were originally collected by James McKeen Cattell, the first professor of psychology in the United States and the first editor of *Science* for nearly 50 years.[5] Cattell (1906, p. v) collected the MoS for his own research, creating "for the first time a fairly complete survey of the scientific activity of a country in a given period." With support from the Carnegie Institution, Cattell published his data for the "chief service [...] to make men of science acquainted with one another and with one another's work."

Entries were based on membership in scientific societies (such as the American Mathematical Society or the American Society of Bacteriologists) and subject to a comprehensive review from "scientific societies, universities, colleges, and industrial laboratories." In the editor's preface, Cattell (1956) thanks "thousands of scientific men who have contributed names and information about those working in science," and "acknowledges the willing counsel of a special joint committee of the American Association for the Advancement of Science and the National Academy of Science National Research Council." Despite its name, the MoS includes male and female scientists in Canada and the United States.

Detailed career data allow us to identify scientists who at some point in their careers took academic jobs; we use these data to examine scientists' career paths inside and outside of academia. To identify these "academic scientists," we use job titles, such as professor, research fellow, or instructor, to identify 52,946 academic scientists who worked in academia at least once. Notably, a substantially higher share of female scientists—3537 female academic scientists (87.7% of the total)—were academic scientists, compared with just 49,409 male academic scientists (74.6%). This is consistent with historical accounts that women scientists in industry were few and far between (e.g., Rossiter (1982), p. 315).

Information on tenure-track jobs (e.g., assistant or associate professor) makes it possible to investigate whether and when scientists entered the tenure track—and whether they left the tenure track due to children. To examine differences in the rate and speed of tenure, we use the timing of promotions to the rank of associate professor and professor. Information on industry employment allows us to investigate whether children raised the probability of dropping out of academia. This is a key feature of our data compared with

[5]This count excludes 6352 duplicate entries who appear in more than one of the three volumes of the MoS (1956), as well as 2549 scientists whose entry consists only of a reference to another edition of the MoS.

research employing faculty rosters (e.g., Iaria, Schwarz, and Waldinger (2022)), which by design are limited to scientists who remain in academia.

Data on the start and end year for each job allow us to determine the precise time when scientists served in academic or industry jobs. We use these data to investigate whether women were more likely to leave academia after marriage, and whether gender differences in exit can explain mothers' lower research output after marriage and children.

3.2. *Female Scientists, Birth Years, Marriages, and Children*

To identify female scientists, we use historical gender frequencies of first names in the U.S. Social Security Administration Records (SSA) between 1880 and 2011, implemented in Python's *gender-detector* package. This approach outperforms hand-matching in a comparison with scientists who attended women's colleges (Supplemental Appendix A (Kim and Moser (2025))). The algorithm assigns the gender of 70,780 scientists (86.2% of the total 82,094), including 4220 women and 66,560 men.

We use data on birth years to investigate changes in academic productivity across the life cycle, and to control for age and cohort fixed effects. We also exploit birth years to create a high-quality match between scientists and their publications, as well as their records in the U.S. census. Birth years are available for 81,461 scientists (99.2%). We know both the birth years and gender for 70,230 scientists (85.5%).

A key advantage of the MoS is that it records the scientist's year of marriage and number of children. For example, Harriet Mylander Maling married in 1943 and had four children:

MALING, DR. HARRIET M(YLANDER), 406 N. Taylor Ave, Annapolis, Md. PHARMACOLOGY. Baltimore, Md, Oct. 2, 19; m. 43; c. 4. A.B, Goucher Col, 40; A.M, Radcliffe Col, 41, Colton fellow, 43-44, Ph.D.(med. sci, physiol), 44. Asst. pharmacol, Harvard Med. Sch, 44-45, instr, 45-46; asst. prof, med. sch, George Washington, 51-52, asst. research prof, 52-54; PHARMACOLOGIST, NAT. HEART INST, NAT. INSTS. HEALTH, U.S. PUB. HEALTH SERV, 54- Soc. Pharmacol; N.Y. Acad. Neurophysiology; cardiovascular drugs; drugs affecting the central nervous system.

While the MoS does not report the birth year of children, we can append this information for 412 scientists whom we match with the census (detailed in Appendix A). These data indicate that the median scientist had their first child after four years of marriage.

3.3. *Scientists Who Married Another Scientist in the MoS*

Using scientists' names, years of marriage, and home addresses, we identify 674 scientists who married another scientist in the MOS. For example, Rachel Blodgett Adams and Clarence Raymond Adams both married in 1922 and lived on 60 Intervale Road, Providence, RI in 1956:

ADAMS, DR. RACHEL B(LODGETT), 60 Intervale Road, Providence 6, R. I. MATHEMATICS. Woburn, Mass, Oct. 13, 94; m. 22. A.B, Wellesley Col, 16; A.M, Radcliffe Col, 19, Mary E. Horton fellow, 20-21, Ph.D.(math), 21; Rome and Gottingen, 22-23. Teacher math, Miss Edgar's Sch, Montreal, 16-18; instr. math, Wellesley Col, 21-22; tutor, Radcliffe Col, 26-41. Math. Soc. Approximate solution of integral equations; determination of coefficients in interpolation formulae.

ADAMS, PROF. C(LARENCE) RAYMOND, 60 Intervale Road, Providence 6, R. I. MATHEMATICS. Cranston, R. I, April 10, 98; m. 22. A.B, Brown, 18, G.A.R. fellow, 18-19, M.S, 20; A.M, Harvard, 21, Ph.D.(math), 22; Sheldon fellow from Harvard, Rome, 22-23, Gottingen, 23. Instr. MATH, BROWN, 18-20, 23-25, asst. prof, 25-28, assoc. prof, 28-36, PROF, 36-, CHAIRMAN DEPT, 42- Assoc. Ed, 'Am. Jour. Math,' 40-42. S.A.T.C, 18-19. A.A; Math. Soc. (councilor, 32-34; v. pres, 39-40); Math. Asn; fel. Am. Acad. Analytic theory of difference equations; multiple series; real function theory.

Six hundred seventy-four scientists (337 couples of men and women) married another scientist; 587 are academic scientists (292 men and 295 women) and 559 academic scientists are part of our balanced panel (Appendix Table I). For 484 academic scientists (242 couples), we observe both the husband and wife in the balanced panel; 304 academic scientists (152 couples) are parents.

3.4. *Matching Scientists With Research Fields Using k-Means Clustering*

To control for differences in publications across research fields, we assign each scientist to a unique field by applying a k-means clustering algorithm to the text that describes each scientist's subject and research topics. Subjects are known for 99.97% of 82,094 scientists in the MoS; research topics are known for 96.4%. Dr. Maling, for example, describes her research subject as "pharmacology," and describes her research topics as "Neurophysiology; cardiovascular drugs; drugs affecting the central nervous system."

Intuitively, k-means clustering works like a multi-dimensional least squares algorithm, which groups together data points (here, scientists) that are most similar in terms of their observable characteristics (here, research topics). A "cluster" (here, a field) refers to a collection of data points (scientists) that are grouped together because they have similar observable characteristics (here, topics). To group scientists into clusters, the k-means algorithm assigns researchers to one of the k clusters by minimizing the distance between the researchers and the cluster's centroid. Supplemental Appendix B (Kim and Moser (2025)) presents a detailed description.

Applying k-means to topics offers several advantages over using subjects alone. First, some listed subjects (such as "chemistry") are extremely broad. Seven thousand ninety-one scientists report their subjects as chemistry and 4883 list physics; these definitions include scientists whose research has little overlap. On the opposite extreme, 384 scientists in the physical sciences define their subject so narrowly that they are the only people in it; another 119 subjects have just two scientists.

Second, classifications by subjects alone miss meaningful connections across scientists' research. For instance, Caesar Fragola and Elder de Turk list their subjects as engineering and physics, respectively. Both work on aircraft instrumentation: Fragola examines "aircraft instrumentation engineering; development of aircraft flight and navigation instruments...." De Turk examines the "design and development of aircraft instruments; test of gravity meters; test, development and evaluation of aircraft armament systems." The k-means algorithm captures this overlap and assigns both scientists to the field of "aircraft."

3.5. *Matching Scientists With Broader Research Disciplines*

In addition to assigning scientists to 100 k-means fields, we match them with 15 broader disciplines (such as chemistry, mathematics, or physics) that are large enough to investigate selection. We build this classification by extending an original system of 12 disciplines in the MoS (Cattell (1921)): anatomy, anthropology, astronomy, botany, chemistry, geology, mathematics, pathology, physics, physiology, psychology, and zoology. We add three disciplines—economics, sociology, and political science, the most frequent subjects listed by social scientists in the MoS (1956), after psychology and anthropology.[6]

Cattell had established this system to identify star scientists within each discipline; the names and disciplines of 2605 stars are reported in Visher's (1947) list of *Scientists starred*. We match 999 stars with scientists in the MoS (1956), using their name and birth year. Then, we assign 32,812 non-star scientists who list one of the 15 disciplines as their subject to that discipline. For example, Rachel Adams from the example above lists her subject as "mathematics," so we assign Adams to the discipline of "mathematics."

MARINE, DR. DAVID, 18 Baltimore Ave, Rehoboth, Del. EXPERIMENTAL MEDICINE. Whitelysburg, Md, Sept. 20, 80; m. 22; c. 1. B.A, West. Maryland Col, 00, hon. M.A, 07, hon. Sc.D, 49; M.D, Hopkins, 05; hon. Sc.D, Western Reserve, 30. Res. pathologist, Lakeside Hosp, Cleveland, 05-06; from demonstrator to assoc. prof. exp. med, Western Reserve, 06-20; director lab, Montefiore Hosp, 20-45; RETIRED. Asst. prof, Columbia, 20-38. M.C, U.S.A, 17-19. N.Y. Acad. Med. award, 30; Squibb award, 53; Bruce award, 54. Asn. Path. & Bact; Soc. Exp. Path; Physiol. Soc; Soc. Exp. Biol; Am. Med. Asn; fel. N.Y. Acad; N.Y. Path. Soc.(v.pres). Pathology and physiology of the ductless glands.

Next, we exploit information on the disciplines of stars to establish unique links between subjects and disciplines. Visher (1947) lists David Marine as a star in "pathology," and the MoS (1956) reports "experimental medicine" as Marine's subject. Since Marine is the only star in "experimental medicine," this subject is linked uniquely with pathology; using this link, we assign seven other (non-star) scientists who report their subject as "experimental medicine" to pathology. By this process, we assign another 7153 scientists in 126 subjects to 15 disciplines.

The 40,964 scientists whom we match provide the training data that allow us to match the remaining scientists with disciplines using the text that describes their research. We apply a nearest centroid algorithm to these data which assigns the remaining 40,868 scientists uniquely to one of the 15 disciplines (see Supplemental Appendix C for a detailed description).

3.6. *Matching Scientists With Publications in Microsoft Academic Graph*

To measure variation in productivity, we match scientists with their publications and citations in Microsoft Academic Graph (MAG, Sinha et al. (2015)).[7] To examine life cycle changes in publications, we focus on a balanced panel of 65,337 scientists whose publications are observable between the ages of 18 and 45 (Appendix Table I). Among them, 49,243 (75.4%) are academic scientists, born between 1882 and 1925; 736 of them are mothers, 2567 other women, 34,320 fathers, and 11,620 other men.

On average, these scientists produced 0.28 publications per scientist and year between 1900 and 1970, and each publication received 20.68 citations (Table I). With 864 articles and books, Carl Djerassi, the inventor of oral contraceptives, has the largest number of

[6] Airoldi and Moser (2024) use these assignments in the MoS (1921) to investigate how a person's childhood socio-economic status (SES) influences other scientists' perception of their work.

[7] MAG was updated weekly until December 2021; we use the version from August 20, 2020. To perform the matching, we restrict the data to authors with at least one English-language publication between 1900 and 1970. We match scientists in the MoS (1956) with *authorids* in the MAG, using first and last names, as well as middle initials. For scientists who are matched with more than one author, we manually check and remove duplicates.

publications. The embryologist Jane Marion Oppenheimer is the most published female scientist, with 240 publications. The average publication has 2.27 authors (with a median of 2.00 and standard deviation of 2.25). In robustness checks that control for variation in the size of author teams, we divide each publication by the count of its authors to calculate author-weighted publications.

Using publications, we can trace changes in academic productivity across the life cycle. Harriet Mylander Maling, for example, did not publish before getting married in 1943 at age 24; she then published four papers before having her first child three years after her marriage, at age 27. After the birth of her first child, Maling did not publish at all for 10 years. At age 37, when her third child had reached school age, Maling started publishing again. She then produced 13 publications between the ages of 37 and 43.

3.7. *Matching Faculty Directories With the Census and the MoS*

To investigate whether women, and especially mothers, were less likely to survive in science and enter the MoS, we manually match all scientists on the faculties of UC Berkeley, UCLA, and Stanford in 1940 with individual records in the U.S. Census of 1940. Digitized faculty records for these universities are available from the UC Cliometric History Project.[8]

Using names, occupations, and locations, we match 1199 of 1541 faculty (77.8%) with their census records in 1940 (Appendix A further details this matching process). Further checks on ages in the birth year of their first child and remarriages create a final data set of 1190 faculty matched with the U.S. census, including 1015 male and 175 female faculty; among them, 370 men and 27 women are in the MoS (1956).

In addition to matching faculty with the U.S. census, we hand-match academic couples with individual census records in 1940 and 1950 to identify the birth years of their children. Two hundred five of 342 couples (59.9%) reported at least one child in the MoS (1956). Of these 205 couples, we match 124 (60.5%) to the U.S. Censuses. Implementing further data checks on ages at first child and remarriages (described in more detail in Appendix A), we arrive at 119 couples for whom we know the exact birth years of their children.

4. CHILDREN AND GENDER DIFFERENCES IN PUBLISHING ACROSS THE LIFE CYCLE

Publications data reveal a unique life cycle pattern of productivity for mothers. Like other scientists, mothers ramp up their publications through their 20s and early-30s (with 0.22 publications per scientist). At 32, however, publications by mothers begin to decline. This decline persists until age 35, when the first child of the median scientist would be 4 years old (Figure 1, Panel A). Publications by mothers begin to recover in their late-30s and early-40s, reaching a maximum of 0.28 publications per year at the age of 43. This transient decline in productivity is unique to mothers; their productivity declines while other scientists experience a sustained increase in productivity. Fathers publish slightly more than other men (Figure 1, Panel B). Marriage cannot explain the differential decline in productivity for mothers; other married women without children publish at rates that are similar to those of single women across their life cycles (Figure A1, Panel A).

[8]Available at http://uccliometric.org/faculty/, accessed August 1, 2020. To focus on research faculty, we exclude non-faculty positions, such as "librarians" and "assistants." If people in these professions are more likely to be female, we overestimate survival rates for women in science.

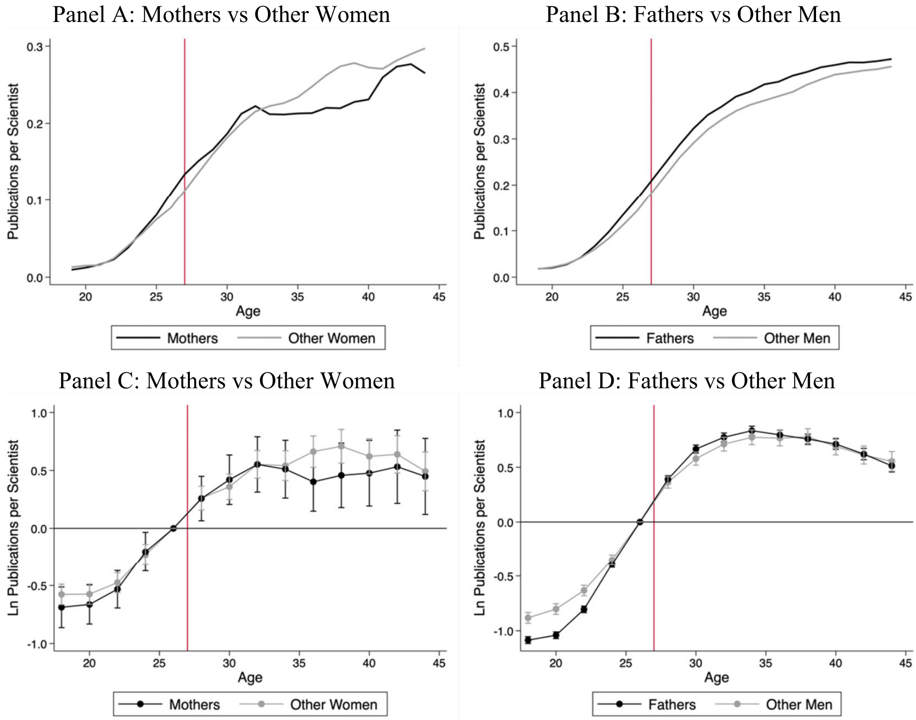


FIGURE 1.—Publications across the life cycle. *Notes*: Panels A and B show a three-year moving average of publications per year for academic scientists between the ages of 18 and 45. The vertical line at age 27 marks the median age of marriage for all academic scientists. Panels C and D present OLS estimates of β_a^d for demographic d (mothers, fathers, other women, and other men) in $\ln\, y_{\text{iat}}^d = \beta_a^d Age_i + \delta_t + \mu_f + \epsilon_{\text{iat}}$, where $\ln\, y_{\text{iat}}^d$ is the natural logarithm of publications (adding 0.001) by scientists of demographic d in two-year age intervals a and two-calendar-year intervals t. The coefficient β_a^d is a vector of age-varying estimates of publications by scientists of age a and demographic d compared with scientists in the same demographic immediately preceding the median age at marriage, at ages 26–27. Calendar-year fixed effects δ_t control for variation in the number of publications over time; field fixed effects μ_f control for variation across fields f. Standard errors are clustered at the scientist level. Data include publications for a balanced panel of 49,243 academic scientists in the MoS (1956) born 1882–1925, whose output we observe between the ages of 18 and 45.

4.1. *Mothers Experience a Temporary Productivity Decline in Their Early to Mid-30s*

To investigate these changes more systematically, we estimate changes in publishing across the life cycle *separately within demographic groups* (mothers, other women, fathers, and other men):

$$\ln y_{\text{iat}}^d = \beta_a^d Age_i + \delta_t + \mu_f + \epsilon_{\text{iat}}, \tag{1}$$

where scientific output $\ln\, y_{\text{iat}}^d$ represents the natural log of publications (adding 0.001) by scientist i of demographic d in a two-year age interval a and two-calendar-year interval t. The coefficient β_a^d is a vector of age-varying estimates of productivity at age interval a by scientists of demographic d compared with scientists in the same demographic at ages 26–27, the median age of marriage for all academic scientists (and the excluded age in our regressions). Publication year fixed effects δ_t capture changes in publications over time (e.g., because of variation in research funding); research field fixed effects μ_f control for variation in the propensity to publish across fields f. Standard errors are clustered at the level of individual scientists.

Age-specific estimates of Eq. (1) confirm the large but transient productivity decline for mothers in their early-30s (Figure 1, Panel C). Until the age of 32, publications by mothers increase smoothly from 49.7% fewer publications at age 18–19 relative to age 26–27 (−0.688 log points, $p = 0.000$) to 73.7% additional publications at age 32–33 (0.552 log points, $p = 0.000$). After this, publications by mothers decline to just 49.5% additional publications at age 36–37 (0.402 log points, $p = 0.002$), but then recover to 70.2% additional publications at 42–43 (0.532 log points, $p = 0.001$).

By comparison, publications by other scientists peak around their mid-30s. Publications by fathers evolve smoothly to a peak of 130.2% more at ages 34–35 (0.834 log points, $p = 0.000$) and decline gradually afterwards. Publications by other women peak at 103.2% additional publications at 38–39 (0.709 log points, $p = 0.000$) before decreasing to 63.6% (0.492 log points, $p = 0.000$) by age 44–45. These results are robust to excluding scientists with the largest number of publications (top 5%). Results are also robust to adjusting for the number of co-authors on each paper.

5. EVENT STUDIES OF ACADEMIC PRODUCTIVITY

An ideal experiment to identify the causal effects of children would randomly assign children to scientists.[9] Since this is impossible, we estimate event studies of changes in academic output after marriage, comparing the output of mothers (and fathers) with that of other married scientists. While a scientist's choice to marry and have children may not have been exogenous, the event of marriage and the arrival of a child leads to a sharp change in productivity that is arguably orthogonal to unobserved determinants of productivity that evolve more smoothly over time. For example, women who choose to have children may have an intrinsic preference to spend time with their family, rather than doing research. Changes in productivity that stem from these underlying preferences would evolve smoothly over time, while changes due to children happen abruptly.

5.1. *Mothers Become Less Productive After 5 Years of Marriage*

OLS event study models compare changes in publications per year relative to the year of marriage for parents with the same changes for other married scientists of the same gender:

$$\ln y^g_{\text{ist}} = \beta^g_{1s} EventTime_i + \beta^g_{2s} Parent_i * EventTime_i + \delta_t + \alpha_a + \mu_f + \epsilon_{\text{ist}}, \quad (2)$$

where event time s is indexed relative to the year of marriage and $\ln\ y^g_{\text{ist}}$ is the natural log of publications (adding 0.001) per scientist i of gender g in two-year event time interval s and two-calendar-year interval t. Omitting the event time dummy at $s = -1$ to 0 implies that event time coefficients β^g_{2s} estimate the impact of children relative to the year before and the year of marriage. The coefficient β^g_{2s} is a vector of time-varying estimates of differences in publications between parents of gender g and other married scientists of the same gender in interval s relative to the level of publications of scientists of gender g in years -1 and 0 years before marriage. Age fixed effects α_a control for variation in output

[9]Earlier studies have used twins or the gender of the first two children to estimate the effects of children (e.g., Angrist and Evans (1998)), but few female scientists have more than one child.

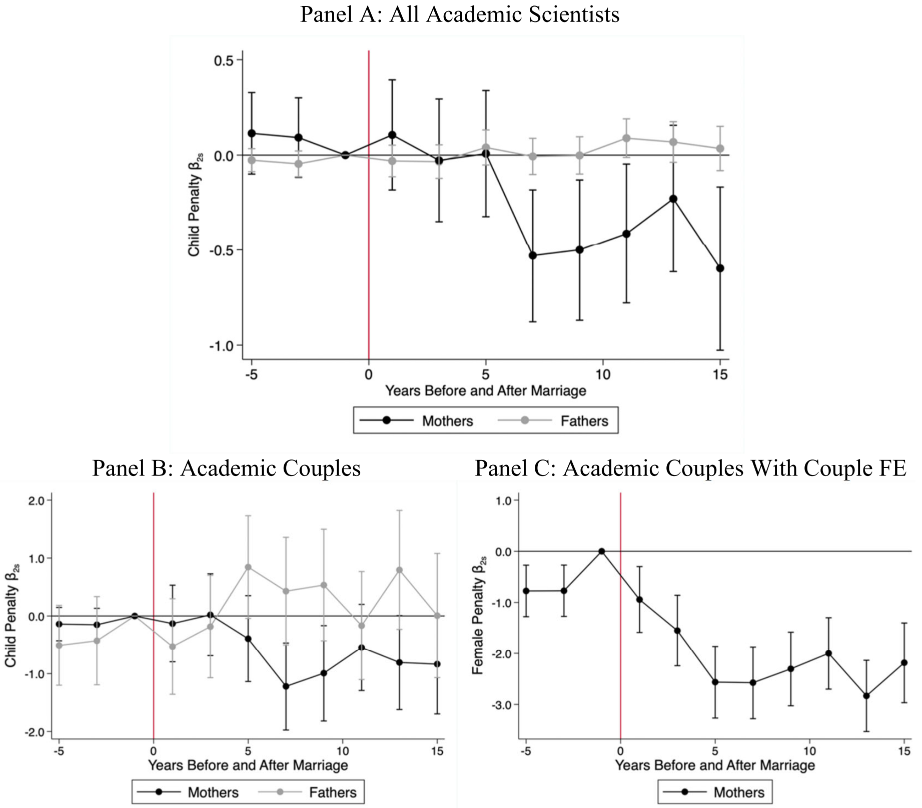


FIGURE 2.—Event studies of changes in publications after marriage. *Notes*: Panels A and B present OLS estimates of β^g_{2s} in $\ln\, y^g_{\text{ist}} = \beta^g_{1s} EventTime_i + \beta^g_{2s} Parent_i * EventTime_i + \delta_t + \alpha_a + \mu_f + \epsilon_{\text{ist}}$, where event time s is indexed relative to the year of marriage and $\ln\, y^g_{\text{ist}}$ is the natural log of publications (adding 0.001) per scientist i of gender g in two-year event time interval s and two-calendar-year interval t. The coefficient β^g_{2s} is a vector of time-varying estimates of the child penalty in publications in interval s by parents of gender g compared with scientists without children of the same gender years -1 and 0 before marriage. δ_t are calendar-year fixed effects, α_a are scientist age fixed effects, and μ_f are research fields fixed effects. Panel A includes all 39,929 married academic scientists; Panel B presents estimates Panel A for 559 academic scientists who married another scientist. Panel C presents estimates with couple fixed effects for 304 scientists in 152 academic couples with children in the equation $\ln\, y_{\text{ist}} = \beta_{1s} EventTime_i + \beta_{2s} Mother_i * EventTime_i + \delta_t + \alpha_a + \mu_f + \theta_c + \epsilon_{\text{ist}}$, where β_{2s} is a vector of time-varying estimates of publications in two-year event time interval s relative to the year of marriage by mothers compared with fathers one year before marriage. θ_c are couple fixed effects and all other variables are as defined above. Standard errors are clustered at the scientist level.

across the life cycle; calendar year and field fixed effects are defined as above. Since there is variation in event time y driven by the year of marriage (conditional on age and year), these specifications identify three separate time dummies for calendar year t, scientist's age a in year t, and event time s. Standard errors are clustered at the individual level.

A potential threat to the identification strategy is that mothers may decide to have children after their productivity has started to decline. Reassuringly, the productivity of mothers does not decline before their first child. Estimates for β^g_{2s} are close to zero before marriage and remain low for the first few years of marriage (Figure 2, Panel A).

Event study estimates indicate that publications by mothers decline after five years of marriage—one year after the median scientist has her first child. After 7–8 years of marriage, mothers published 41.1% (Figure 2, Panel A, -0.530 log points, $p = 0.003$) less than other married women, relative to married women's productivity levels before marriage. These estimates are robust to excluding scientists who were born after 1911 and would have been less than 45 years old in 1956 (Figure A3, Panel A), and to alternative estimation strategies (implementing Chen and Roth (2024)), including a Poisson pseudo-maximum likelihood specification (Figure A3, Panel B).

5.2. *When Productivity Declines, the Median Mother Has a 1-Year-Old Child*

While we cannot observe the exact year of childbirth for *all* parents in the MoS, we are able to observe the birth years of children for 412 parents whom we have hand-matched with the census (Appendix A). These census-linked data show that the median (male or female) scientist had their first child after four years of marriage (Figure A4). Among 174 male and female scientists who served on the faculty at UC Berkeley, UCLA, and Stanford in 1940 and whom we have been able to match with the 1940 census, scientists had their first child within 4.02 years of marriage, with a median of 4 years. Information on the birth years of children in academic couples confirm these findings. Two hundred thirty-eight scientists in academic couples had their first child within 4.53 years of marriage, with a median of 4 years.

Why are mothers less productive while their children are young? Survey data indicate that, even today, children create more work when they are young, and that mothers do most of that work. Since 2003, mothers in the population have spent 2.23 times more time per day caring for infants (children under the age of 5) than fathers (IPUMS Time Use (2024)). Among scientists, mothers have spent 1.41 times more time per day since 2003 compared with fathers (OCC = 3, IPUMS Time Use (2024)).

5.3. *Mothers Never Fully Recover While Fathers Experience No Adverse Effects*

The productivity gap between mothers and other married women remains large with 39.4% (-0.500 log points, $p = 0.008$) after 9–10 years of marriage and 45.0% (-0.597 log points, $p = 0.007$) after 15–16 years (Figure 2, Panel A). This persistent decline is consistent with high returns to labor market experience, which may be particularly salient for science.[10] For example, a "has-been" model of skill obsolescence implies that obsolescence increases with the pace of technological change (MacDonald and Weisbach (2004)), and McDowell (1982) documents exceptional decay rates of knowledge in science, especially in physics and chemistry.

Event study estimates for fathers are consistently close to zero and never statistically significant. Estimates range from -0.027 log points ($p = 0.389$) in years 5–4 before marriage to 0.035 ($p = 0.559$) after 15–16 years of marriage (Figure 2, Panel A, gray line). All results are robust to adjusting for the number of co-authors, controlling for the quality of publications through citations (Figure A2, Panel A), and to winsorizing the data by dropping the top 5% of publishers.

[10]Investigating the career costs of children, Adda, Dustmann, and Stevens (2017) estimate a dynamic life cycle model of labor supply, fertility, and savings that incorporates occupational choices with specific wage paths and skill atrophy that vary over a person's career. Examining workers who select into apprenticeship programs (rather than a university education) in Germany, they find that fertility explains an important part of the gender wage gap, especially for women in their 30s. Examining the returns to labor market experience for mothers, Kuka and Shenav (2024) show that mothers who faced increased incentives to return to work after the 1993 reform of the Earned Income Tax Credit accrued 0.5–0.6 additional years of work experience and had 4.2% higher earnings. Compared with these results, our analysis is focused on high-skilled occupations in science, in which labor market disruptions are likely to carry even larger costs.

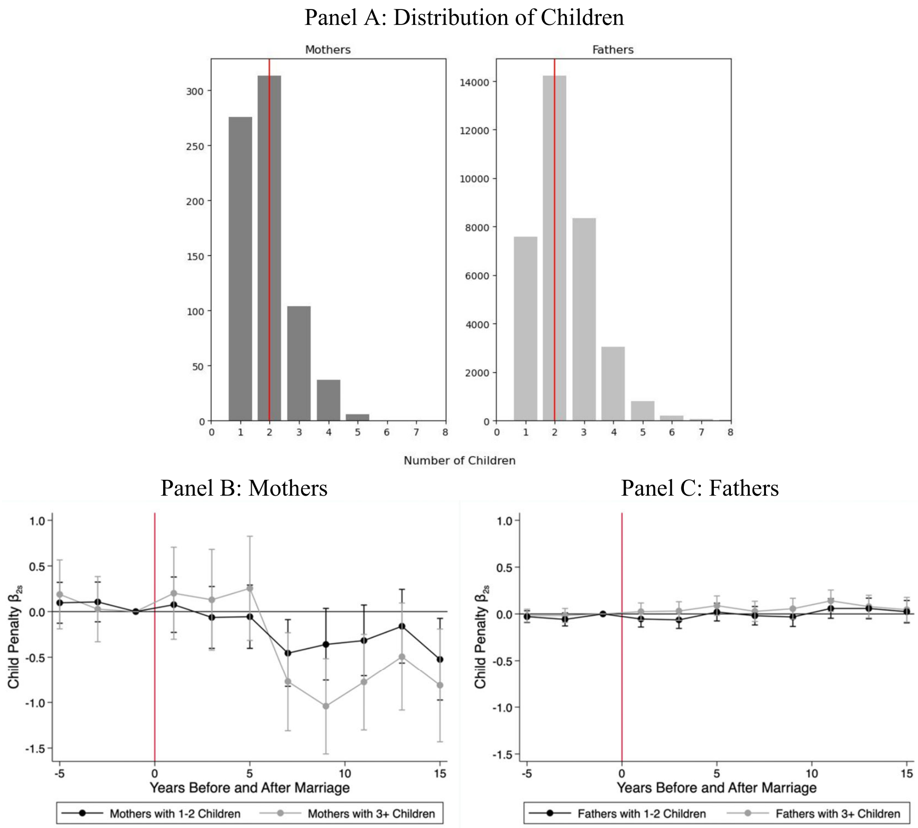


FIGURE 3.—Differences in the number of children for mothers versus fathers. *Notes*: Panel A shows the distribution of the number of children for mothers and fathers. The vertical line marks the median number of children for mothers and fathers. Panels B and C investigate the differences in the number of children as a mechanism for the decline in publishing by mothers. To do this, we re-estimate the event studies in Figure 2, Panel A separately for parents with 1–2 children and with 3 or more children. Panel B shows this comparison for mothers, while Panel C shows it for fathers.

5.4. *Mothers With More Children Experience a Larger Decline*

If children drive the observed decline in mothers' productivity, women with more children should, all else equal, experience a larger decline in publishing. To investigate this question, we re-estimate event studies in Eq. (2) for mothers and fathers with up to two children (the median number of children in our data, Figure 3 Panel A) and three or more children (above the median, Figure 3 Panel A).

These estimates confirm that mothers who have more children experience a larger and more persistent decline in productivity. Like the baseline estimates, the productivity of mothers does not decline before their first child. For mothers with one or two children, publications decline after 5 years of marriage—one year after the median scientist has her first child. After 7–8 years of marriage, mothers published 36.6% less than other married women, relative to married women's productivity levels before marriage (Figure 3, Panel B, −0.456 log points, $p = 0.015$). Mothers who have more (3+) children experience an even larger and more persistent decline in publishing, with a 53.8% decline after 7–8 years of marriage (Figure 3, Panel B, -0.771 log points, $p = 0.005$) and 64.7% decline after 9–10 years (-1.041 log points, $p = 0.000$).

Event study estimates for fathers are again consistently close to zero and not statistically significant; if anything, fathers with more children are slightly more productive (Figure 3, Panel C). Estimates that separate parents with a single and multiple children confirm these findings.

5.5. *Mothers Who Are Married to Another Scientist Experience an Even Stronger Decline*

Access to childcare, attitudes toward gender roles, individual traits of children, and other forces that vary across families may influence the career effects of children. To control for such forces, we match scientists with their partners and estimate event studies with family fixed effects.

First, we re-estimate event study estimates (in Eq. (2) and in Figure 2, Panel A) for academic couples. These estimates show that mothers in academic couples become substantially less productive relative to other women, while fathers become more productive relative to other married men (Figure 2, Panel B). After 7–8 years, when the median couple's first child would be 3–4 years old, mothers publish 70.5% (-1.221 log points, $p = 0.002$) less than other married women. Five to six years after marriage, fathers enjoy a publication advantage of 132.7% (0.844 log points, $p = 0.063$). Fathers retain this advantage with 121.4% additional publications after 13–14 years of marriage (0.795 log points, $p = 0.130$), when mothers publish 55.4% less (-0.807 log points, $p = 0.053$). Results are robust to adjusting for the number of co-authors and to controlling for the quality of publications through citations (Figure A2, Panel B).

To control for access to childcare and other factors that vary across families, we estimate event studies for academic couples with family fixed effects. These estimates (in Figure 2, Panel C) compare changes in publications for mothers and fathers within the same academic couple (rather than comparing mothers with other married women, as in Figure 2, Panels A and B). Specifically, we estimate OLS regressions:

$$\ln y_{\text{ist}} = \beta_{1s} EventTime_i + \beta_{2s} Female_i * EventTime_i + \delta_t + \alpha_a + \mu_f + \theta_c + \epsilon_{\text{ist}}, \qquad (3)$$

where event time s is indexed relative to the year of marriage and $\ln\ y_{\text{ist}}$ is the natural log of publications per parent i in two-year event time interval s and two-calendar-year interval t. The coefficient β_{2s} is a vector of time-varying estimates of differences in the number of publications by mothers in event year interval s relative to marriage compared with their partners -1 and 0 years before marriage. θ_c are family fixed effects; all other variables are as defined above. Standard errors are clustered at the scientist level.

Estimates with couple fixed effects confirm that women who are married to another academic scientist experience an even larger decline in publications (Figure 2, Panel C). After 3–4 years of marriage to another scientist, publications by mothers decline by 78.8% (-1.551 log points, $p = 0.000$) relative to their partners and relative to publications of all future parents in academic couples -1 and 0 years before marriage. The gender gap in publications grows to 92.4% after 7–8 years (-2.574 log points, $p = 0.000$) and 94.1% after 13–14 years (-2.833 log points, $p = 0.000$), and it stays large at 88.7% (-2.184 log points, $p = 0.000$) after 15–16 years. Results are robust to adjusting for the number of co-authors and to controlling for citations (Figure A2, Panel C).

Biographical data suggest that many mothers in academic couples supported their husband's research after the birth of a child, when they could not work on their own research. Many scientists in academic couples met in graduate school and worked in related fields.

One hundred nineteen of 342 academic couples (34.8%) graduated from the same PhD program, and another 68 and 41 (19.9% and 12.0%) graduated from the same master's and undergraduate institution, respectively.

A famous example of this pattern is Mileva Marić, Albert Einstein's first wife, who studied physics with Albert at the ETH Zurich. They married after Albert started his full-time job at the patent office in January 1903. Their correspondence describes an intense and productive collaboration, yet, concerned that a publication with a woman would have carried less weight, the couple submitted all research under Albert's name. Albert's "miracle" year in 1905 followed the birth of their son Hans-Albert on May 14, 1904. He published five articles, including one on the photoelectric effect (cited for the 1921 Nobel Prize), two on Brownian motion, one on special relativity and the famous $E = mc^2$, commented on 21 scientific papers, and submitted his thesis on the dimensions of molecules. Their letters document that Mileva supported this work, even though she never shared authorship. After spending five weeks completing the article on special relativity, Albert "went to bed for two weeks. Mileva checked the article again and again, and then mailed it" (Krstić (2004), Popović (2003)).

Other prominent examples of academic couples who collaborated on their research include Esther and Joshua Lederberg, as well as Beatrix and David Hamburg. David's obituary in the *NY Times* (April 23, 2019) reports that he had been "Conducting some of his research with his wife." Yet, Beatrix, who was the first self-identifying Black woman to graduate from Vassar in 1944 and from Yale Medical School in 1948, was missing from the MoS (1956), after marrying in 1951 and having two children. If women like Beatrix Hamburg expected to get less credit for their research (e.g., Sarsons et al. (2021)), they may have rationally decided to focus on supporting their husband's research while their children were young.

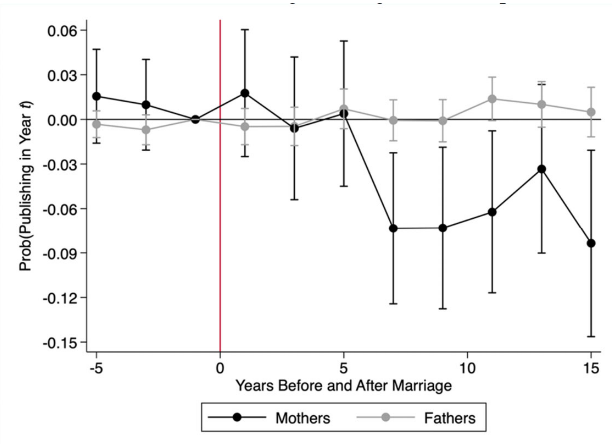
Irrespective of children, women in academic couples may publish less if couples prioritize the husband's career in joint location decisions, resulting in worse job matches for married women. To investigate this channel, we collect geographic data on the workplace of all scientists in academic couples; these data are available for 46 couples.[11] Thirteen scientists moved to be in the same state as their spouse. Women were slightly more likely to move to be with their spouse: four male and five female scientists moved. In another two couples, both partners moved to a new state when they married. Men and women remained in academia at similar rates after they moved to be with their partners (83% and 71% for men and women, respectively), suggesting that joint location decisions are unlikely to drive the productivity decline for women relative to men.

5.6. *The Decline for Mothers Is Driven Primarily by Changes at the Extensive Margin*

The example of Beatrix Hamburg suggests that the decline in publications may have been driven by mothers who temporarily stopped publishing while their children were young. To investigate this mechanism, we separately estimate changes at the extensive and intensive margin. Extensive margin regressions estimate Eq. (2) with the probability that scientist i publishes at least one paper in period t as the outcome variable. In intensive margin regressions, the outcome variable is the number of publications in period t by scientists with at least one publication in that period.

[11] We use GPT 4.0 API to collect data on scientists' place of employment two years before and after marriage. Scientists in 31 of 46 couples (67%) lived in the same state within two years before marriage. After two years of marriage, scientists in 41 couples (89%) lived in the same state.

Panel A: Extensive Margin Changes in Participation



Panel B: Intensive Margin Changes in the Number of Publications

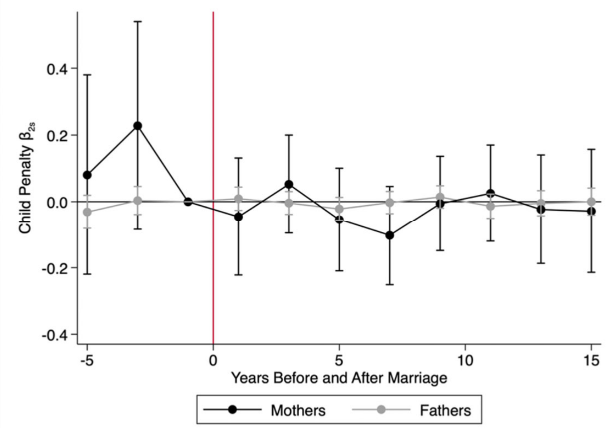


FIGURE 4.—Decomposing changes at the extensive and intensive margins. *Notes*: Panel A reports extensive margin OLS estimates of β^g_{2s} in the equation $y^g_{\text{ist}} = \beta^g_{1s} EventTime_i + \beta^g_{2s} Parent_i * EventTime_i + \delta_t + \alpha_a + \mu_f + \epsilon_{\text{ist}}$, where y^g_{ist} equals 1 if an academic scientist I of gender g published at least one paper in two-year event interval s and two-calendar-year interval t. All other variables are as defined in Figure 2. Relative to the pre-marriage probability of publishing at least one paper per two-year interval before marriage of 0.099, an estimate of -0.077 in years 7–8 implies that mothers are 78% less likely to publish after 7–8 years of marriage compared with their pre-marriage participation rates. Panel B reports intensive margin OLS estimates of β^g_{2s} for years in which the academic scientist published at least one paper. The outcome variable y^g_{ist} counts publications in a two-year event interval s. Years without publications are dropped and standard errors are clustered at the scientist level.

These estimates confirm that the temporary decline in output by mothers was driven primarily by changes at the extensive margin (Figure 4, Panel A). In the five years leading up to marriage and in the first five years of marriage, mothers are as likely as other married women to publish at least one paper in a two-year interval. After 7–8 years of marriage, when the median first child would have been 3–4 years old, participation by mothers reaches its lowest point. At this time, mothers are 7.3 percentage points ($p = 0.005$) less likely to publish compared with women's probability of publishing before marriage. Relative to a 9.9% probability of publishing for mothers before marriage, this estimate implies a 73.7% decline in participation. After 9–10 and 11–12 years of marriage, mothers are 7.3

($p = 0.009$) and 6.2 ($p = 0.025$) percentage points less likely to publish, implying a 73.7% and 62.6% decline, respectively. Participation never recovers fully, with an 8.4 percentage point ($p = 0.009$) decline 15–16 years after marriage. By comparison, there are no significant changes in participation for men.

Estimates at the intensive margin are large but not statistically significant due to the small number of mothers who publish while their children are young (Figure 4, Panel B). After 7–8 years of marriage, mothers produce 9.8% fewer publications (−0.103 log points, $p = 0.176$) compared with publications by women at −1 and 0 years before marriage.

5.7. *Female Assistant Professors With Children Are More Likely to Leave Academia*

One potential channel for the declining research productivity of mothers is that they may leave academia and lose access to laboratory space, research assistance, or other resources that universities offer to facilitate research. To explore this channel, we examine the employment histories of all 49,243 academic scientists, including 736 mothers and 2567 other women. We use the start and end dates of academic appointments to identify years when each scientist held an academic job and when they left academia.[12]

First, we examine whether children increased the risks of leaving academia for female assistant professors (Figure A5, Panel A). Until marriage, female assistant professors with and without children remain in academia at similar rates: 86.2% of mothers and 85.7% of other women who were assistant professors before marriage remain assistant professors in the year of marriage. After three years after marriage, however, only 53.4% of mothers remain in academia, compared to 67.0% of other women. By comparison, fathers are *less* likely to exit academia after marriage than other married men: 78.7% of fathers remain in academia after three years of marriage compared to 74.6% of other married men (Figure A5, Panel B). In contrast, mothers are no more likely than other demographic groups to leave positions *off the tenure track*, as instructors (Figure A5, Panel C).[13]

To investigate whether—and how much of—the productivity decline for mothers is due to mothers losing their academic jobs, we re-estimate the baseline specification in Eq. (2) with a time-varying indicator for years when a scientist held an academic job. As in the main specifications, estimates before marriage are indistinguishable from the baseline (Figure A6, Panel A). After 7–8 years of marriage, mothers are 34.5% (−0.423 log points, $p = 0.026$) less likely to publish controlling for academic employment, compared with 41.1% (−0.530 log points, $p = 0.003$) in the baseline. This suggests that up to one quarter of the estimated productivity decline for mothers is due to mothers exiting academia at a larger rate. As above, estimates for men remain largely unchanged controlling for academic employment (Figure A6, Panel B).

5.8. *Gender Differences in Tenure Are Driven Almost Entirely by Children*

Differences in the timing of productivity have important implications for tenure and promotions. Analyzing scientists' career histories, we find that just 27% of mothers who are academic scientists achieve tenure, compared with 48% for fathers and 49% for other men (Table II). Notably, tenure rates for female scientists without children are nearly

[12]Data include 170 married female assistant professors who held that position before marriage: 58 of them are mothers and another 112 are married women without children; and 4096 male assistant professors who held that position before marriage, including 3075 fathers and 1021 other married men.

[13]Data include 12,841 scientists who held positions as instructor when they married; 233 of them are mothers, 247 other married women, 10,097 fathers, and 2263 other married men.

TABLE II

THE ACADEMIC PIPELINE FROM PHD TO TENURE.

	All	Mothers	Other Women	Fathers	Other Men
Academic scientists / all scientists	75.4%	84.9%	88.7%	73.6%	77.7%
PhD / academic scientists	77.9%	83.0%	84.5%	76.6%	79.9%
Tenure-track / academic scientists	46.1%	36.0%	45.9%	45.7%	48.0%
Tenured / academic scientists	47.9%	26.9%	46.7%	48.1%	49.1%
N all scientists	65,337	867	2893	46,621	14,956
N academic scientists	49,243	736	2567	34,320	11,620

Note: *Notes: Academic scientists* are scientists who held a university appointment (e.g., as a lecturer or professor) at least once. *Tenure-track scientists* are academic scientists who worked as assistant professors at least once. *PhD scientists* are scientists who have earned a PhD. *Tenured scientists* are scientists who have been promoted to associate and full professors. Data include a balanced panel of 65,337 MoS (1956) scientists born between 1882 and 1925, whose publishing output we observe for all years between the ages of 18 and 45; 49,243 of them are academic scientists.

identical to tenure rates for men (at 47%).[14] These results are consistent with experimental evidence on competition in high-status jobs, which suggests that high-stakes competition in the workplace (e.g., competition to publish in prestigious journals and achieve tenure) fuels gender inequality both directly (since men are more likely to enter), and indirectly, by raising work hours, hurting women with children (Miller, Petrie, and Segal (2024)).

Using data on the timing of tenure, we find that mothers either receive tenure early, within the first six years of being an assistant professor, or not at all (Figure 5, Panel A). Counting from their first year as an assistant professor, mothers have comparable tenure rates in the first six years, reaching 30% in year six. After year six, however, tenure rates for mothers plateau below 40%, while rates for fathers continue to increase for 15 years to a rate of 62%. In addition to differences in tenure rates, mothers are less likely to get tenure-track jobs. Just 36% of mothers get appointments as tenure-track assistant professors compared with 46% of other women, 46% of fathers, and 48% of other men (Table II).

Notably, mothers publish more after tenure, while publications by other scientists peak around the tenure year (Figure 5, Panel B). Data on changes in publications per year relative to the tenure year show that publications by mothers increase continuously from 0.22 publications in the year before tenure to 0.39 publications five years after tenure. By comparison, publications by fathers increase significantly less from 0.40 to 0.48 publications, from 0.15 to 0.17 publications for other women, and from 0.32 to 0.41 publications for other men.

6. INVESTIGATING SELECTION

Throughout the 20th century, university faculties remained "almost adamantly opposed to advancing or promoting any but the most extraordinary" women in science (Rossiter (1982), p. xvi). In this section, we investigate such selection at the level of getting a PhD, marriage, parenthood, research fields, and survival in science for the full sample of 3760

[14]Tenure rates for married women female assistant professors increase as they get older and their "risk" of having children declines (Figure 6, Panel B). Overall, 31.0% of married female scientists get tenure, compared with 51.3% of single scientists (Appendix Table II).

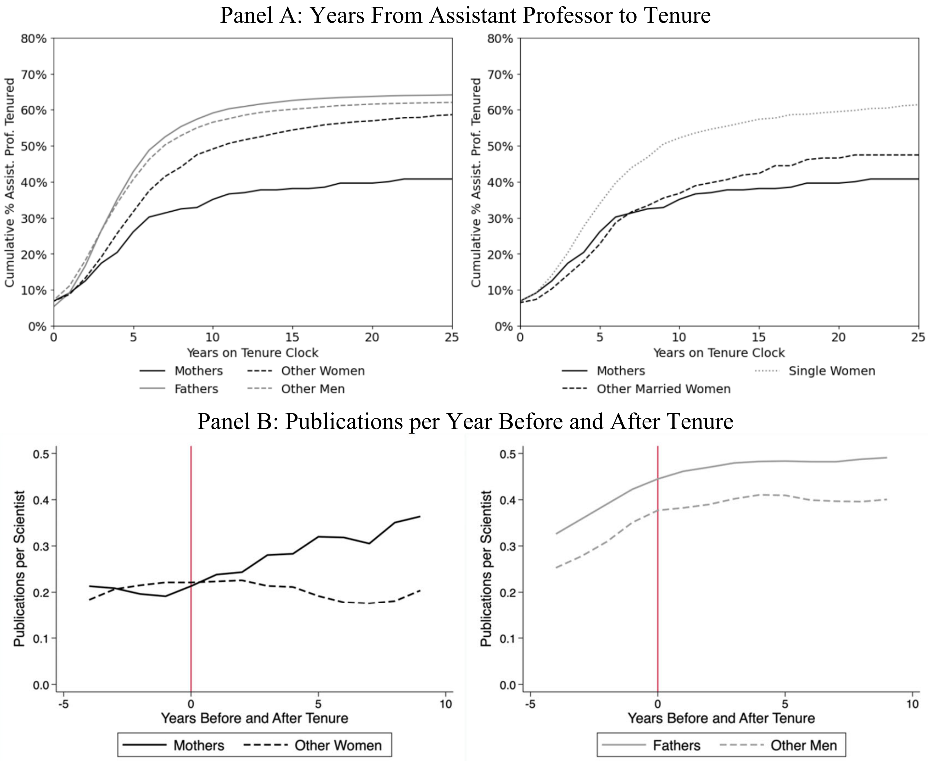


FIGURE 5.—Promotion to tenure. *Notes*: Panel A plots the cumulative share of tenure-track assistant professors who receive tenure within *t* years of starting as an assistant professor. Data include 22,706 academic scientists who were assistant professors. Panel B presents three-year moving averages of publications per scientist and year before and after tenure (the vertical red line). Data include 22,862 academic scientists who earned tenure.

female and 61,577 male scientists, with and without PhDs, including parents, other married, and single scientists.

6.1. *Mothers Are More Likely to Have PhDs Than Fathers*

Models of human capital investment imply that women, who spend less time in the labor market, have weaker incentives to invest in human capital that is valued by the labor market, such as a PhD (e.g., Altonji and Blank (1999), pp. 3166–3167). Women also face formal and informal barriers in access to education, which may discourage them from pursuing a PhD. In the 1950s and 1960s, many graduate departments still refused to admit female applicants (Kevles (1995), p. 371), and even departments that admitted women struggled to support them. The future "Queen of RNA" Joan Steitz was turned down by a prospective advisor at Harvard in the 1960s: "but you are a woman, and you'll get married, and you'll have kids, and what good will a PhD have done?" (Lucci-Canapari (2019)). Despite these obstacles, women may have decided to pursue a PhD, if they faced labor market discrimination and had to be more qualified to obtain the same jobs.

Consistent with labor market discrimination, women were *more likely* to have PhDs than men. This finding is consistent with historical accounts suggesting that, "to be considered 'equal' to men, [...] women had to be 'better'." (Rossiter (1982), p. 159.) Mothers were

TABLE III

SELECTION AND SURVIVAL IN ACADEMIC SCIENCE.

	Mothers	Other Women	Fathers	Other Men
	Panel A: Pubs. Before Marriage			
Academic scientists				
Publications per year	0.059	0.053	0.079	0.069
	(0.330)	(0.308)	(0.408)	(0.387)
Citations per publication (mean | median)	27.55 | 5.66	15.78 | 5.00	16.67 | 4.83	16.67 | 4.00
	(135.28)	(52.52)	(93.70)	(73.80)
N academic scientists	736	2567	34,320	11,620
Scientists in academic couples:				
Publications per year	0.065	0.047	0.154	0.149
	(0.335)	(0.329)	(0.555)	(0.615)
Citations per publication (mean | median)	69.51 | 7.50	11.96 | 5.00	16.74 | 6.50	20.96 | 5.00
	(264.63)	(16.22)	(26.59)	(48.31)
N scientists in academic couples	152	90	152	90
	Panel B: Survival in Science			
% surviving to enter MoS 1956	4.0%	17.3%	40.2%	32.1%
N CA faculty in 1940	25	150	542	473

Note: To investigate selection into parenting, we compare measures for the quantity and quality of publications for academic scientists and couples before the median age at marriage. Both the mean and median citations per publication are reported, with standard errors in the parentheses. The median publications per year for all scientists was 0. Data include a balanced panel of 49,243 academic scientists and 484 academic scientists married to another academic scientist, born 1882–1925, whose publications we observe at ages 18–45. Publications and their citations are reported up to the median age at marriage, 27 for male scientists and 28 for female scientists. Academic scientists are scientists in the MoS (1956) who held a university appointment (e.g., as a lecturer, researcher, or professor of any rank) at least once. To investigate differences in the rate at which mothers and other scientists survived to enter the MoS, we matched 1541 scientists who were faculty at UC Berkeley, UCLA, and Stanford in 1940 with the U.S. Census of 1940 (to identify mothers and fathers) and with the MoS (1956). Faculty directories are available from the UC Cliometric History Project (http://uccliometric.org/faculty). Appendix A describes the census matching.

significantly more likely to hold a PhD than fathers (83.2% compared with 76.6%), but slightly less likely than other women (84.4%).

6.2. *Mothers Are Positively Selected, Especially in Academic Couples*

Mothers who survived to enter the MoS were positively selected. Leading up to the age of 28, the median age of marriage for female scientists, mothers publish 11.3% more than other women, and their papers are more highly cited, with an average of 27.55 citations per paper, 74.6% more than the 16 citations per paper by other women (Table III, Panel A). In contrast, fathers publish 14.5% more than other men, but there is no difference in quality (with 16.67 citations each).

Notably, mothers in academic couples are even more positively selected. Compared with other women in academic couples, mothers publish 38.3% more, and their papers receive more than five times as many citations, with 69.51 citations per paper before marriage for mothers, compared with just 11.96 for other women.

Part of this difference in citations may be driven by selection into disciplines, for example, if mothers disproportionately work in disciplines where scientists publish or cite each other more. To address this issue, we compare highly cited papers for mothers and other women within disciplines. This analysis confirms that mothers are positively selected: Before reaching the median age at marriage, 2.0% of mothers produced at least one highly cited paper in the top 5% of citations in their discipline—42.9% more compared with

1.4% for other women (Figure A7). Similarly, 3.3% of mothers produced at least one paper in the top 10% of highly cited papers in their discipline—17.9% more compared with 2.8% of other women. Fathers are less positively selected compared with other men.

6.3. *Mothers Are Underrepresented in Chemistry, Which Requires Laboratory Work*

In addition to influencing the level of academic productivity, children may influence the type of jobs that mothers can pursue. Most importantly, children may make it difficult for women to pursue "greedy work in science"—research requiring long hours of laboratory work, in the spirit of Goldin (2021, 2014).

Consistent with this idea, we find that mothers were underrepresented in chemistry: Just 11.2% of mothers worked in chemistry, compared with 15.4% of other female scientists (Figure A8, Panel A), 23.3% of fathers, and 20.4% of other men (Panel B). Instead of chemistry, mothers were more likely to pursue research in psychology, which, at the time, offered more flexible work arrangements. Twenty point one percent of mothers worked in psychology, compared with 13.1% of other female scientists, 6.1% of fathers, and 5.4% of other male scientists. Mothers are also overrepresented in subjects related to pharmacy, which Goldin and Katz (2016) call the most "family-friendly profession." Searching for the word stem "pharm" in the subject codes, we find that the research of 1.6% of mothers relates to pharmacy, compared with just 0.7% of other women. Fathers and other men worked in these subjects at similar levels at 1.7% and 1.5%, respectively.[15] By comparison, fathers were more equally distributed across disciplines, and slightly overrepresented in chemistry (23.3% compared with 20.4% of other men, Panel B), physics (14.0% compared with 12.2% of other men), and pathology (11.0% compared with 7.9% of other men).

6.4. *Women Are Less Likely to Marry, and They Have Fewer Children*

Notably, female scientists internalized the career costs of children by having fewer children. Compared with men, female scientists were less than one-third as likely to have children, with 22.3% and 75.7%, respectively. While it became more common to have children over time (with 17.2% for birth cohorts until 1905 and 29.2% for cohorts between 1916 and 1925), female scientists always remained less likely to have children (Figure A9, Panel C).

Female scientists were also less likely to marry, and they married late. Just 38.3% of women married, compared with 84.2% of men. Though marriage rates increased over time, they remained substantially below the share of married men (Figure A9, Panel A).[16] Moreover, female scientists married later than men, at an average age of 29.04 and a median of 28, compared with an average age of 27.75 and a median of 27 for men.

6.5. *Mothers Are Less Likely to Survive in Science*

To examine survival in science, we match faculty rosters for UC Berkeley, UCLA, and Stanford in 1940 with individual records in the U.S. census of 1940 (to identify parents)

[15]To identify scientists working in pharmacy-related subjects, we created a variable that identified subjects containing the string "pharm." These subjects included mostly "Pharmacology," "Pharmacy," "Pharmaceutical Chemistry," and "Pharmacognosy."

[16]For a sample of notable American women, Goldin (2021, pp. 25–30) shows that women born between 1898 and 1923 first achieved a job and then a family; only an exceptional few of them worked for pay after marriage. Bertrand et al. (2021) find that the difference in marriage rates between college-educated and other women increased for women born from the early 1930s to the mid-1950s but declined for younger cohorts. Since the 1960s, college-educated women have been more likely to marry than other women.

and with the MoS (to examine selection into survival). Using a combination of algorithmic and hand-matching techniques (described in Section 3.5 and in Appendix A), we link 1199 of 1541 faculty (77.8%) with individual records in the U.S. census.

Linking matched faculty-census pairs with the MoS (1956), we find that female faculty with children were much less likely to survive in science compared with fathers and other women: Just 4.0% of faculty mothers in 1940 survived to enter the MoS in 1956, compared with 40.2% of fathers (Table III). Female faculty without children were over four times as likely to survive and enter the MoS (17.3%, Table III, Panel B).

6.6. *The Missing Mothers of the Baby Boom*

Finally, we investigate whether the burden of raising the children of the baby boom discouraged women in the generation of the baby boom parents from participating in science. To investigate this question, we compare changes in the number of male and female scientists across birth cohorts, holding constant the demand for academic scientists. We define the generation of baby boom parents (gray-shaded cohorts in Figure 6) as individuals who were of child-bearing age (between 20 and 40 years) at the beginning of the baby boom.

Cohort comparisons suggest that nearly one in four women are missing from the generation of baby boom parents (Figure 6, Panel A). For women in this generation, participation declined both in absolute and relative terms. The birth cohort of 1920 produced just 99 female scientists; 13.9% fewer compared with 115 female scientists born in 1910. By comparison, the number of male scientists increased by 33.9% from 1866 born in 1910 to 2498 in 1920. Assuming parallel annual growth rates between men and women for the birth cohorts of the baby boom parents (using 1905 as the base), an additional 604 female scientists from the 1905–1925 birth cohorts would have been active in American science in 1956 (an estimated 2743 female scientists born 1905–1925, relative to the 2139 female scientists from the same cohorts in the MoS). This implies a 22.0% loss relative to the counterfactual with parallel growth rates.

Census data show that the loss of baby boom mothers was not unique to our sample of MoS scientists; in fact, this loss was even larger in the general population of professors (Figure 6, Panel B). Specifically, we use the 5% random sample of the U.S. population in 1960 to compare changes in the number of male and female professors in the birth cohort of the baby boom parents.[17] Applying the same estimation strategy shows an even greater loss of female professors: Had the number of female professors continued to grow at the same rate as that of male professors for the baby boom parents, the U.S. would have had an additional 20,327 female professors in 1960 (1017 for the 5% sample, times 20), with an estimated total of 43,727 female professors. Relative to the actual number of 23,400 female professors, this implies a 46.5% loss.

7. CONCLUSIONS

Linking rich biographical data on American scientists with individual-level publications, we show that mothers have a unique life cycle pattern of productivity: While other scientists are most productive in their mid-30s, mothers experience a temporary decline in productivity in their mid-30s and reach peak productivity in their early-40s.

[17]U.S. census microdata, available at https://usa.ipums.org/usa/ (IPUMS USA (2023)). To calculate the number of professors per gender and birth year, we count professors and instructors, corresponding to occupational codes (OCC) 31, 32, 34, 35, 40, 41, 42, 43, 45, 50, 51, 52, 53, 54, and 60.

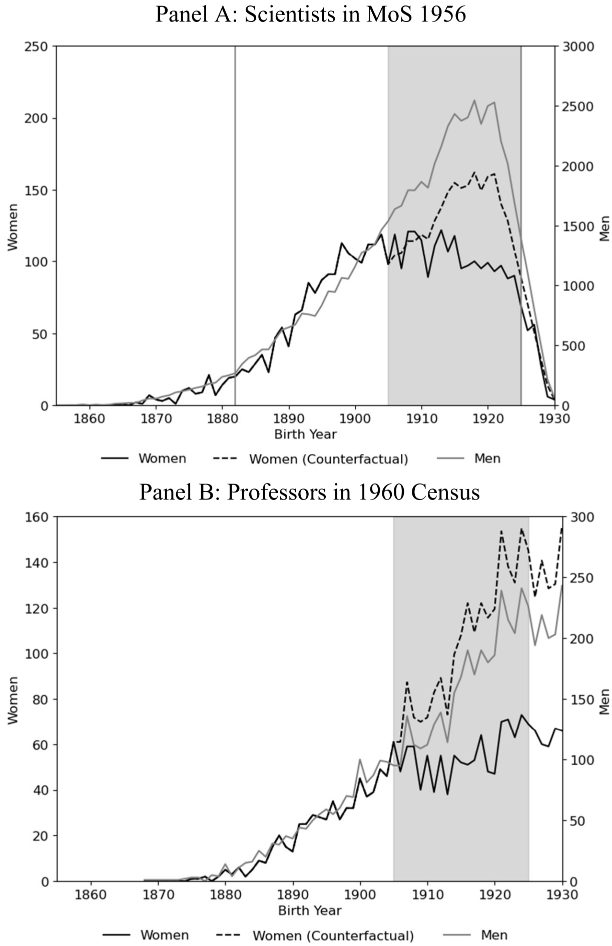


FIGURE 6.—Missing mothers of the baby boom. *Notes*: To examine changes in participation across birth cohorts, we plot the number of male and female scientists in the MoS (1956, Panel A) and the number of male and female professors in the 1960 U.S. census (Panel B) per birth year. Shaded years mark the birth cohorts of the parents of the baby boom, defined as individuals who were of child-bearing age (between 20 and 40 years) at the beginning of the baby boom. Dashed lines plot the counterfactual number of female scientists assuming parallel annual growth rates between men and women for the birth cohorts of the baby boom parents and assuming no changes in the demand for scientists. The vertical gray lines mark the balanced panel of 65,337 scientists in the MoS born between 1882 and 1925 whose publications we observe between the ages of 18 and 45. Data include 70,230 scientists with known gender and birth year in the MoS (1956) and 7762 individuals in the 5% random sample of individual 1960 census records from IPUMS USA who list their profession as professors and instructors.

Event study estimates suggest that this temporary decline is driven by children, who reduce their mothers' productivity until they reach school age. Separating changes at the extensive and intensive margin, we show that the disproportionate productivity decline for mothers is driven largely by changes in participation. Mothers are least likely to publish after 7–8 years of marriage, when the first child of the median scientist would be 3–4 years old. While, in principle, female scientists could choose to have children when their productivity is starting to decline, event studies show no evidence of differential pretrends in publishing. Exploiting data on academic couples, we estimate event studies of academic output with controls for couple fixed effects. These analyses show a strong and persistent decline in publishing for mothers relative to fathers. While mothers become less productive after the birth of a child, fathers publish more, creating a gendered effect of children.

These differences in the timing of productivity have important implications for women reaching the top levels of academic science. In our data, just 26.9% of mothers who are academic scientists achieve tenure compared with 48.1% of fathers and 46.7% of women without children. Linking faculty records with the U.S. census and the MoS, we show that mothers are half as likely to survive in science compared with other female faculty. Examining selection, we find that mothers who survive in science are positively selected, both in terms of the level and the quality of publications before marriage.

The historical context is important for interpreting our results. During the baby boom, the burden of bearing and raising children fell entirely on women. As late as 1965, mothers spent eight times as much time caring for children below the age of five compared with fathers (American Heritage Time Use Survey (1965)). By 2018, however, mothers spent just 2.61 times as much time compared with fathers (American Time Use Survey (2018)). As the gender gap in childcare narrows, the gendered effects of children should decline.[18] Yet, research on top departments indicates that gender-neutral tenure policies continue to disadvantage women, at least in economics (Antecol, Bedard, and Stearns (2018)). This suggests that children disproportionately harm the productivity of female academics today, despite advances that have benefited women overall.

Due to the disparate impact of children on female scientists, only the most exceptional mothers survived in science. Had the number of female scientists grown at the same rate as that of men, an additional 604 female scientists would have entered American science, nearly 30% more. Equivalent estimates for census data imply an even larger number of missing female professors. This implies an enormous loss in exposure to female role models, which has been shown to encourage participation in science (Carrell, Page, and West (2010), Porter and Serra (2020)) and invention (Bell et al. (2019)).[19] Moreover, the loss of female scientists may have discouraged medical advances and other innovations that benefit women (Koning, Samila, and Ferguson (2020, 2021)). As a result, the shadow of the baby boom may affect science to this day.

APPENDIX A: MATCHING FACULTY AND MARRIED COUPLES WITH THE U.S. CENSUS

To collect the birth years of children, we match the faculty of UC Berkeley, UCLA, and Stanford in 1940 (Bleemer (2018)) and all scientists who are married to another MoS scientist with individual records in the U.S. Censuses of 1940 and 1950. Demographic variables and information on household members in the Census allow us to classify scientists by their gender and parental status.

[18] Conditional on publications and citations, women are today more likely to become members of the Econometric Society (Card et al. (2022)), as well as the National Academy of Sciences and the American Academy of Arts and Sciences (Card et al. (2023)).

[19] Carrell, Page, and West (2010), for instance, show that female students at the U.S. Air Force Academy who were randomly assigned to female professors performed better in introductory math and science and were more likely to pursue STEM majors. Porter and Serra (2020) show that exposure to charismatic female economists inspires female students to enroll in more advanced economics classes. Bell et al. (2019) show that girls are more likely to invent in a particular technology field if they grow up in an area with more female (but not male) inventors in that field. Fernández, Fogli, and Olivetti (2004) show that exposure to working mothers changes the preferences of both women and men toward gender inequality.

California Faculty

1. We extract data on 1541 scientists who served as faculty in 1940 and use information on their names and places of residence to establish a high-quality match with the census.
    a. Information in the directories on the scientist's university in 1940 allows us to determine their county of residence in 1940. For example, the entry in UC Berkeley's directory for Kenneth S. Pitzer shows that he was an Assistant Professor of Chemistry in 1940, and thus employed in Alameda Country, California in 1940.

ID	Year	Field	FName	MName	LName	Position	Degree	Area
1860	1940	Chemistry	Kenneth	S	Pitzer	AstP	PhD	Chemistry

2. *Algorithmic Matching*: Using the scientist's name, their county of residence in 1940, and their occupation, we manually identify 1199 (77.8%) matches for the 1541 Californian faculty in 1940 within the 1940 Census.
3. *Manual Checks for Ambiguous Matches*: To resolve ambiguities in the algorithmic matching (e.g., for scientists with identical first, last names and the same middle initial, but different full middle names), we search for biographical information for affected scientists.
4. *Matching Faculty Members with the MoS (1956)*: Using the scientist's name, their career history in the MoS, and their birth years, we create a Python algorithm that identifies scientists in the MoS (1956) who worked at the three universities in 1940. Among the 1199 matched faculty members, 406 survived to enter the MoS in 1956 (33.9%).
5. *Checking for Remarriages*: In the final step of data cleaning, we check for remarriages for the 406 scientists who survived to enter the MoS (1956). Sturla Einarsson, for example, was a UC Berkeley faculty member born in 1879. He married and had his first child at the age of 35 with Anna Kidder. Anna Kidder passed away in 1940, and Sturla married Thea Hustvet in 1946. Einarsson only reports the year of his current marriage, which is 35 years after the birth of his first child. To address this issue, we drop nine faculty members who had their first child more than 5 years before marriage, leaving us with 397 faculty members who are matched with both the 1940 Census and the MoS (1956).
6. *Determining Time to Child from Marriage*: Using data on marriage years from the MoS and birth years of children from the 1940 census, we are able to determine the time to first child from marriage for 174 of the 397 matched faculty members.

MoS Couples

1. We also match 410 scientists who are married to another scientist and report having children (205 couples) in the MoS (1956) with their census records in 1940 and 1950. For these scientists, we use information on their name, birth year, birth location, and education/career histories to determine their location in 1940 and 1950 to establish a high-quality match with the census.
2. *Algorithmic Matching*: Using the scientist's name, birth year, birth location, and career and educational histories, we manually match 124 couples (60.5%) with the census. Among them, 51 are matched with the 1940 census and 73 with the 1950 census. Using both census waves allows us to observe children when they are living with the scientists in our data.

APPENDIX TABLE I

SCIENTISTS WHO MARRIED OTHER SCIENTISTS IN THE MOS.

	All	Mothers	Other Women	Fathers	Other Men
Scientists who married another scientist					
All	637	195	121	196	125
Academic scientists	559	174	105	171	109
Scientists in academic couples	484	152	90	152	90

Note: MoS couples are married scientists whose partners are scientists in the MoS (1956); there are 674 scientists in 337 couples. *All scientists* is a balanced sample of 637 scientists born between 1882 and 1925. *Academic scientists* are scientists who have had a university appointment at least once. *Scientists in academic couples* are academic scientists in the balanced panel whose partners are also academic scientists and in the balanced sample.

APPENDIX TABLE II

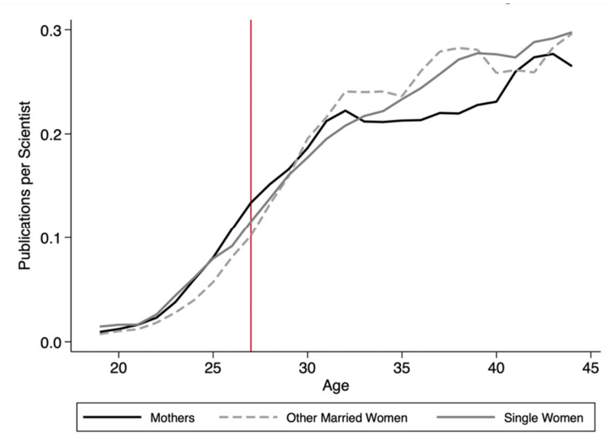
THE ACADEMIC PIPELINE FROM PHD TO TENURE COMPARING PARENTS WITH OTHER MARRIED AND SINGLE SCIENTISTS.

	Mothers	Other Married Women	Single Women	Fathers	Other Married Men	Single Men
Academic scientists / all scientists	84.9%	87.0%	89.2%	73.6%	74.4%	81.4%
PhD / academic scientists	83.0%	84.7%	84.4%	76.6%	79.3%	80.6%
Tenure-track / academic scientists	36.0%	40.1%	47.5%	45.7%	47.3%	48.7%
Tenured / academic scientists	26.9%	31.0%	51.3%	48.1%	43.8%	54.7%
N all scientists	867	670	2223	46,621	7933	7023
N academic scientists	736	583	1984	34,320	5902	5718

Note: This table replicates Table II, breaking down "Other Women" and "Other Men" by whether they were married without children or single. Data include a balanced panel of 65,337 MoS (1956) scientists born between 1882 and 1925, whose publishing output we observe for all years between the ages of 18 and 45; 49,243 of them are academic scientists.

3. *Manual Checks for Ambiguous Matches*: To resolve ambiguities in the algorithmic matching (e.g., for scientists with identical first and last names and the same middle initial, but different full middle names), we search for biographical information of these scientists.
4. *Checking for Remarriages*: In the final step of data cleaning, we check whether scientists may have remarried. For example, Leland Hemenway (married to Harriet Hemenway in the MoS 1956) was born in 1895 and was first married to Clara Hinckley, with whom he had his first child in 1921 (at the age of 26). Clara passed away in 1942, after which Leland married Harriet Hemenway in 1946. Leland only reports his most recent marriage year, which is 25 years after the birth of his first child. Data on the timing of marriage and the birth year of children suggests that remarriages may have been possible for 248 of the 410 scientists in couples. Among them, we drop five couples who had their first child more than 5 years before marriage, leaving us with 119 couples (238 scientists) who are matched with either the 1940 or 1950 censuses.
5. *Determining Time to Child from Marriage*: For married couples of scientists, we use data on marriage years from the MoS and birth years of children from the 1940 and 1950 census to determine when scientists had their first child relative to their year of marriage. We calculate this statistic for the 238 matched scientists in our data.

Panel A: Mothers vs. Other Married Women vs. Single Women



Panel B: Fathers vs. Other Married Men vs. Single Men

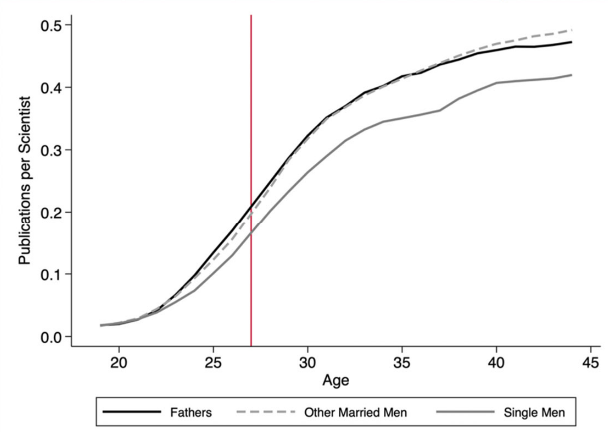


FIGURE A1.—Publications across the life cycle comparing parents with other married and single scientists. *Notes*: Panel A shows three-year moving averages of publications per year for mothers, other married women, and single women who are academic scientists between the ages of 18 and 45. Panel B shows the same for fathers, other married men, and single men. The vertical line at age 27 marks the median age of marriage for all academic scientists.

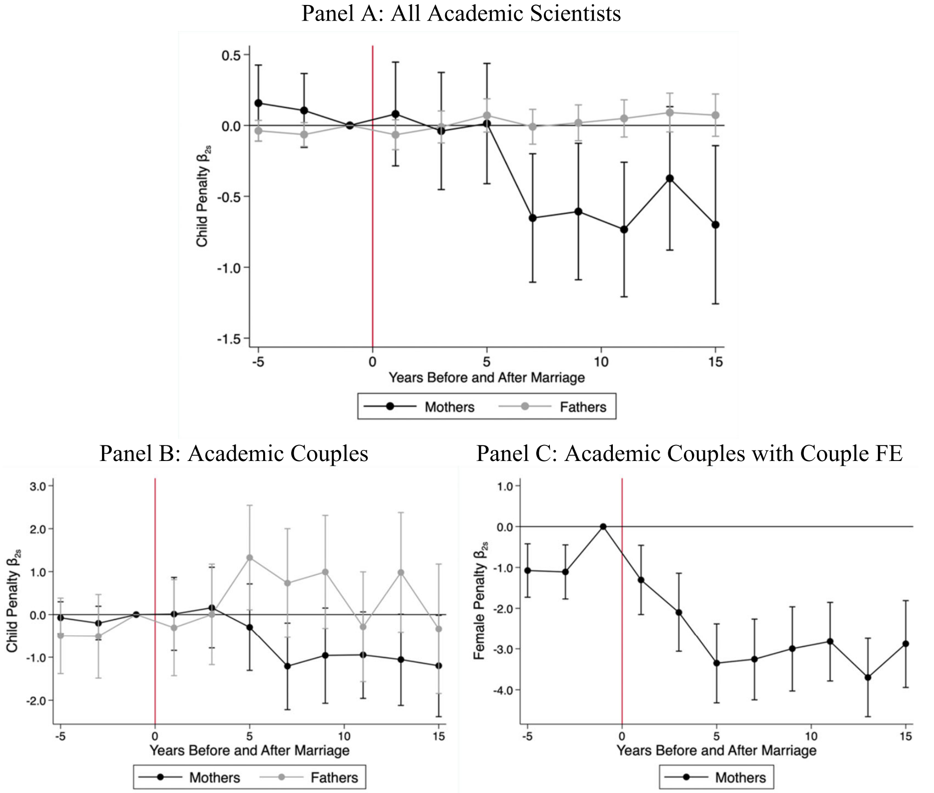


FIGURE A2.—Event study using citations to control for the quality of publications. *Notes*: This figure replicates Figure 2, controlling for the quality of publications through the number of citations. Panels A and B show OLS estimates of β^g_{2s} in $\ln\, y^g_{\text{ist}} = \beta^g_{1s} EventTime_i + \beta^g_{2s} Parent_i * EventTime_i + \delta_t + \alpha_a + \mu_f + \epsilon_{\text{ist}}$, where $\ln\, y^g_{\text{ist}}$ is the natural log of citations to publications per academic scientist of gender g and two-year event time interval s relative to the year of marriage and two-calendar-year interval t. The coefficient β^g_{2s} is a vector of time-varying estimates of the child penalty parents face in terms of citations in event interval s relative to the year of marriage by parents of gender g compared with scientists without children of the same gender one year before marriage. δ_t are calendar year fixed effects, α_a are scientist age fixed effects, and μ_f are research fields fixed effects. Panel A includes all 39,730 married academic scientists and their 6,192,588 citations; Panel B presents estimates Panel A for 559 academic scientists who married another scientist. Panel C presents estimates with couple fixed effects for 304 scientists in 152 academic couples with children in $\ln\, y_{\text{ist}} = \beta_{1s} EventTime_i + \beta_{2s} Mother_i * EventTime_i + \delta_t + \alpha_a + \mu_f + \theta_c + \epsilon_{\text{ist}}$, where β_{2s} is a vector of time-varying estimates of citations in two-year event interval s relative to the year of marriage by mothers compared with fathers one year before marriage. θ_c are couple fixed effects; all other variables are as defined above. Standard errors are clustered at the scientist level.

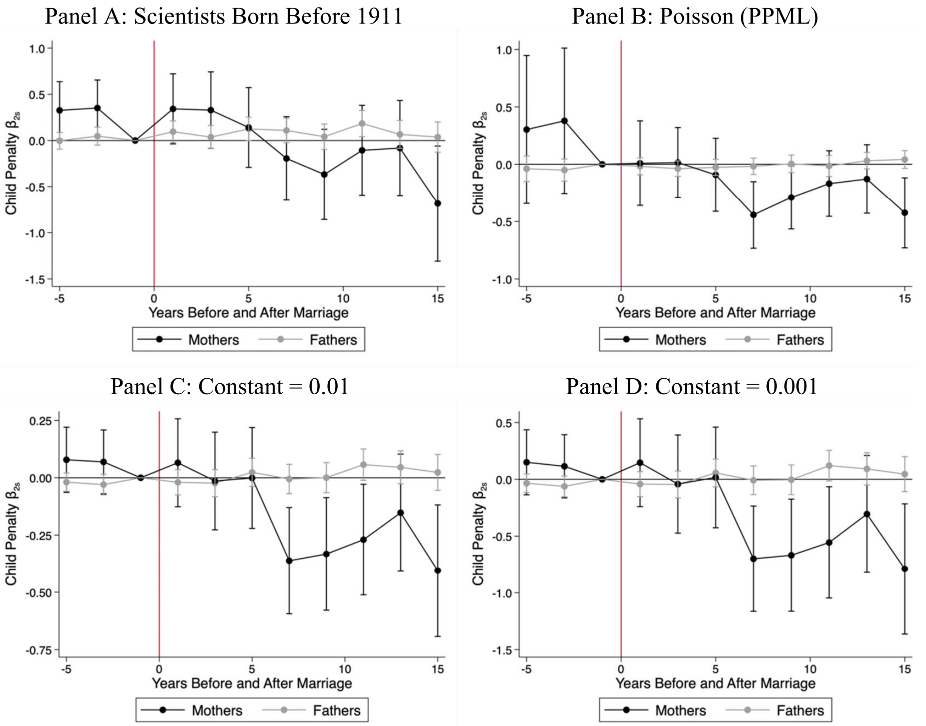


FIGURE A3.—Additional robustness checks. *Notes*: Panel A replicates the baseline specification (Figure 2, Panel A), excluding scientists who were born after 1911. These scientists were less than 45 years old in 1956 and may have had children after we observe them in the MoS (1956). Panel B replicates the same baseline specification, but instead estimates a Poisson pseudo-maximum likelihood event study where the dependent variable is in publication levels instead of logs. Panels C and D re-estimate the baseline specification adding a constant of 0.01 and 0.0001, respectively.

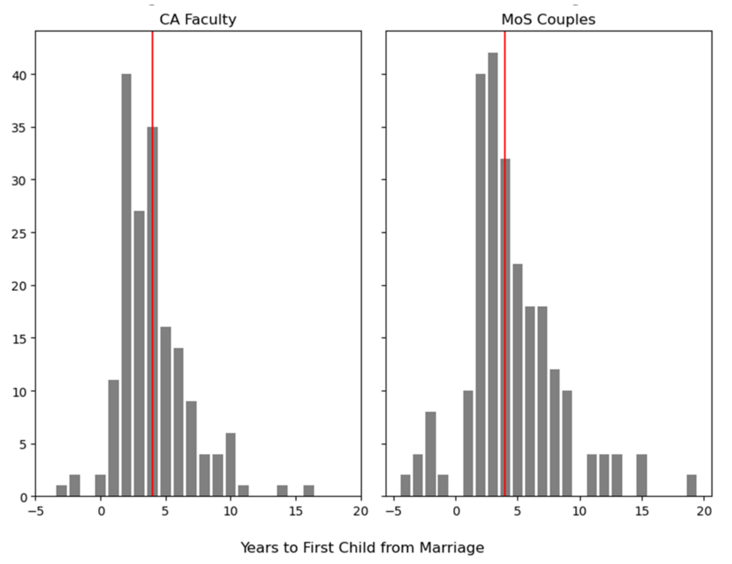


FIGURE A4.—Years to first child after marriage. *Notes*: Figure A4 plots the distribution of years between the year of marriage and the birth year of a couple's first child for 238 CA faculty and 174 MoS couples (348 scientists) whom we have been able to match with the U.S. census. The vertical line at four years marks the median time to the birth year of the first child after marriage for both samples. To account for remarriages, we drop couples who had their first child more than 5 years before marriage, as detailed in Appendix A.

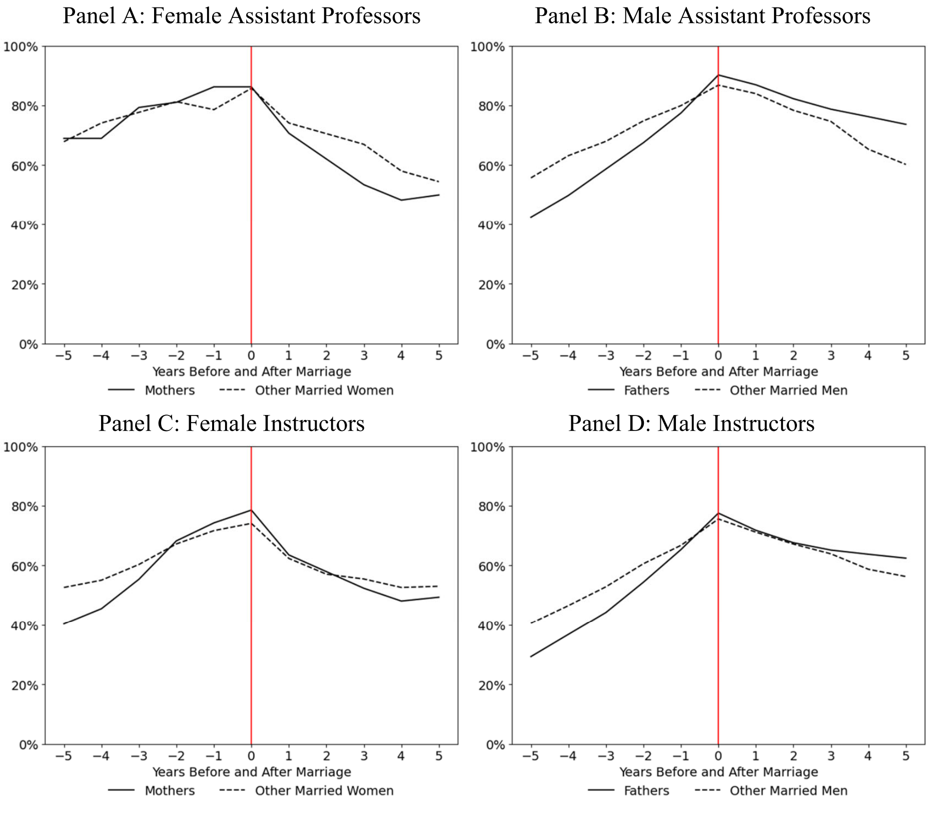


FIGURE A5.—Share of academic scientists remaining in academia after marriage. *Notes*: Panels A and B show academic participation rates 5 years before and after marriage by women and men, respectively, who started assistant professorships before marriage. Panels C and D show the same for women and men, respectively, who started instructor positions before marriage. Data include 170 female assistant professors (58 mothers and 112 other married women), 4096 male assistant professors (3075 fathers and 1021 other married men), 480 female instructors (233 mothers and 247 other married women), and 12,360 male instructors (10,097 fathers and 2263 other married men).

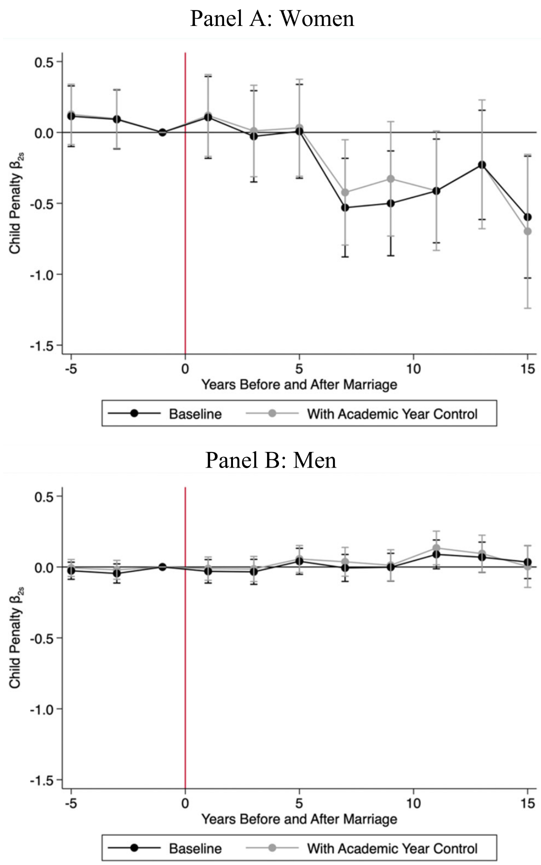


FIGURE A6.—Event studies controlling for academic employment. *Notes*: To investigate whether—and how much of—the productivity decline for mothers is due to mothers losing their academic jobs, we re-estimate the baseline specification (Figure 2A) with a time-varying indicator for academic employment β^g_{2s} in $\ln\ y^g_{\text{ist}} = \beta^g_{1s} EventTime_i + \beta^g_{2s} Parent_i * EventTime_i + Academia_{\text{it}} + \delta_t + \alpha_a + \mu_f + \epsilon_{\text{ist}}$, where $Academia_{\text{it}}$ equals 1 if scientist i held an academic title in two-calendar-year interval t.

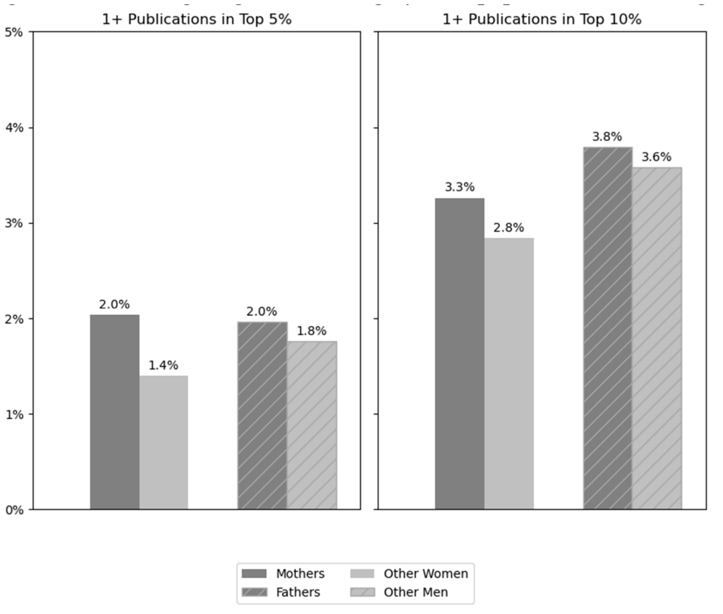


FIGURE A7.—Investigating selection: highly cited papers before marriage. *Notes*: If mothers are more likely to publish in disciplines with generous citation practices, papers by mothers may be more highly cited because they work with disciplines with more citations. To address this possibility, we compare citations within disciplines. Specifically, we compare the share of scientists who—before the median age of marriage—published at least one highly cited paper in the top 5% and 10% of citations in their discipline.

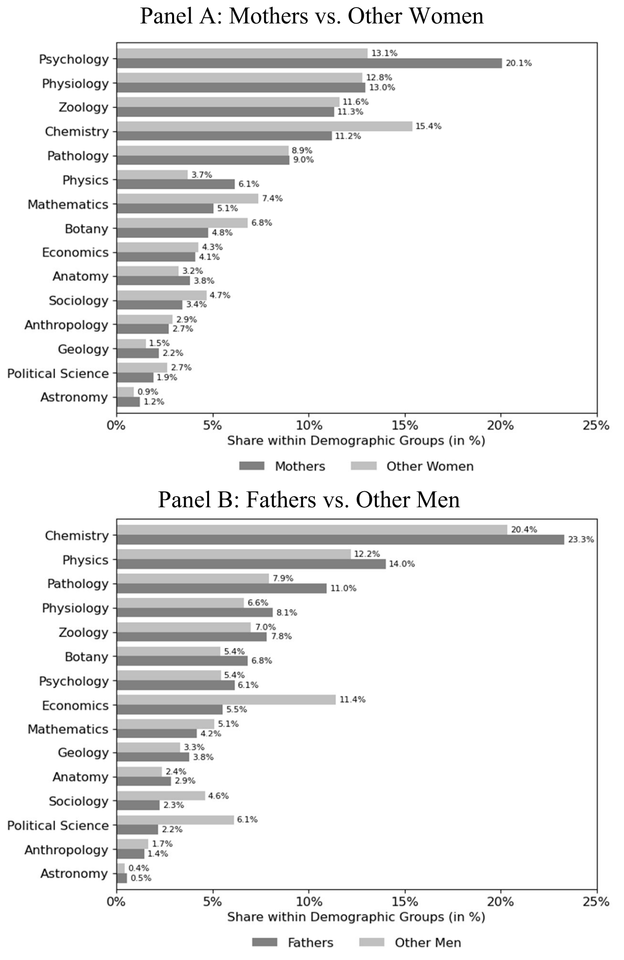


FIGURE A8.—Selection into academic disciplines. *Notes*: Panel A shows the distribution of mothers and other women into academic disciplines, and Panel B shows the distribution of fathers and other men. Data include 49,243 academic scientists across 15 academic disciplines in the physical, biological, and social sciences.

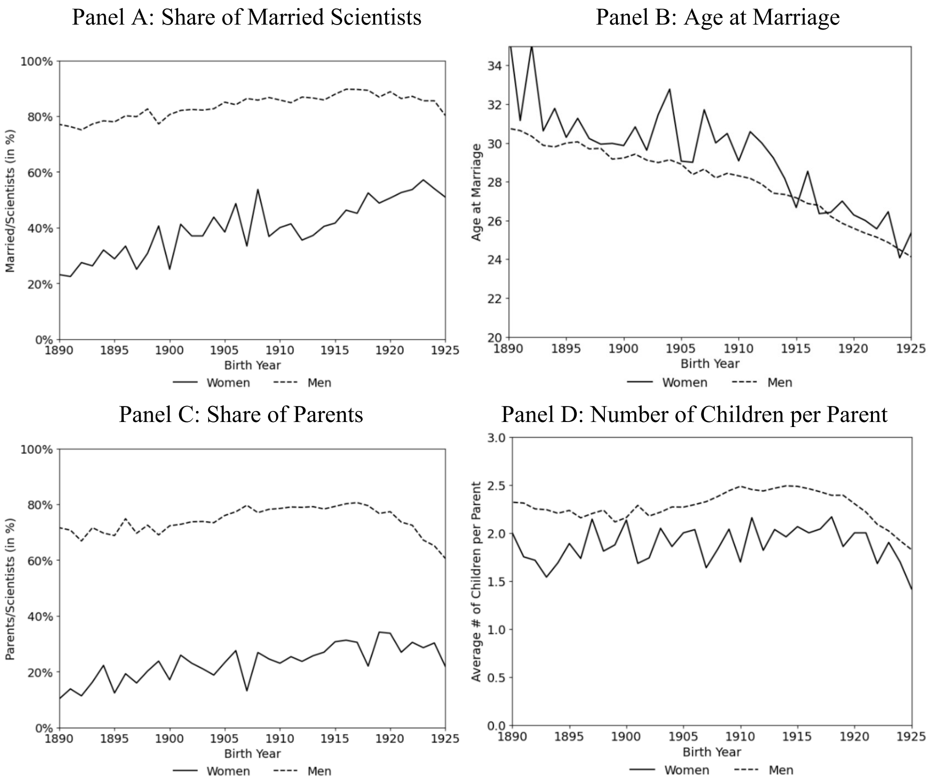


FIGURE A9.—Changes in marriage rates and children across birth cohorts. *Notes*: To investigate selection into marriage and parenting, we examine changes across birth cohorts in the share of scientists who decided to marry and have children. Panel A plots the share of scientists who were married, Panel B shows the mean age at which scientists got married, Panel C plots the share of scientists (in %) who are parents, and Panel D reports the average number of children per parent. Data include 49,243 academic scientists with known birth years and gender in our balanced panel.

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