Women in Science.
Lessons from the Baby Boom

Scott Kim, Wharton

Petra Moser, NYU, NBER and CEPR

Women and minorities are severely underrepresented in science

- 8 in 10 women and minority students who enroll in STEM drop out or switch out of STEM before finishing degree (Waldrop 2015)
- Women comprise a minority of senior staff and are promoted more slowly (National Academy of Sciences 2006)
- Women are more likely to leave STEM (Shaw and Stanton 2012)

- Lack of role models among faculty (Porter and Serra 2020) and in teaching materials (Stevenson and Zlotnik 2018)
- Structural impediments
  - Discrimination at hire, glass ceiling in promotion, and inequity in salary and support (Settles et al. 1996; Sonnert and Holton 1996)

An unequal burden of parenting

- In American Time Use Survey 2018
  - Married mothers working full-time spent an average of 72 min/day caring for kids compared with 49 min for married fathers
  - In households where both spouses were working full time, mothers spent 2.1 h/day on household cooking, cleaning and other chores while fathers spent 1.4 hours.
- Women do more housework and childcare even when they earn more (Besen-Cassino and Cassino 2014) and if their husbands are unemployed (van der Lippe, Treas, Norbutas 2018)



"I'll be home late. I've joined a support group for women who need a reason to stay at work until the house is picked up and dinner is on the table."

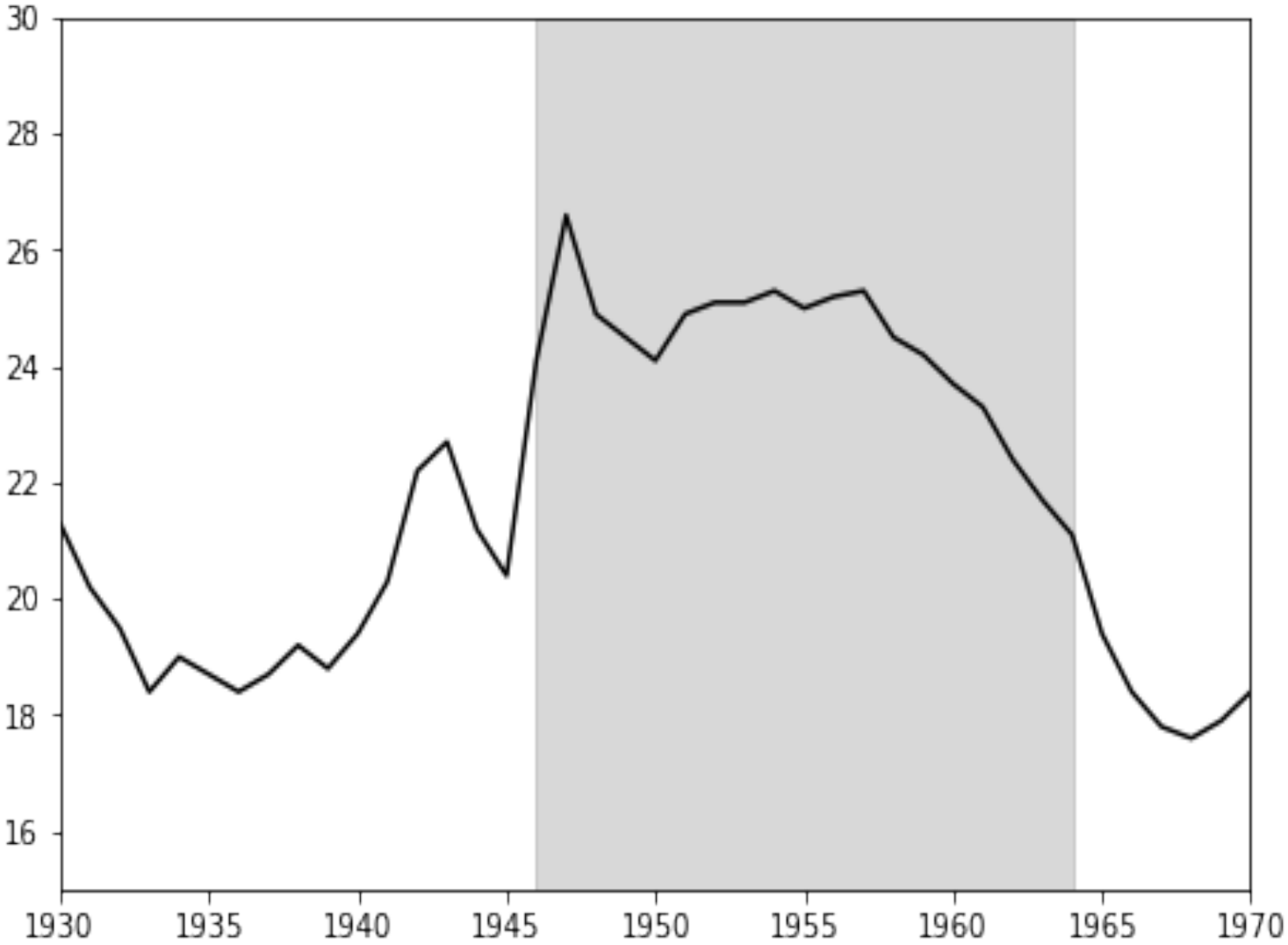
Baby Boom 1946-64

- 4.24 million babies born per year 1946-64
  - 76 million boomers in the U.S.
  - 6 million “boomies” in Canada
- Women give birth at a younger age and have more kids
- Shift in family values
  - Youthful, suburban, prolific, and “traditional”
  - *Archives of the Institute for Human Development* (Dyer, 1960)
- Shift in the 1960s towards greater equality (Weiss 2020)



A staff nurse greets some new arrivals at the Queen Charlotte Hospital in London, 1945.

US births/year increase from 22.7/1,000 in 1943 and 20.4 in 1945 to 24.1 in 1946 and 25.0 per year between 1946-56

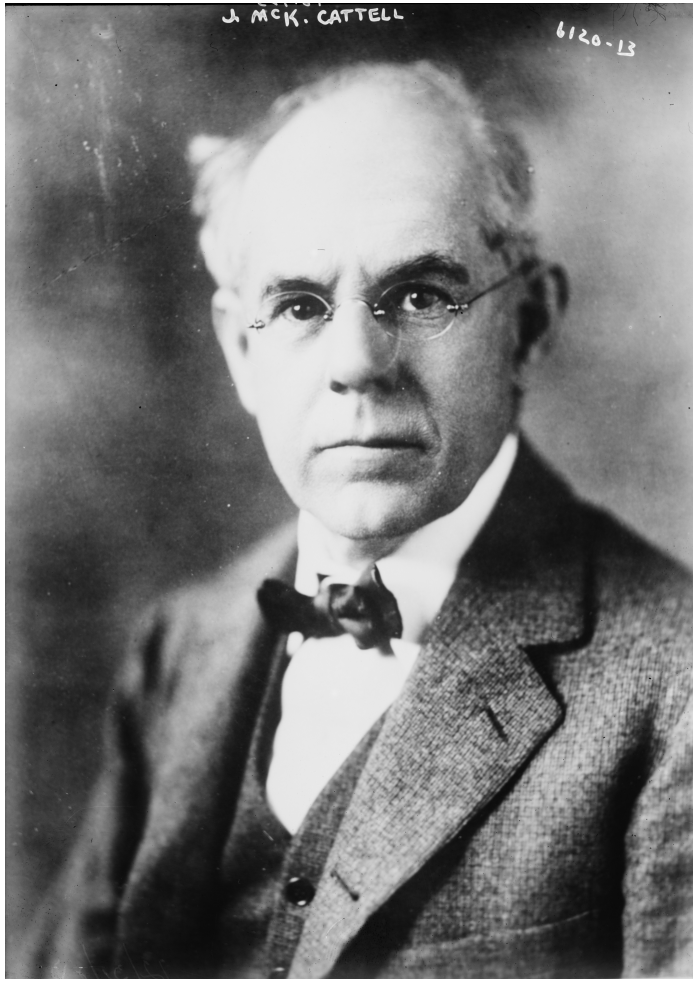


Mothers in Science

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- Data
  - Biographies of American scientists in 1956
  - Apply *k*-means to research topics to define fields
  - Matched with patents
- Changes in productivity
  - Across the life cycle
  - After marriage
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James McKeen Cattell (1860-1944)

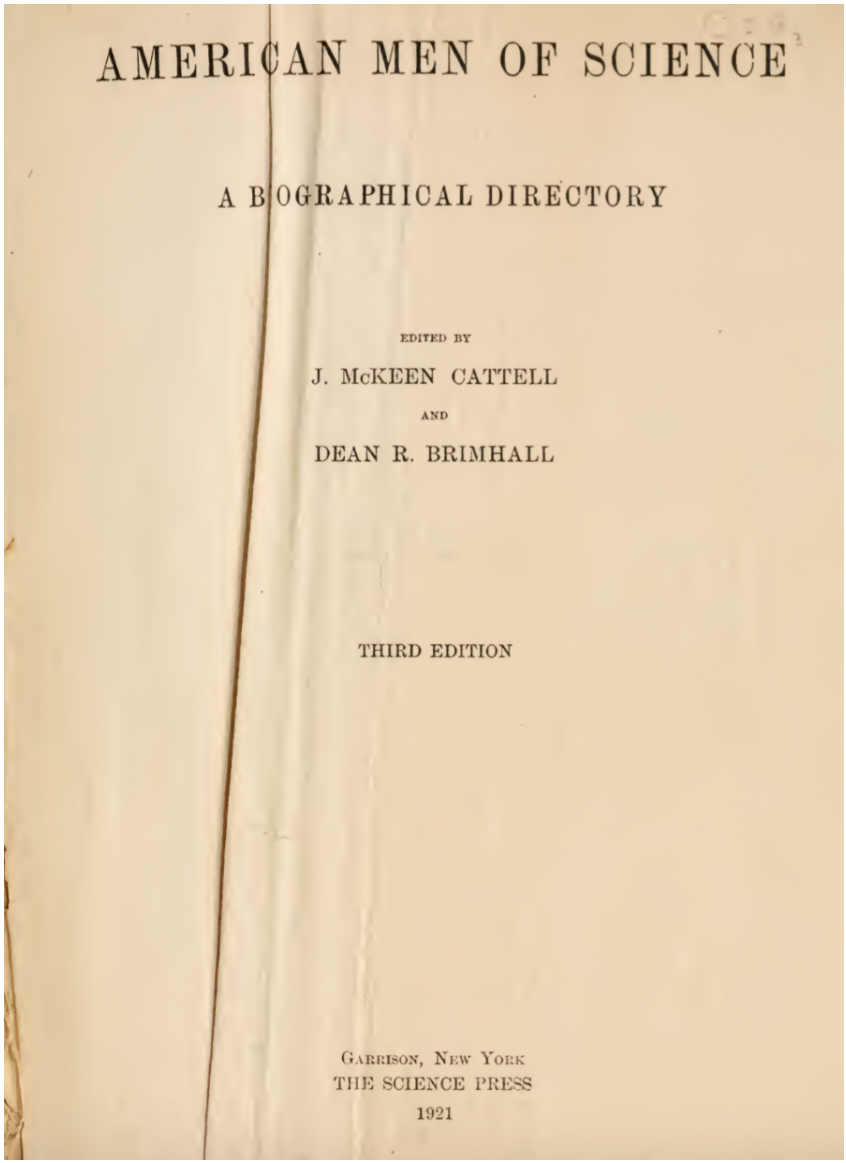
- First US professor of psychology
  - BA MA Lafayette College
  - PhD Leipzig
  - University of Pennsylvania in 1888
- Editor of *Science* for nearly 50 years
- Research on biological sources of intelligence and creativity
  - Offered his kids $1,000 each for marrying offspring of professor



By Bain News Service - This image is available from the United States Library of Congress's Prints and Photographs division under the digital ID ggbain.36662.T

"American Men of Science. A Biographical Directory"

- "...initially intended as a reference list for the Carnegie Institution of Washington....But the chief service it should render is to make men of science acquainted with one another and with one another's work." (Cattell 1921)
- All members of scientific societies
- Includes male and female scientists in Canada and the US
- Handcollected biographies of all scientists in MoS in 1921 and 1956
- Matched with patents 1910-1970


AMERICAN MEN OF SCIENCE

A BIOGRAPHICAL DIRECTORY

EDITED BY

J. McKEEN CATTELL

AND

DEAN R. BRIMHALL

THIRD EDITION

GARRISON, NEW YORK
THE SCIENCE PRESS
1921

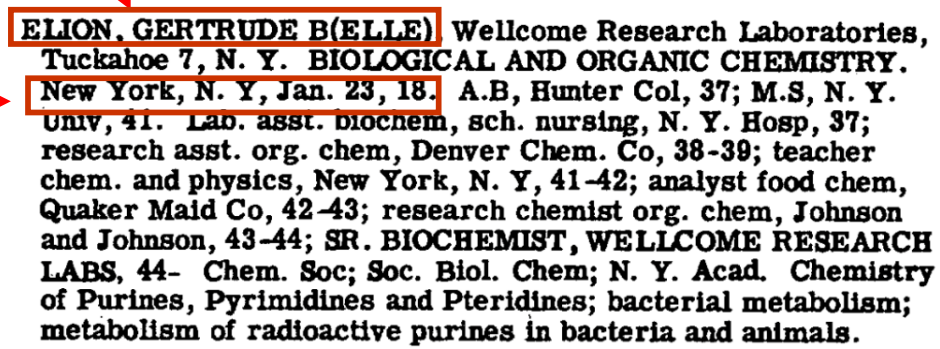
Full name (with middle name)

- Assign gender
- Match with US patents

ELION, GERTRUDE B(ELLE) Wellcome Research Laboratories, Tuckahoe 7, N. Y. BIOLOGICAL AND ORGANIC CHEMISTRY. New York, N. Y, Jan. 23, 18. A.B, Hunter Col, 37; M.S, N. Y. Univ, 41. Lab. asst. biochem, sch. nursing, N. Y. Hosp, 37; research asst. org. chem, Denver Chem. Co, 38-39; teacher chem. and physics, New York, N. Y, 41-42; analyst food chem, Quaker Maid Co, 42-43; research chemist org. chem, Johnson and Johnson, 43-44; SR. BIOCHEMIST, WELLCOME RESEARCH LABS, 44- Chem. Soc; Soc. Biol. Chem; N. Y. Acad. Chemistry of Purines, Pyrimidines and Pteridines; bacterial metabolism; metabolism of radioactive purines in bacteria and animals.

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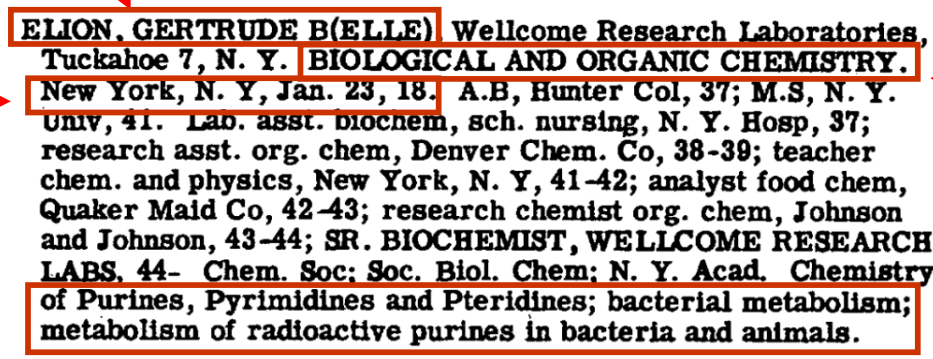
Birthplace and date
- Age
- Birth cohort
- US- vs foreign-born
- Match with US census (w Anna Airoldi)



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Discipline and research topics
- Assign scientists to fields using k-means clustering (Moser and San 2020)
- Control for variation in patenting across fields
- Investigate selection into fields

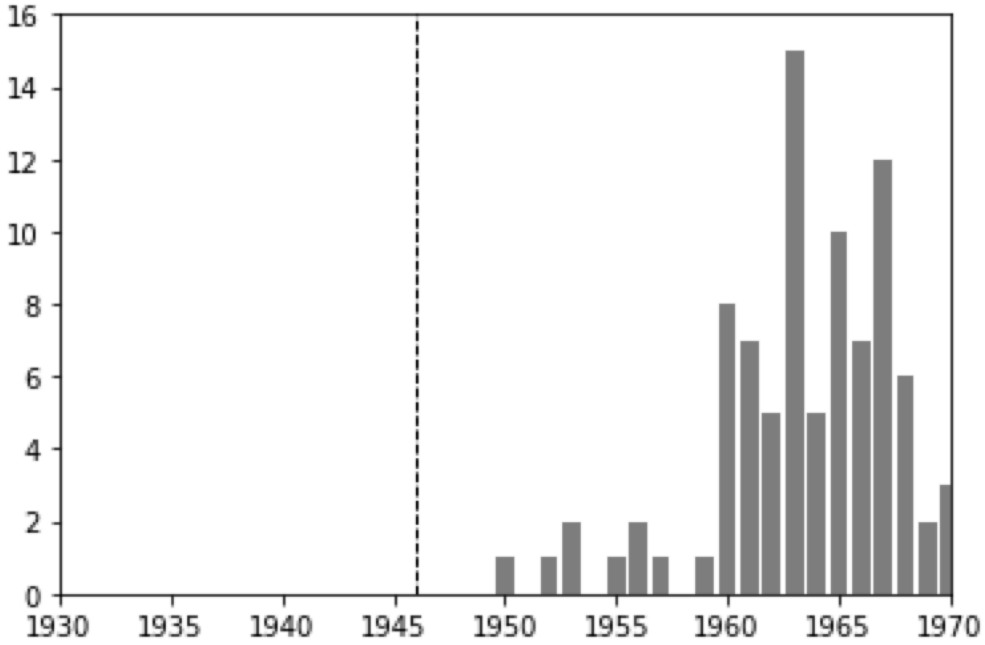
Dr Giuliana Cavaglieri Tesoro



- Born in Venice 1921
  - Jewish, not allowed to attend University in Italy under Fascist Racial Laws
  - Moved to Switzerland first and to US in 1939
  - Yale PhD in organic chemistry in 1943
- Married Victor Tesoro in 1943
  - Following her marriage, Tesoro worked part-time in summer job for Calco Chemical Company 43-44
  - Took a job as research chemist with Onyx Oil 1944
  - Promoted to Head of Organic Synthesis Dept. 1946
- 2 children by 1956
- 89 US patents
  - Including patent for flame-retardant fiber

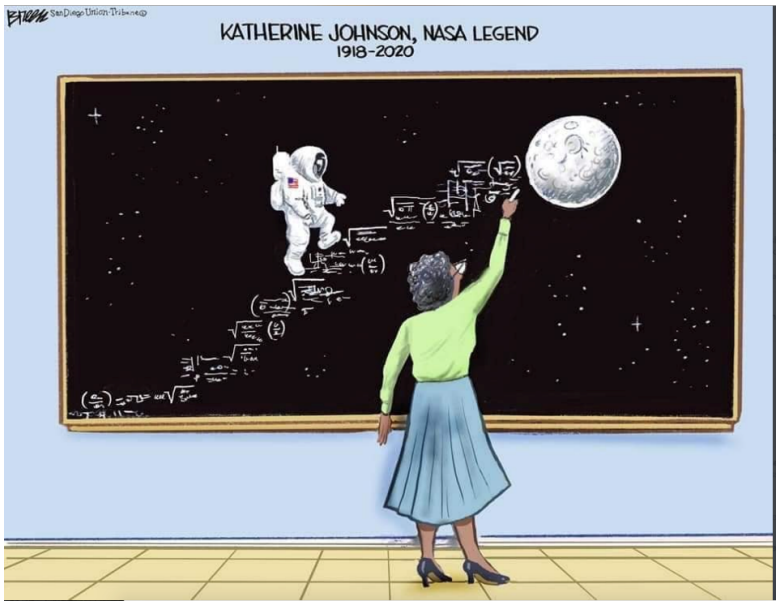
Marriage status, year of marriage & number of children

TESORO, DR. GIULIANA C, 278 Clinton Ave, Dobbs Ferry, N. Y.
ORGANIC CHEMISTRY. Venice, Italy, June 1, 21, nat. 46; m. 43; c. 2. Ph.D.(org. chem), Yale, 43. Research chemist, Calco Chem. Co, N. J, 43-44; ONYX OIL & CHEM. CO, 44-46, HEAD ORG. SYNTHESIS DEPT, 46- Chem. Soc; N. Y. Acad. Synthesis of pharmaceuticals, textile chemicals, germicides and insecticides; synthesis and rearrangement of glycols in the hydrogenated naphthalene series.



MoS is focused on research scientists, members of professional organizations

- *Hidden Figures* remain largely hidden because computers were not "scientists"
- Dr. Katherine Johnson
  - 1 of 3 first black graduate students at West Virginia University
  - Started as "computer" at NACA (NASA's predecessor) in 1953
- Computer = someone who performs mathematical equations and calculations by hand
  - Langley 1935-70
  - Designed to process test data more efficiently, relieving engineers of essential, but time-consuming work
  - Calculating data "more rapidly and accurately" (Cramer 1942)



Who was a female scientist?

This sounds more trivial than it is. We compared 4 different ways

- Manual assignment
  - Data typists assign gender based on their perception of gender
  - Problem: Based on perception of names today
- Algorithm using frequencies of male and female names in US census 1940
  - Uses historical perception of names in 1940
  - Assign gender based on % female in census of 1940
- Attendance at women's college
  - Built a list of women's colleges, w dates when they admitted men
- US Social Security Administration data, 1880-2011
  - Frequencies of male and female first names

Main specifications use SSA data to detect female names

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  - Python module "gender-detector"

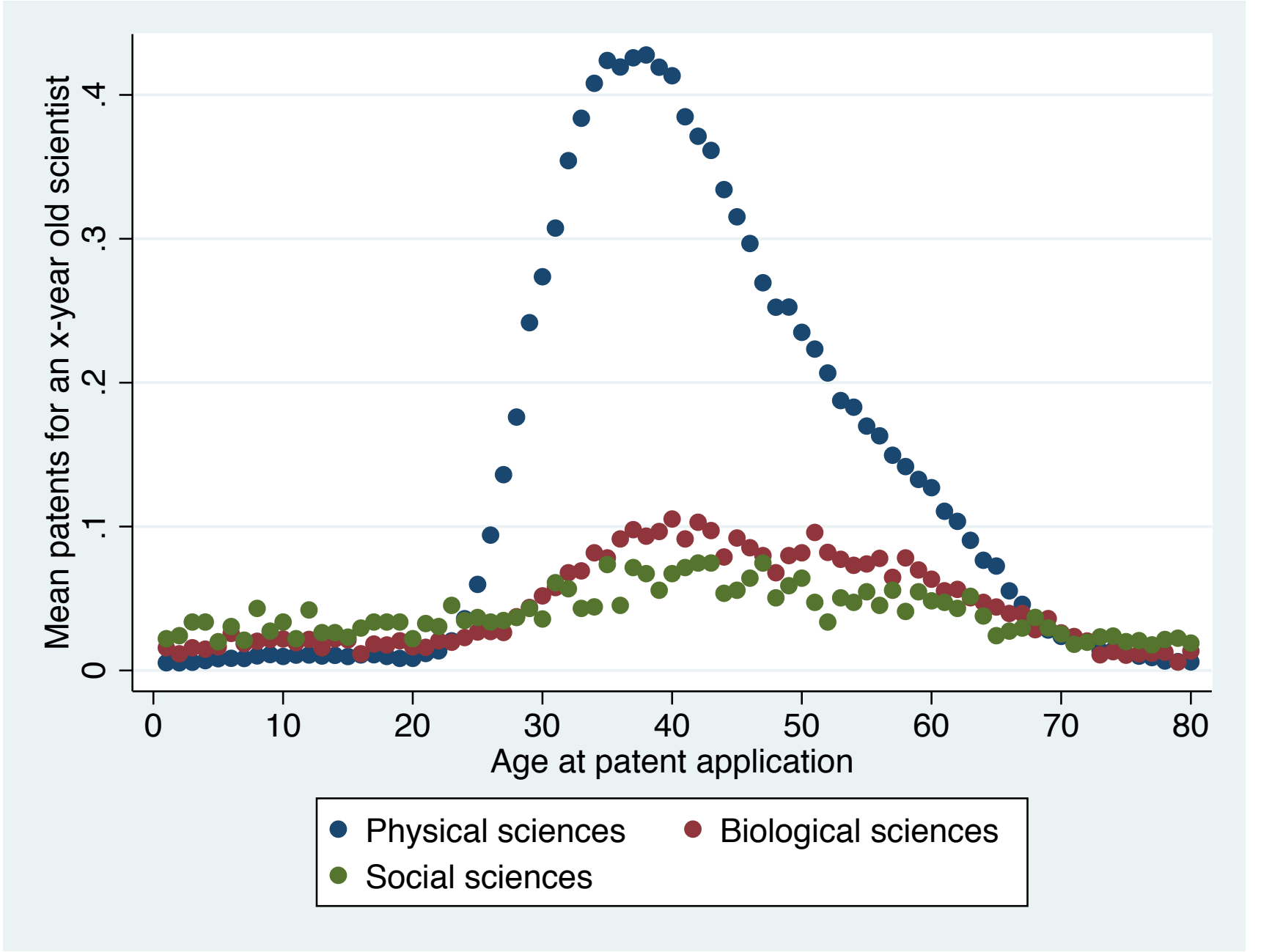
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- Productivity
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  - Across the life cycle
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Measure productivity through patents

- Possibly less bias than publications
- But propensity to patent varies across fields (Moser 2012)
  - Control for fields
- Match scientists with patents
  - Match using first, middle, and last names
    - Levenstein distance measure
    - Allow 1 letter to be difference
  - Use age to filter out improbable matches
    - Use patents between 0 and 18 to calculate error rate
  - Disciplines
    - Physical, biological, and social sciences
  - Frequency of names
  - Drop the top 20 percent of frequent names

Focus on physical sciences (STEM): chemistry, physics, engineering, mathematics

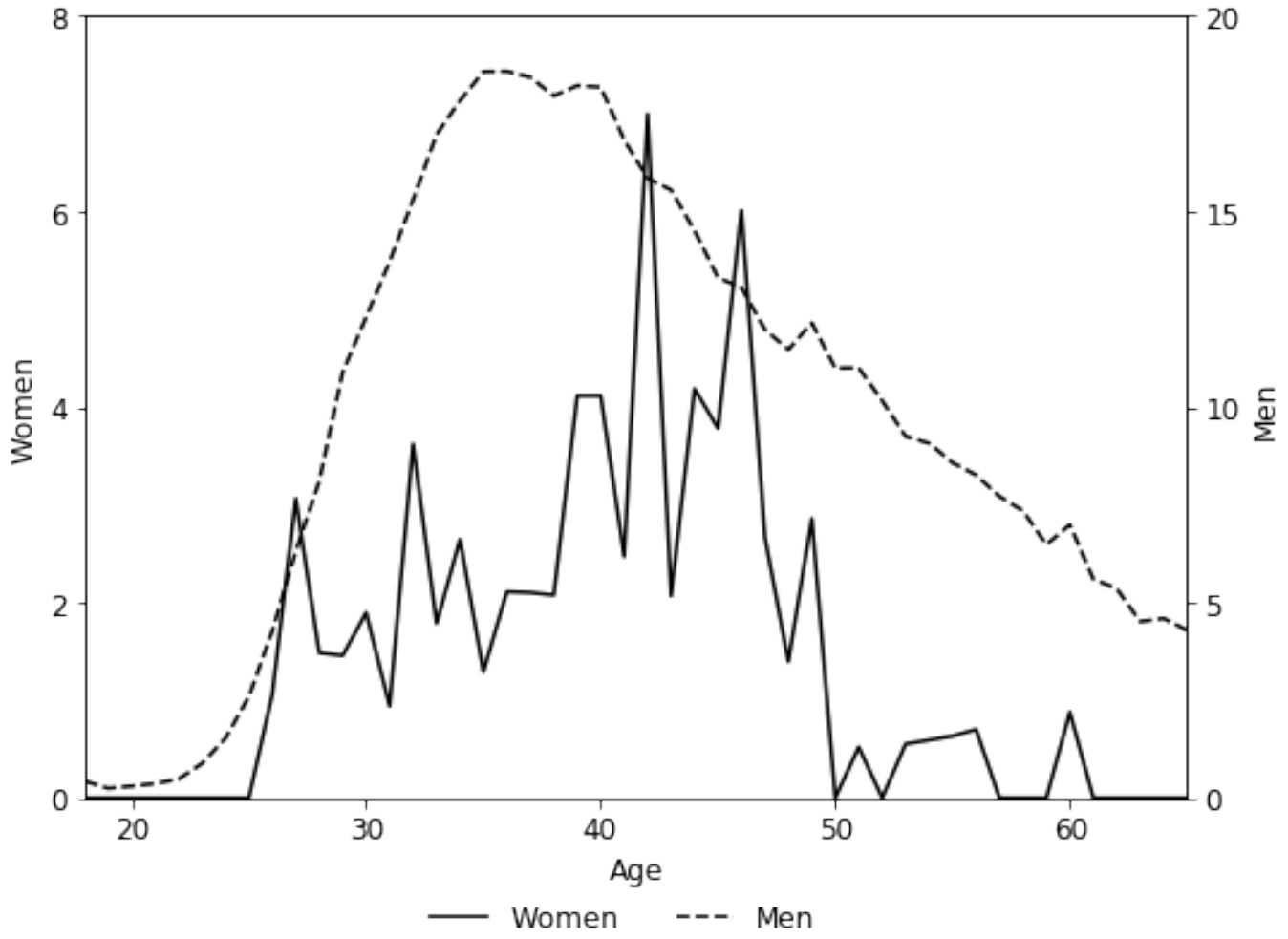


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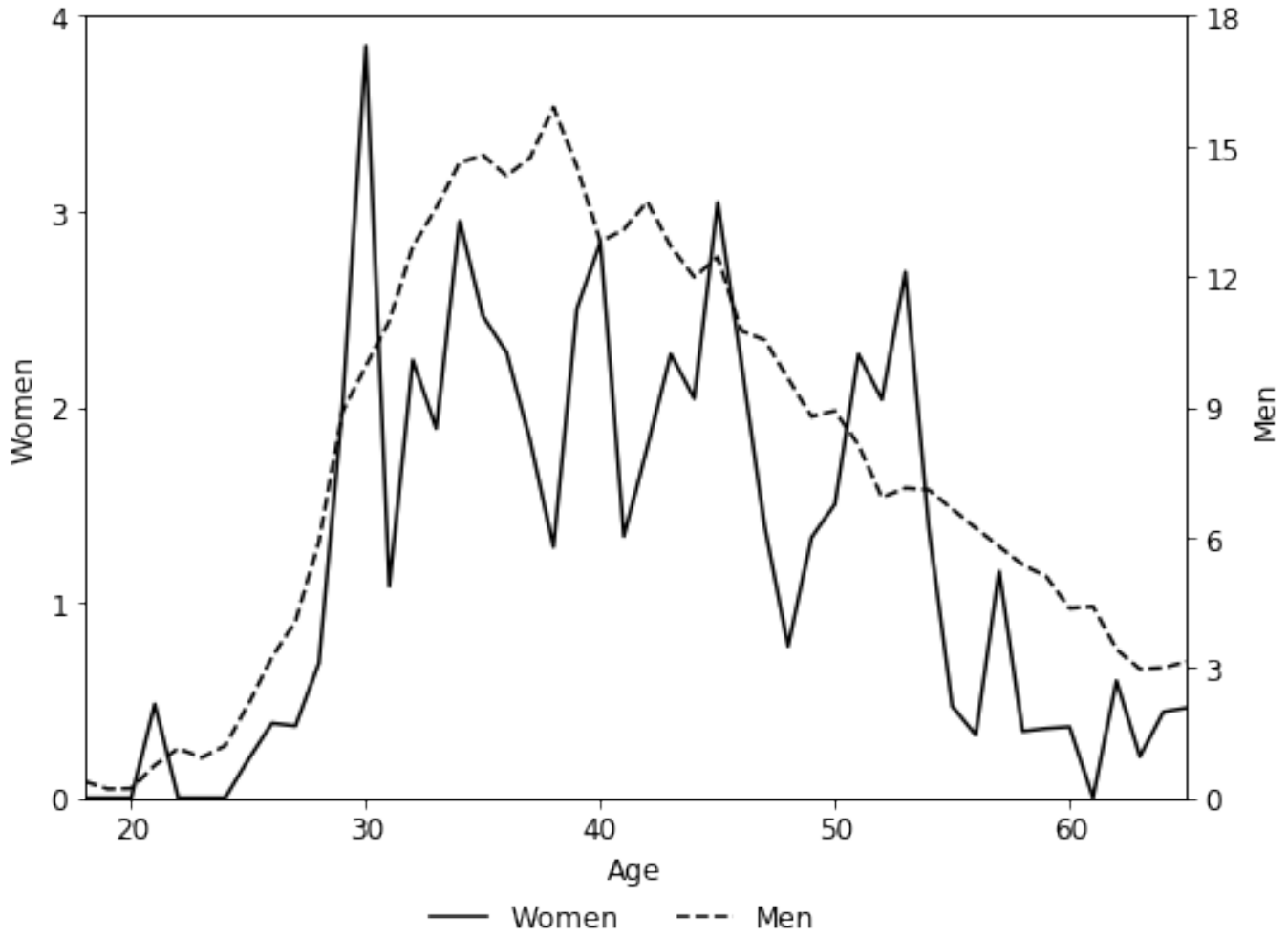
Fathers' productivity peaks in late 30s, mothers' after 40

Figure A2, Panel A: Male vs. Female Parents



No significant differences for men and women w/o kids

Figure A2, Panel B: Male vs. Female Scientists w/o Children



Mothers become more productive after age 35

Figure 2: Age-Varying Effects of Parenting and Gender on Patenting

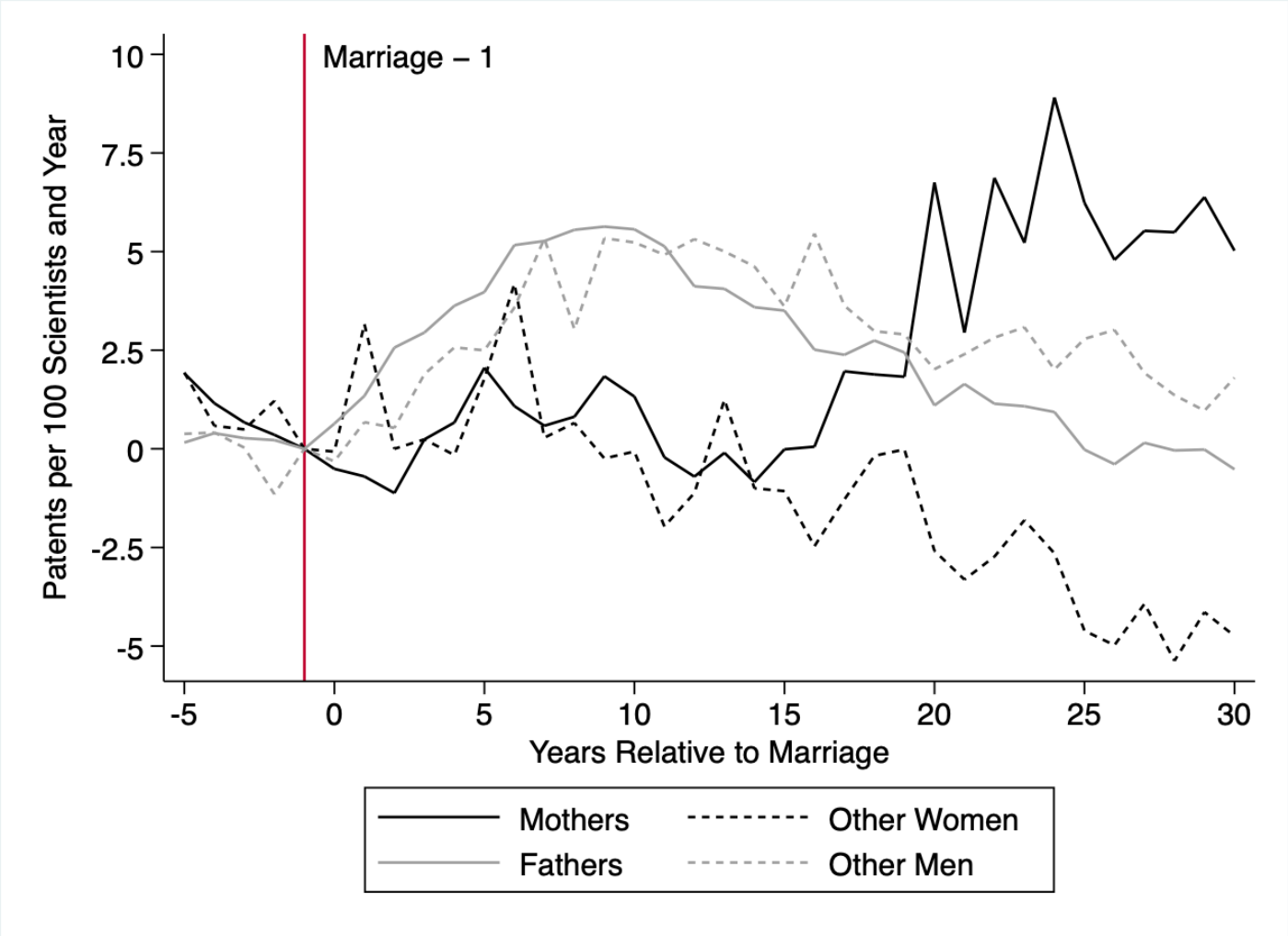


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Mothers' productivity increases dramatically 15 years after year of marriage

Figure 3: Event Study Estimates of Changes in Patenting After Marriage



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COSMOS

GERTRUDE BELLE ELION



Many examples of exceptional women dropping out of academia

Gertrude Belle Ellion, Nobel 1988



Gertrude Elion as student at Hunter College, which she attended from 1933 to 1937 (Courtesy of Gertrude B. Elion Foundation)

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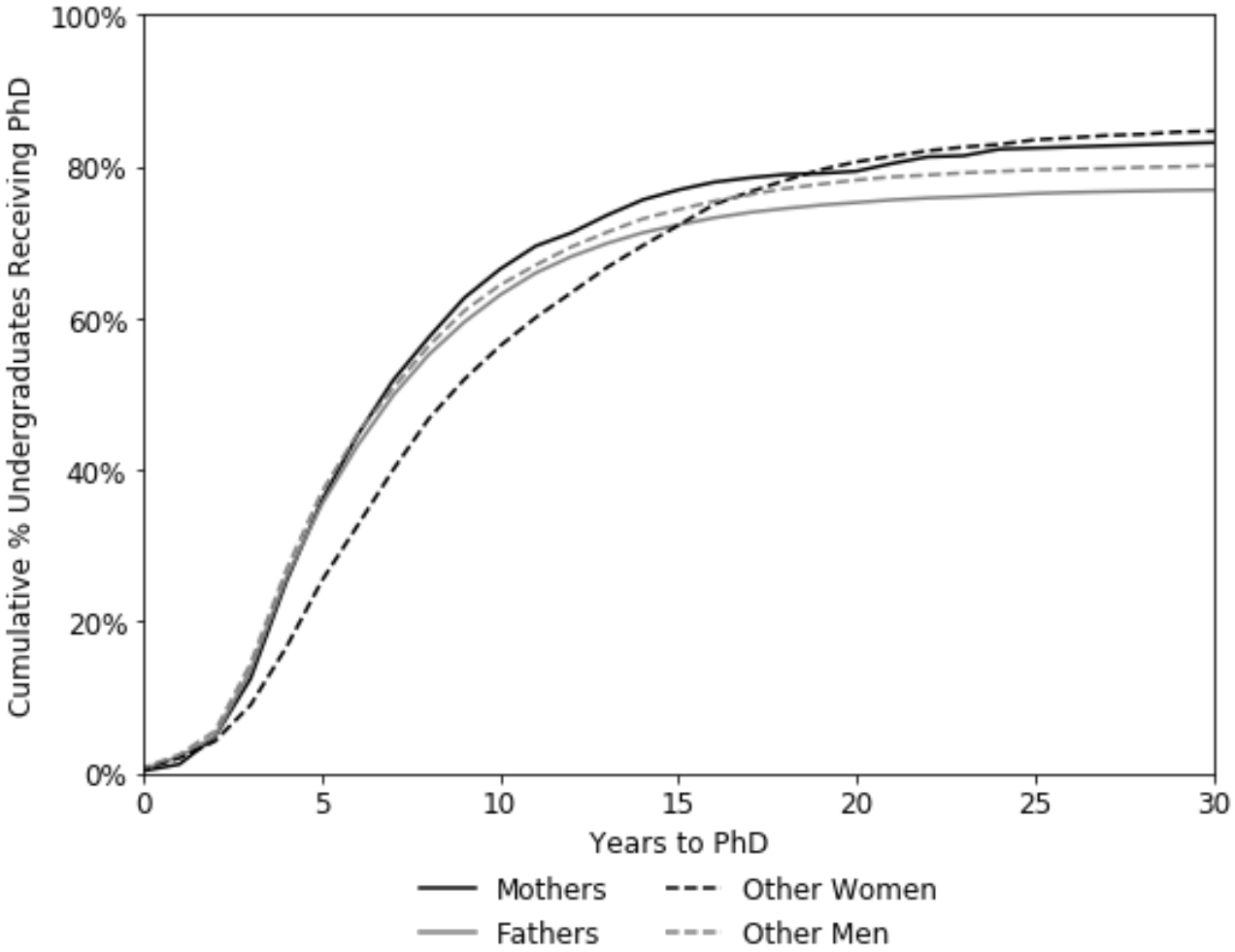
Formal and informal barriers made it difficult for women to earn PhDs

- Example, Joan Steitz, “Queen of RNA”
  - Interaction of the ribosome and messenger RNA, via complementary base pairing
  - Discovery of small nuclear ribonuclearproteins (snRNPs) whose function is essential to RNA transcription
  - Diagnosis and treatment of lupus
- At Harvard in the 1960s turned down by professor she asked to be her advisor: “but you are a woman, and you’ll get married, and you’ll have kids, and what good will a PhD have done?”
- Married classmate Tom Steitz, 1 child
  - 2009 Nobel Prize in Chemistry (w Venkatraman Ramakrishnan and Ada Yonath) "for studies of the structure and function of the ribosome”



Women in science in 1956 were more likely to have PhD. 85 in 100 female scientists have PhD, 78 male scientists

Figure A4: Years from Undergraduate to PhD



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Many accomplished women “fell off” tenure track

- Example, Dr. Esther Lederberg
- Microbiology and genetics
- Discovery of lambda phage in 1951
  - Temperate virus that infects E. coli bacteria, and lives for some side inside a cell
  - Model for animal viruses that have similar life cycles, including tumor and herpes viruses
  - Widely used tool for studying genetic recombination and gene regulation
- Collaborated with husband, Joshua Lederberg
  - Developed a technique of replica plating in 1952, still widely used in genetics labs
  - Joshua won the 1958 Nobel Prize for Physiology or Medicine for discoveries on how bacteria mate
- In 1959, Esther became a research associate at Stanford’s School of Medicine
  - Joshua became the chair of the Department of genetics

LEDERBERG, DR. ESTHER M(ARILYN), Dept. of Genetics, University of Wisconsin, Madison 6, Wis. GENETICS. New York, N.Y, Dec. 18, 22; m. 46. A.B, Hunter Col, 42; M.A, Stanford, 46; U.S. Pub. Health Serv. fellow, 47-49; fellow, Wisconsin, 49-50; Ph.D,(genetics), 50. PROJ. ASSOC. GENETICS, WISCONSIN, 50- A.A; Genetics Soc; Soc. Gen. Microbiol. Gt. Britain. Genetics of microorganisms; lysogenicity; bacterial recombination.

LEDERBERG, PROF. JOSHUA, Dept. of Genetics, University of Wisconsin, Madison 6, Wis. BIOLOGY. N.J, May 23, 25. B.A, Columbia Col, 44; Ph.D. (microbiol), Yale, 47. Asst. prof. GENETICS, WISCONSIN, 47-50, assoc. prof, 50-54, PROF, 54- U.S.N.R, 43-45. Genetics.

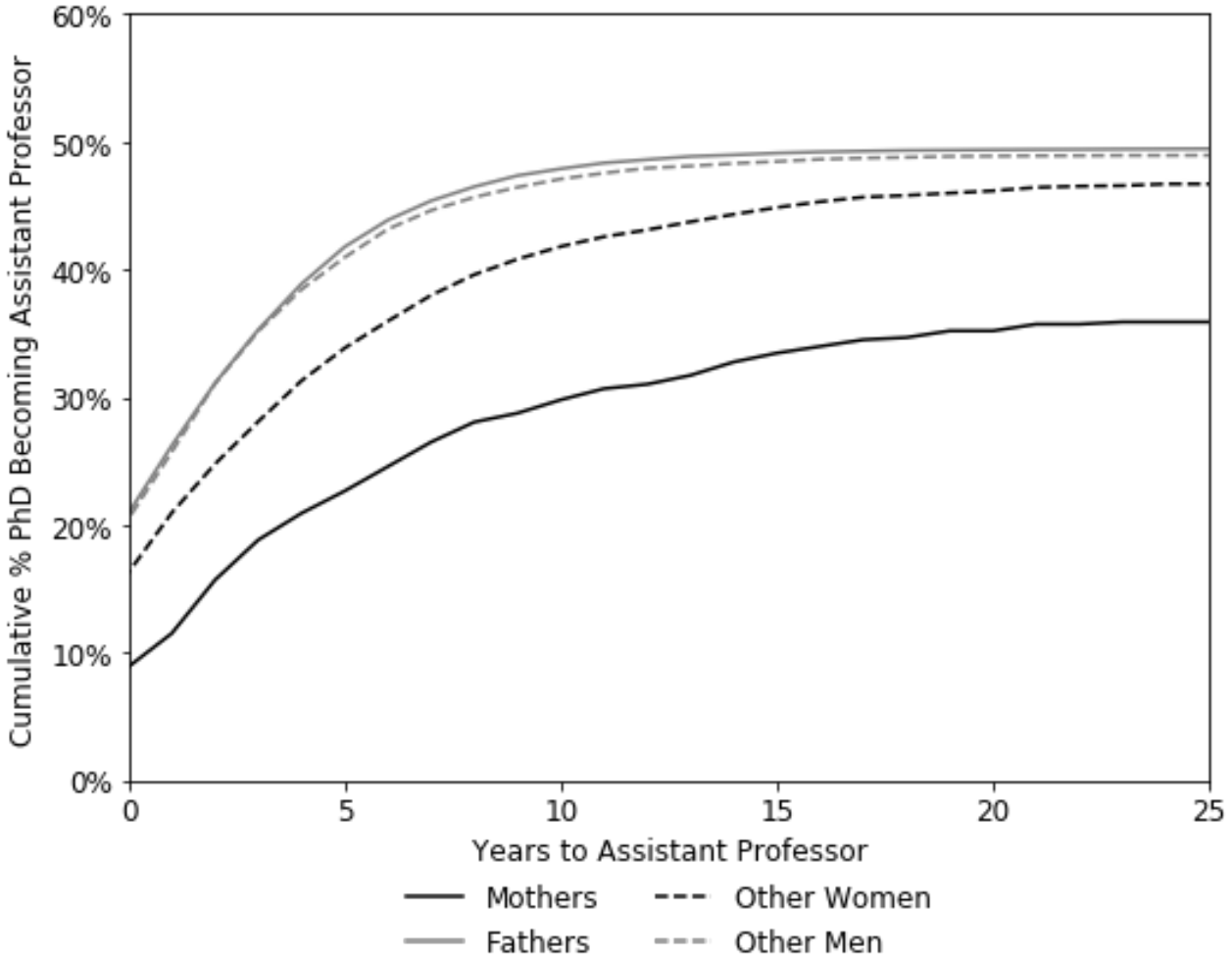


Women w PhDs were less likely to get tenure track jobs, especially if they had kids

- Mothers with PhD were 13% less likely to become assistant professors compared with fathers
  - 11% less than other women
- 36 in 100 mothers with PhD became assistant professors compared with 49 in 100 fathers
  - 47 in 100 other women

Mothers took 4.4 years to get first tenure track job compared with 1.3 for fathers and 2.8 for other women

Figure 4: Years from PhD to Assistant Professor

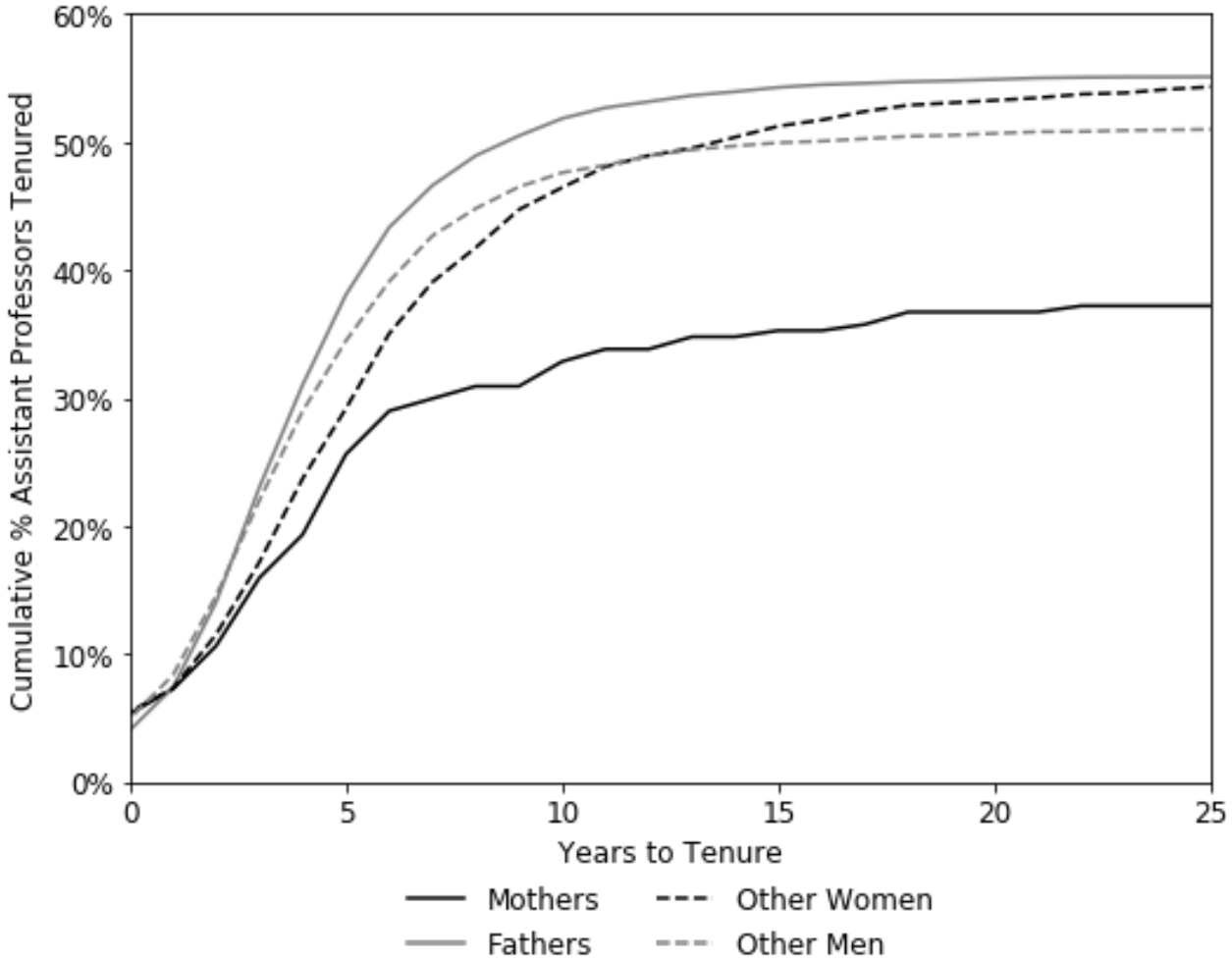


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Mothers were much less likely to get tenure
Only 38 in 100 mothers who were assistant professors achieved tenure, 17 percent less compared with other women (55 in 100) and compared with fathers (55 in 100)

Figure 5: Years from PhD to Assistant Professor

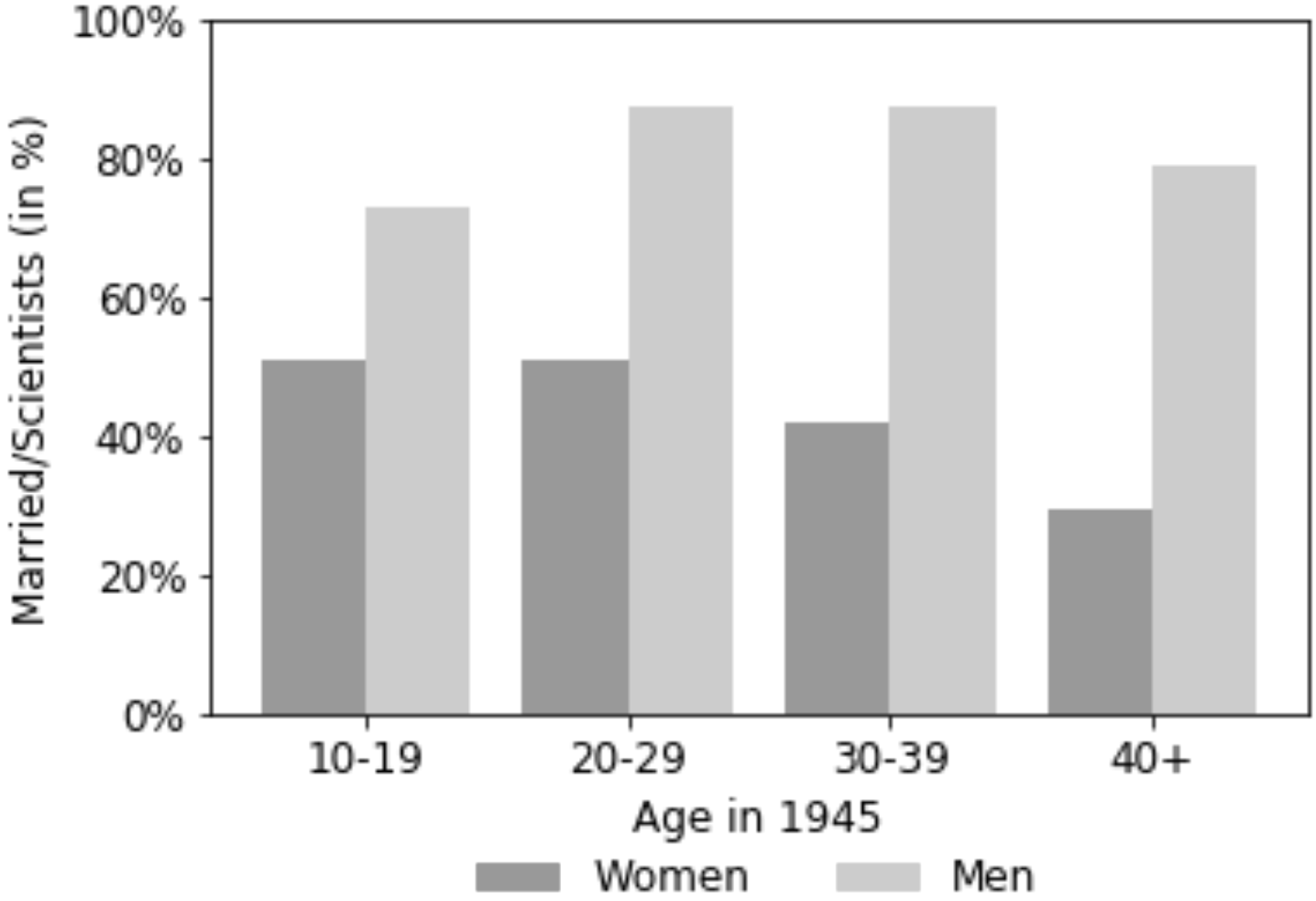


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Just xx % of women scientists in 1956 were married, compared with xx% of men

Figure 6, Panel B: Share of Married Scientists

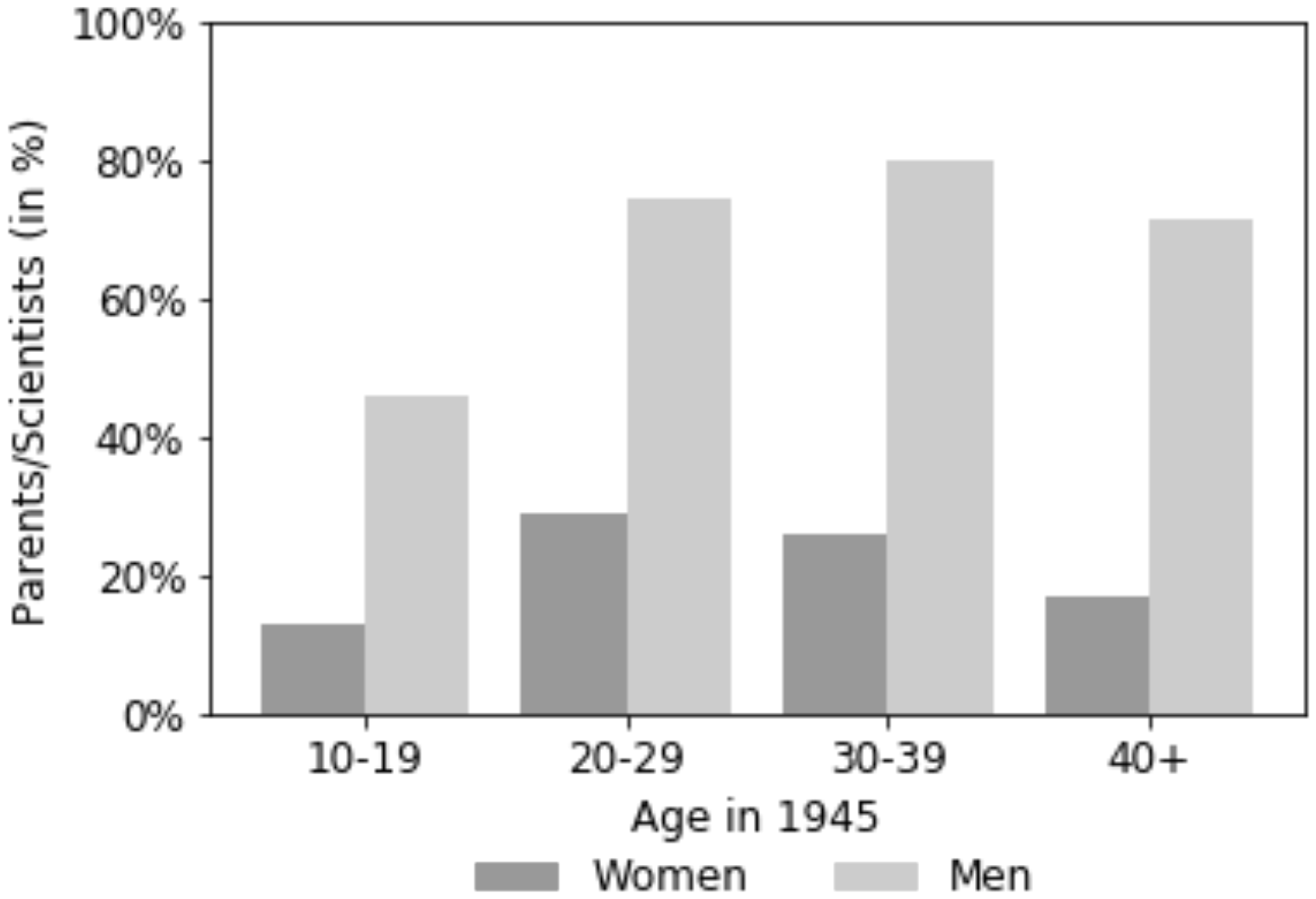


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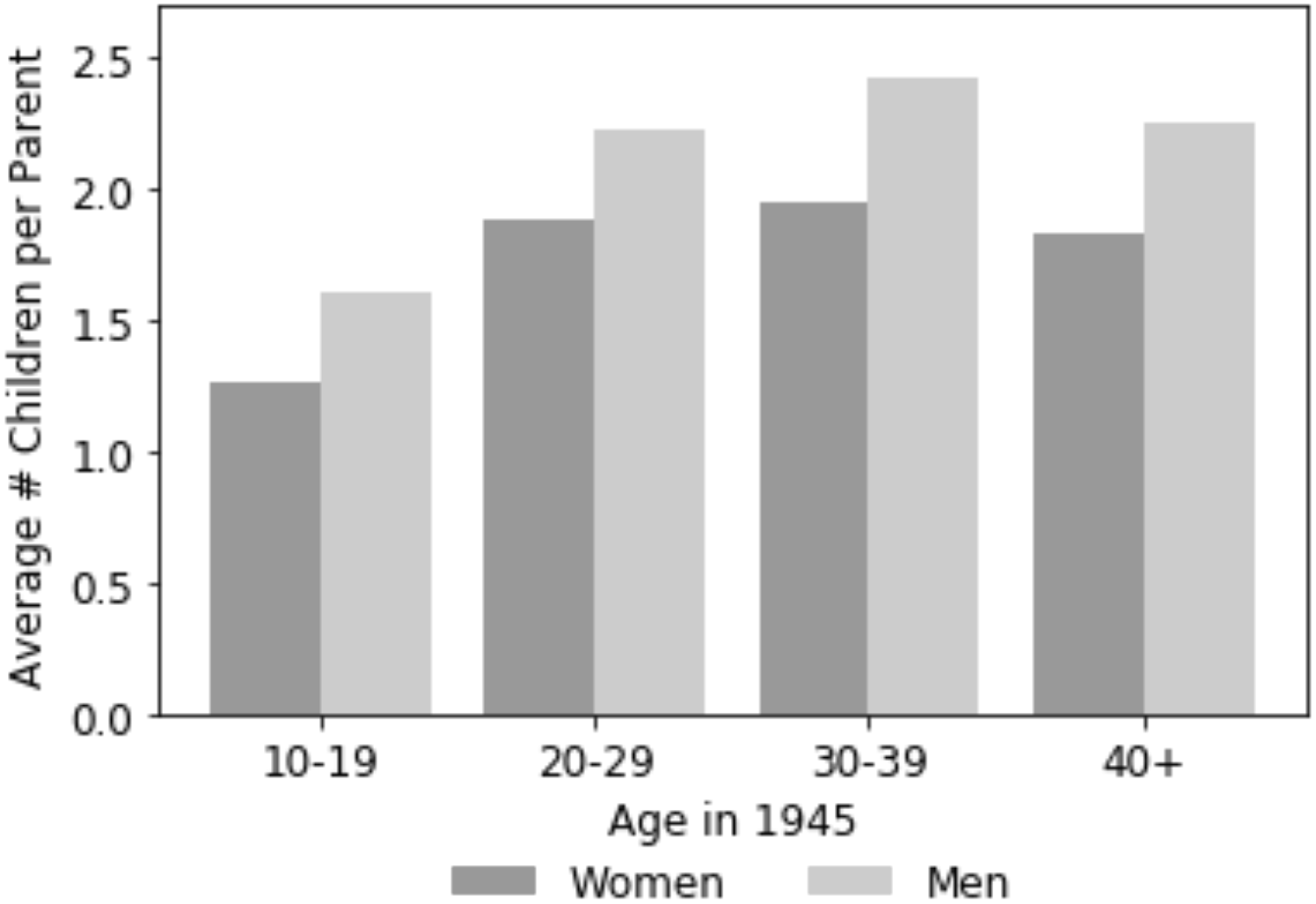
Just xx% of female scientists had kids, compared with xx% of men

Figure 6, Panel A: Share of Parents



Mothers had xx kids on average, compared with xx for fathers

Figure 6, Panel D: Number of Children per Parent

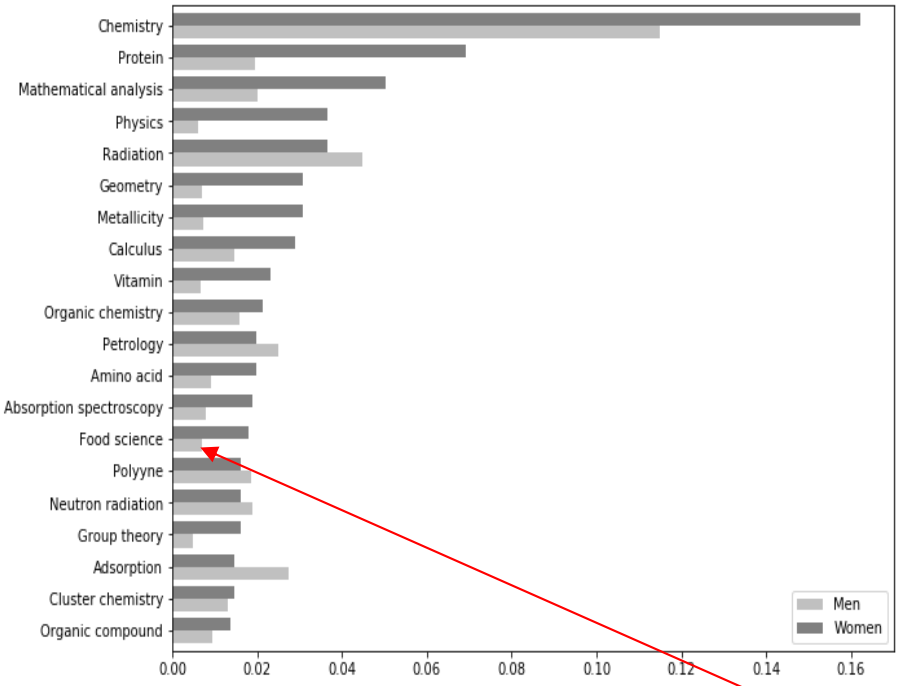


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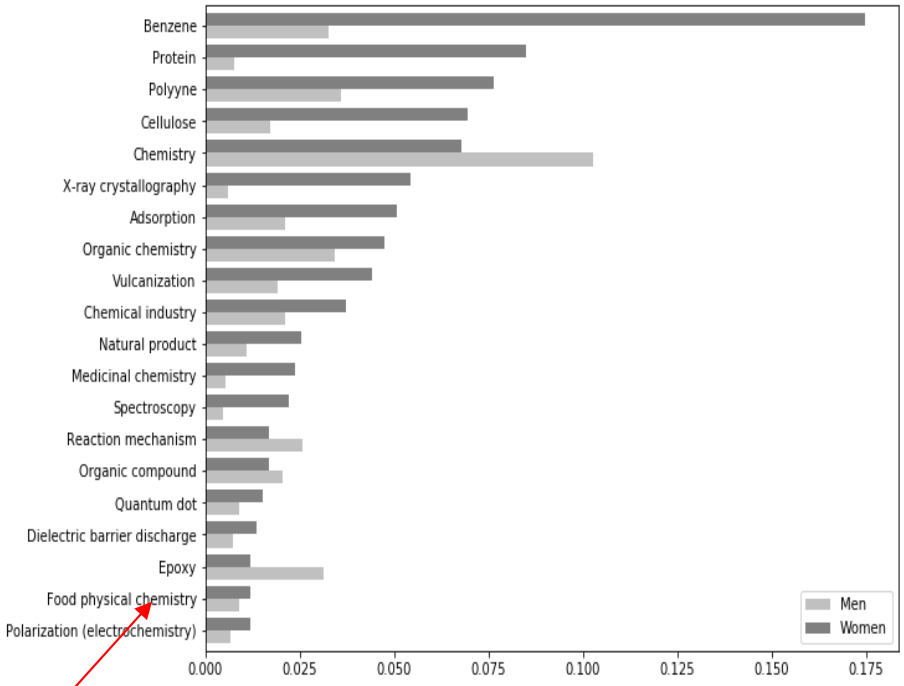
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Selection into research fields

Share of scientists (in %)



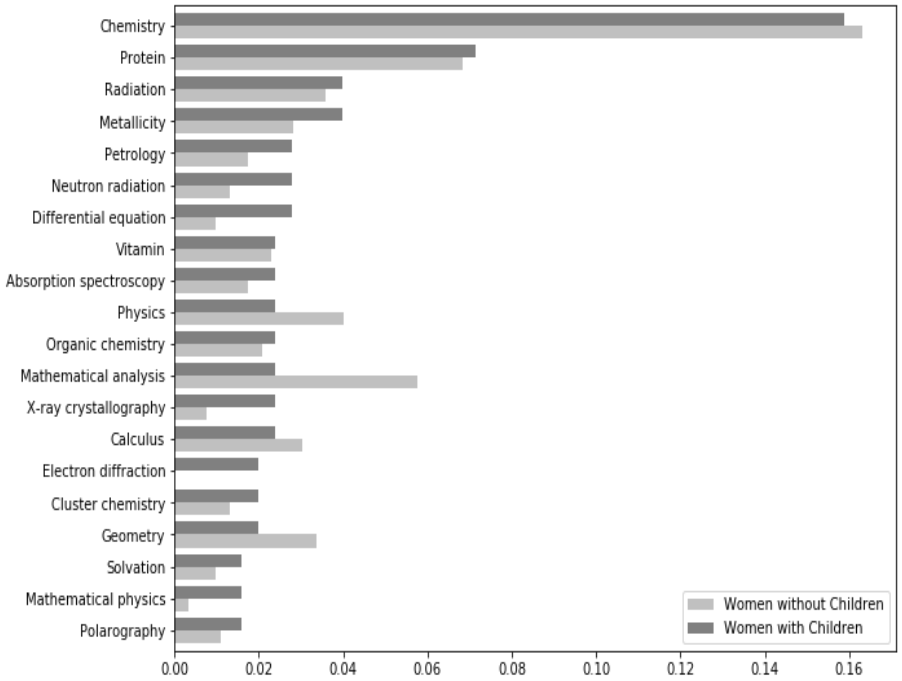
Share of patents (in %)



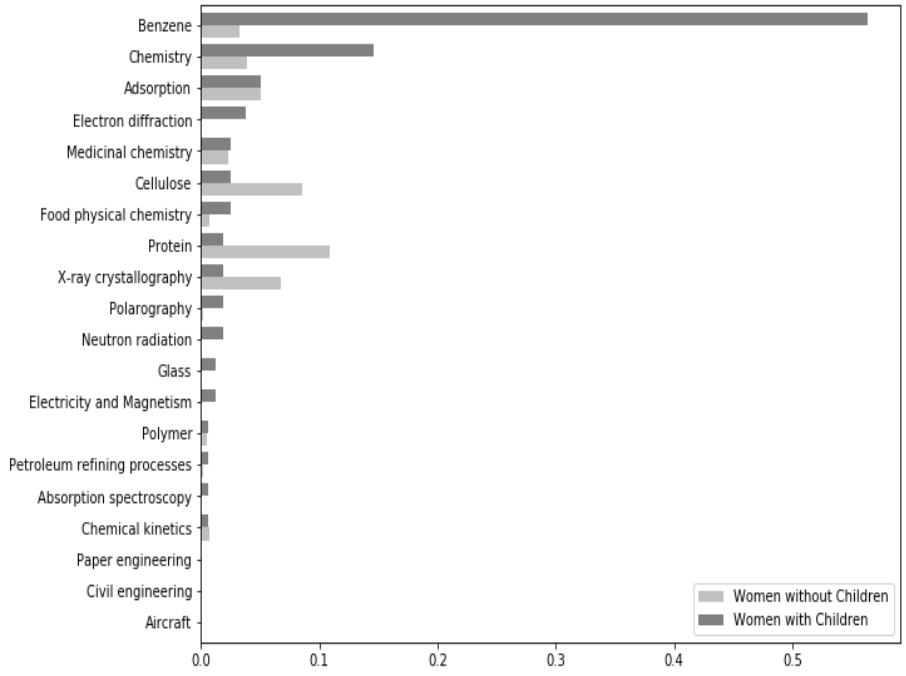
Food science and food chemistry

Fewer mothers in mathematical analysis, geometry, calculus and physics. But more in differential equations and mathematical physics

Shares of scientists (in %)



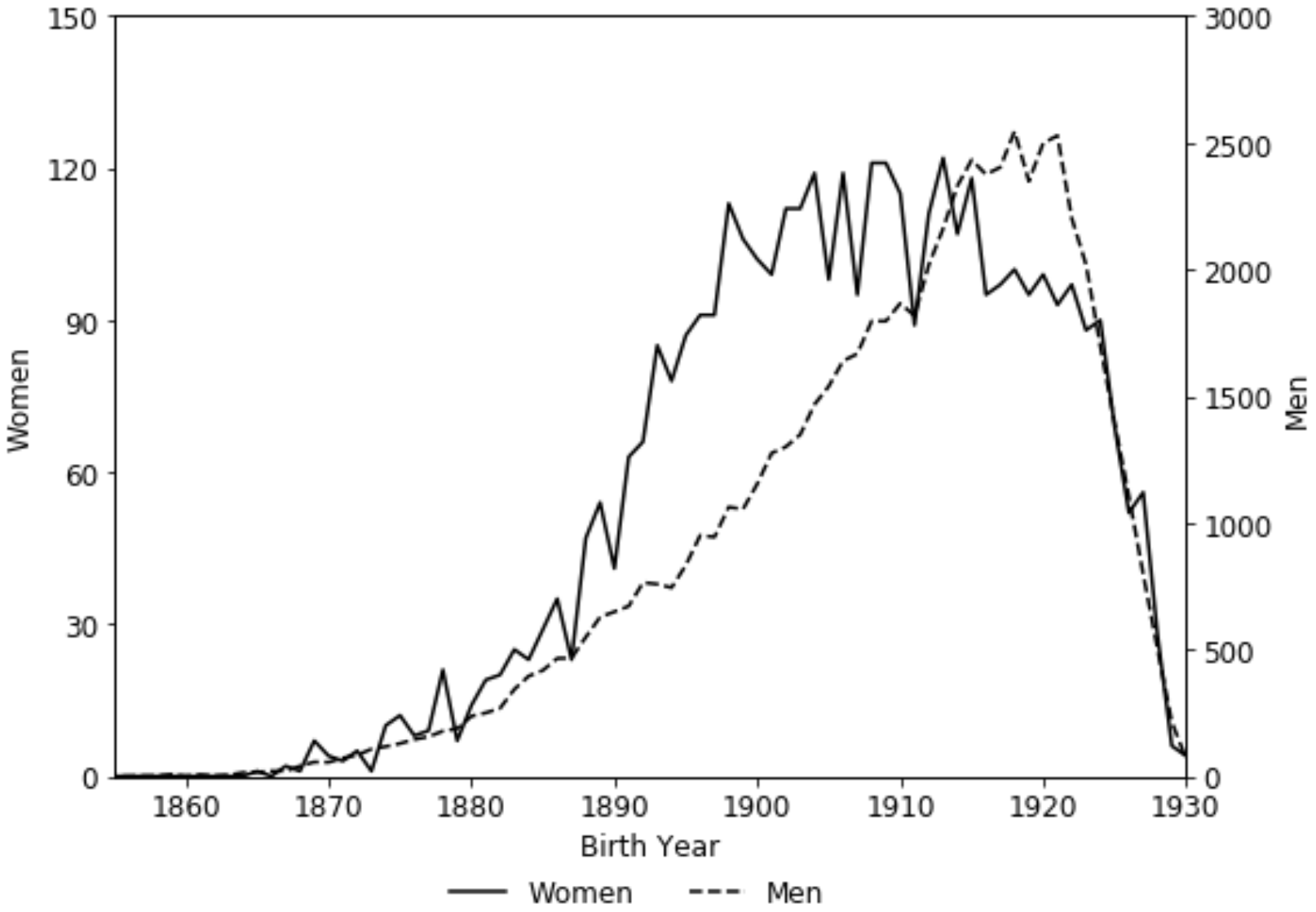
Shares of patents (in %)



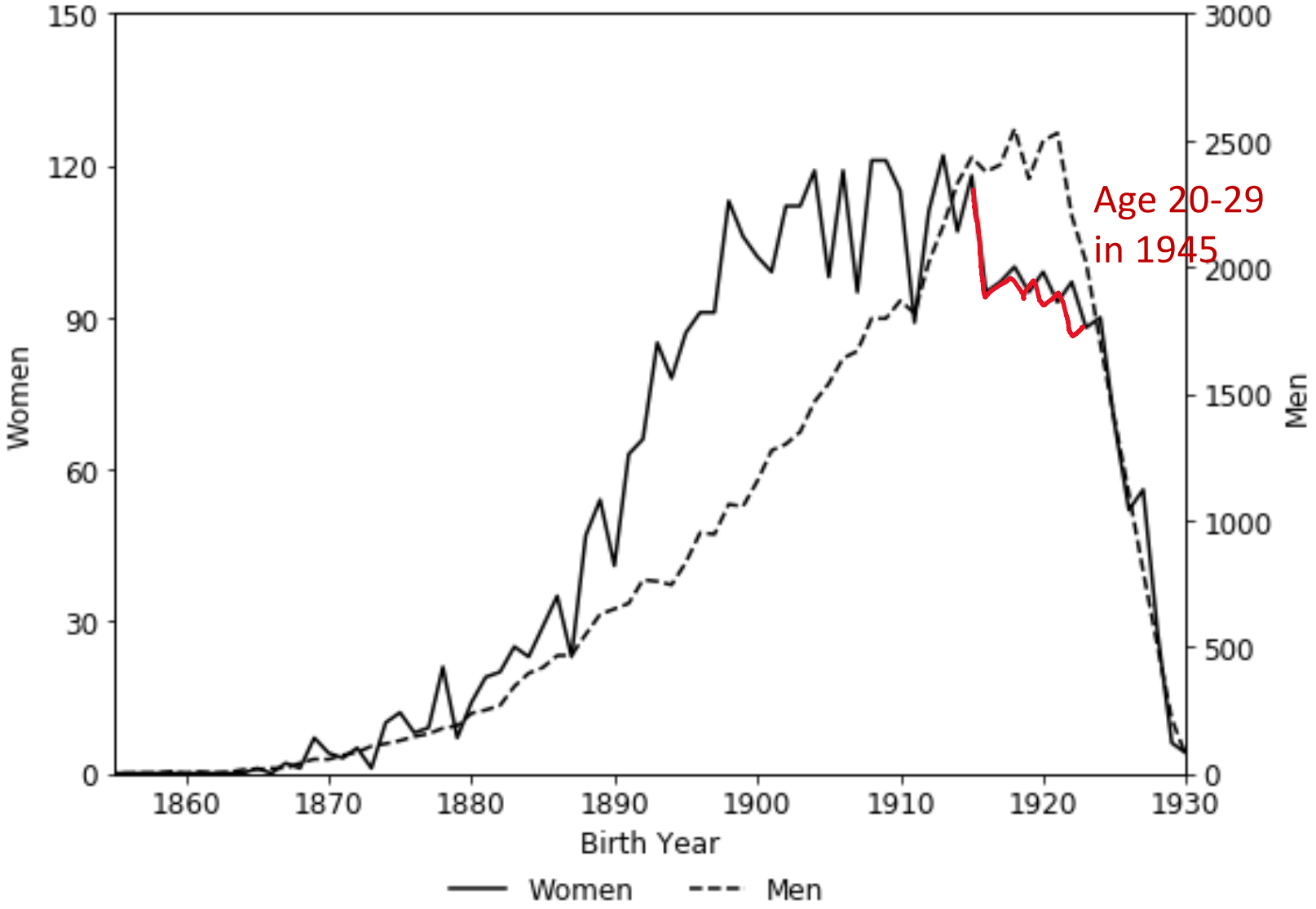
Mothers in Science

- Historical background
- Data
  - Biographies of American scientists in 1956
  - Apply *k*-means to research topics to define fields
  - Matched with patents
- Changes in productivity
  - Across the life cycle
  - After marriage
- Changes in promotion
  - From undergraduate to PhD
  - From PhD to assistant professor
  - From assistant professor to tenure
- Selection
  - Into marriage
  - Into parenting
  - Into research fields
  - Into survival
- Aggregate effects on participation
- Next steps

Entry by women declined by 16% from 110/year for women born 1900-15 to 92.3 for women born 1916-25



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Lost generation of baby boom mothers (b. 1916-25)

Share women among entrants into US science declined by 40% from 7% in 1940-45 to 4.3% per year in 1946-50

