The Current Landscape of Postgraduate STEMM Development

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July 22, 2025

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Overview

- The Supply of Graduate Students and Postdocs
- The Demand for STEM Doctorates
- Research on the Postdoc:
  - The Impact of the Postdoc on Early Careers
  - How Does Team Size Affect Careers?
- The current challenges facing science
  - Suggestions for how to navigate these turbulent times.

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The Supply of Graduate Students and Postdocs

The role of demographic characteristics and immigration

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Data Sources

- Information on graduate students comes from the Survey of Earned Doctorates
  - A census of all doctorates awarded in the US
- Information about postdoctoral researchers comes from the NSF's Survey of Graduate Students and Postdoctorates in Science
  - These data tended to undercount postdocs prior to 2015.
  - There is no single source of truth about the number of postdocs working in the US

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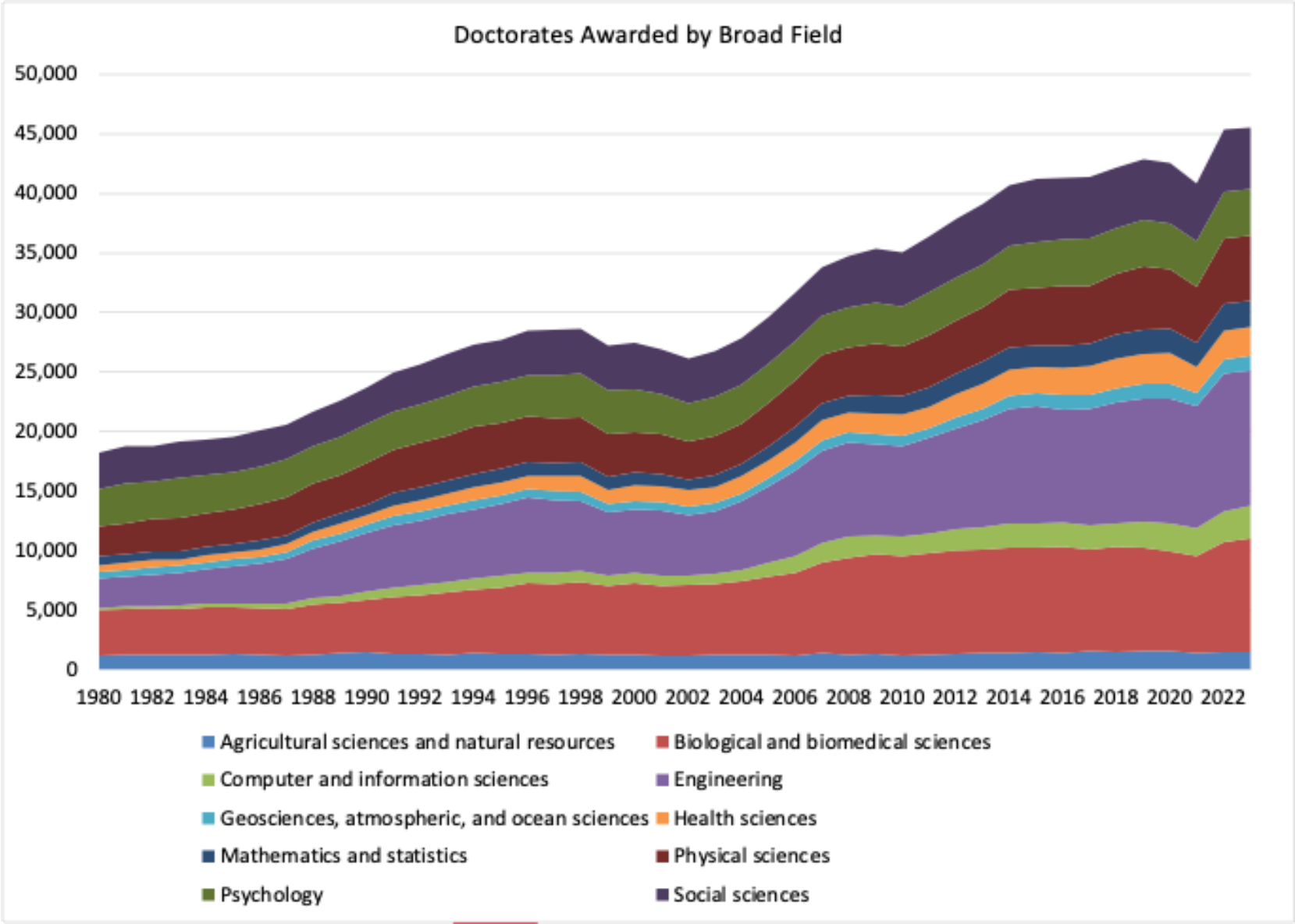
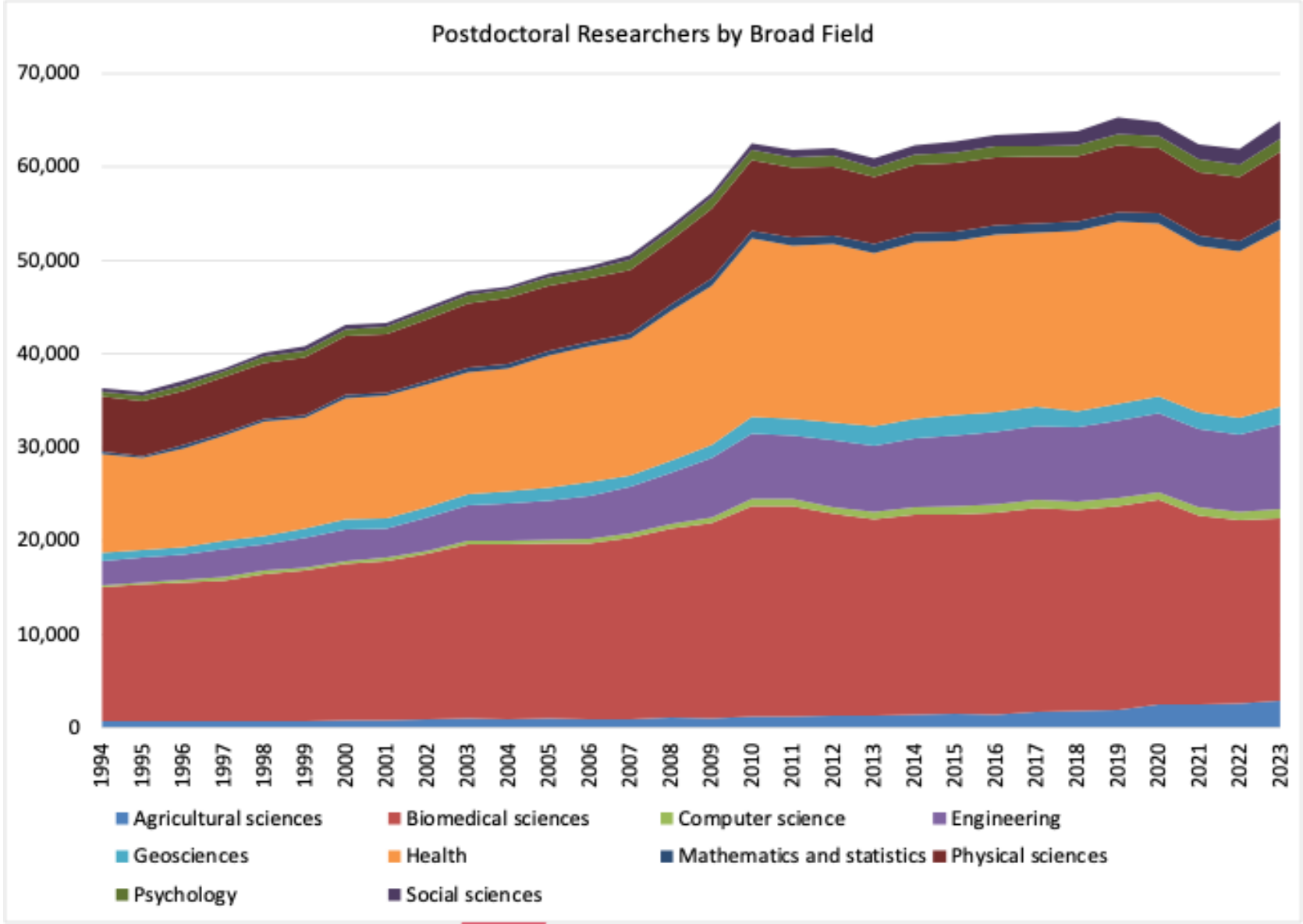
Doctorates Awarded by Broad Field

- Engineering and Biomedicine are the largest fields.
  - Engineering now growing at a faster rate.
- Large variation in size by field.
- Throughout will focus on biomedicine, engineering and chemistry because these fields have postdocs.



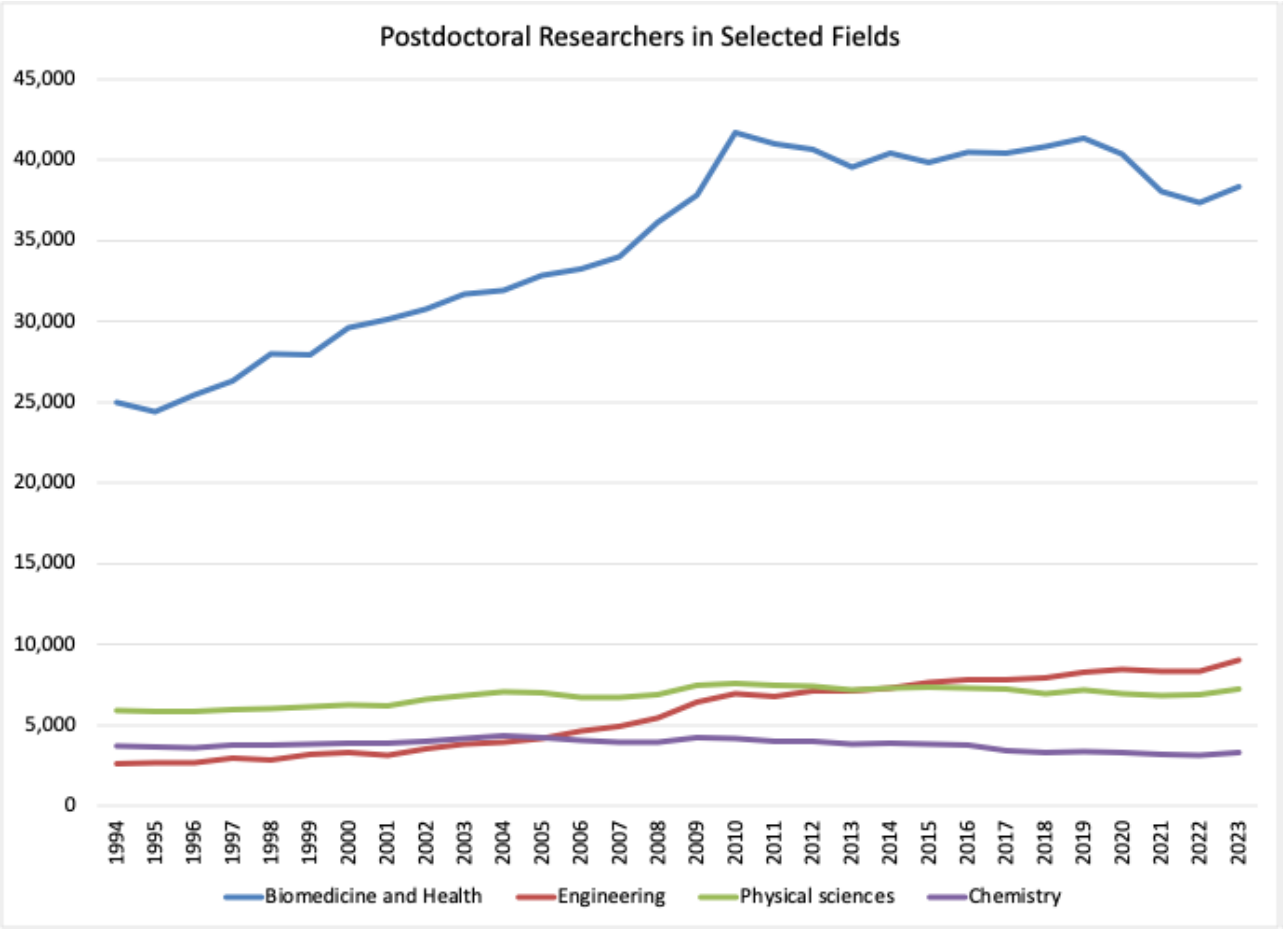
Postdoctorates by Broad Field

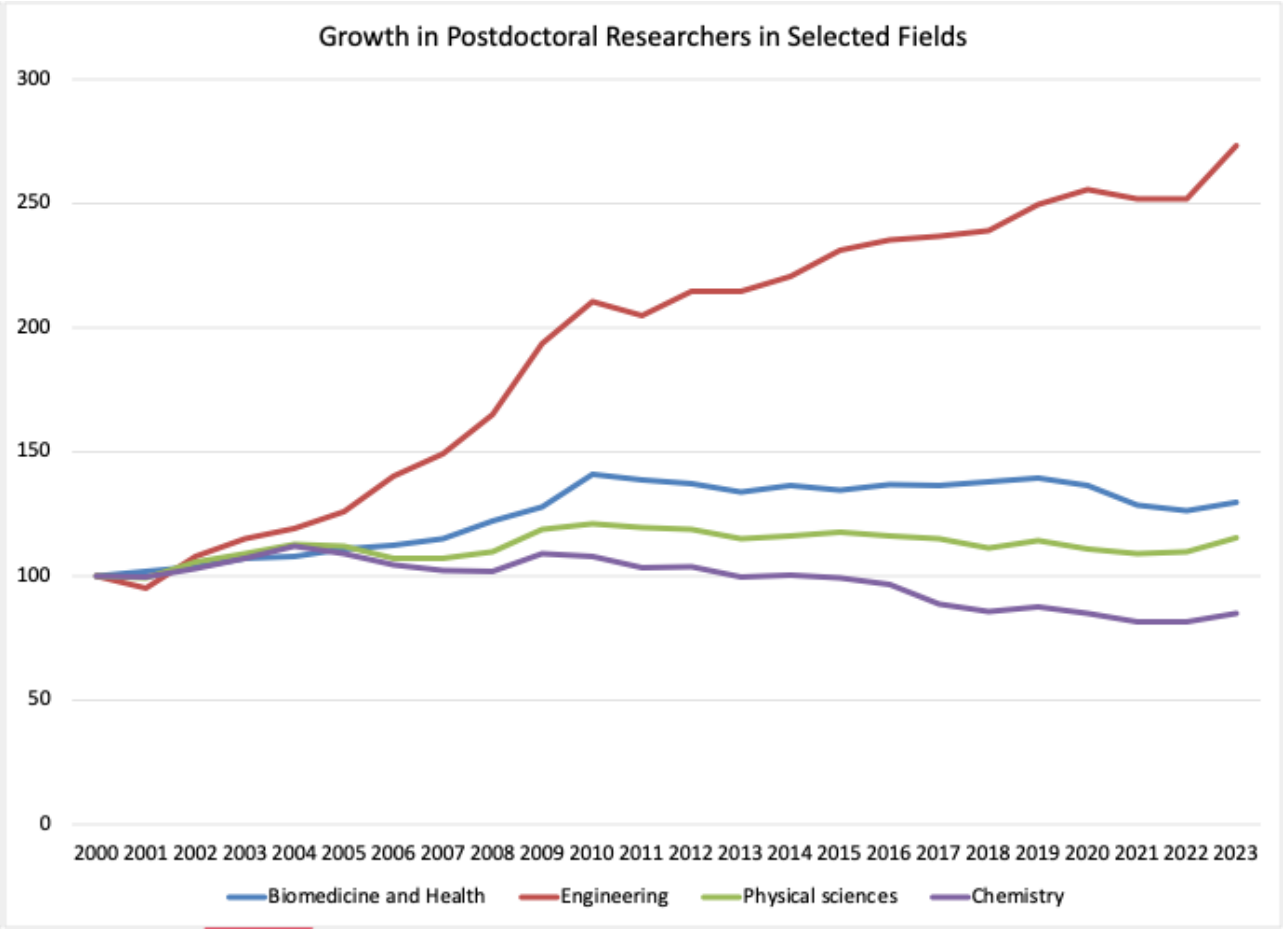
- Health, Biomedicine, engineering and physical sciences account for the majority of postdocs.
- Postdocs peaked at 66,000 in 2019.
- Throughout will focus on biomedicine combined with health, engineering and physical science because these fields have postdocs.



Postdocs in Selected Fields

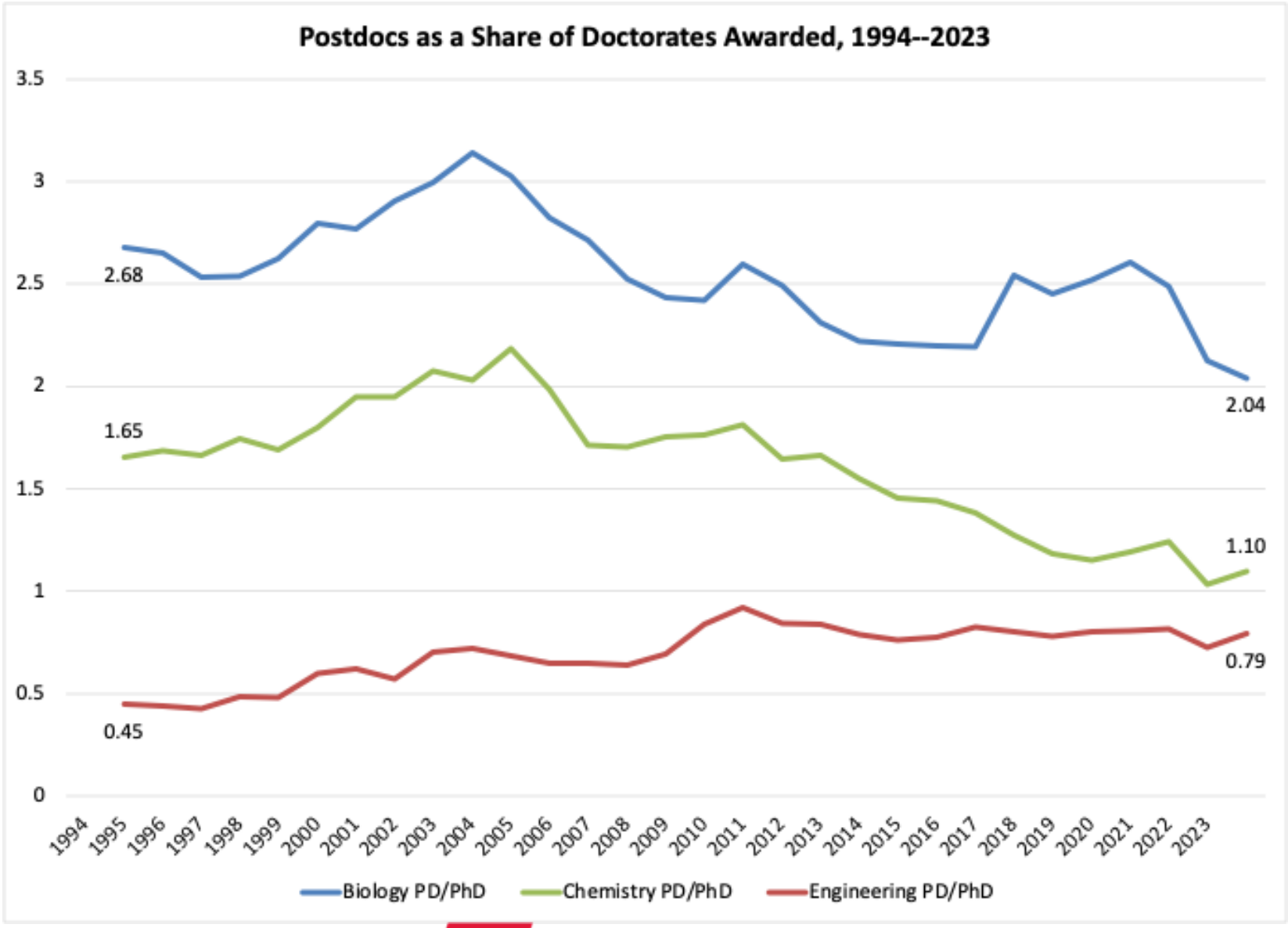
- Although Biomedicine and Health have the most postdocs, engineering postdocs have grown the fastest, and chemistry postdocs have declined since 2016.



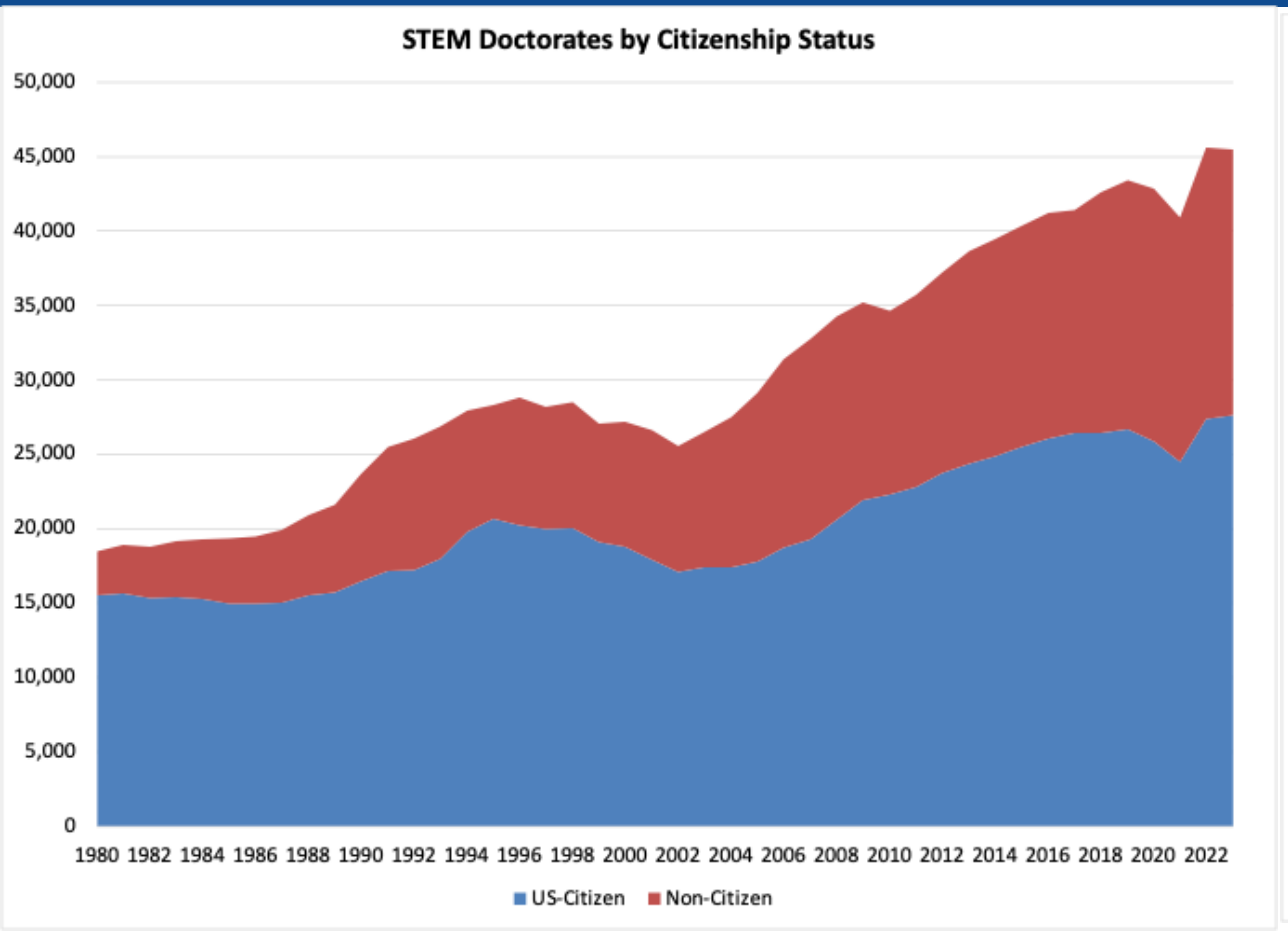


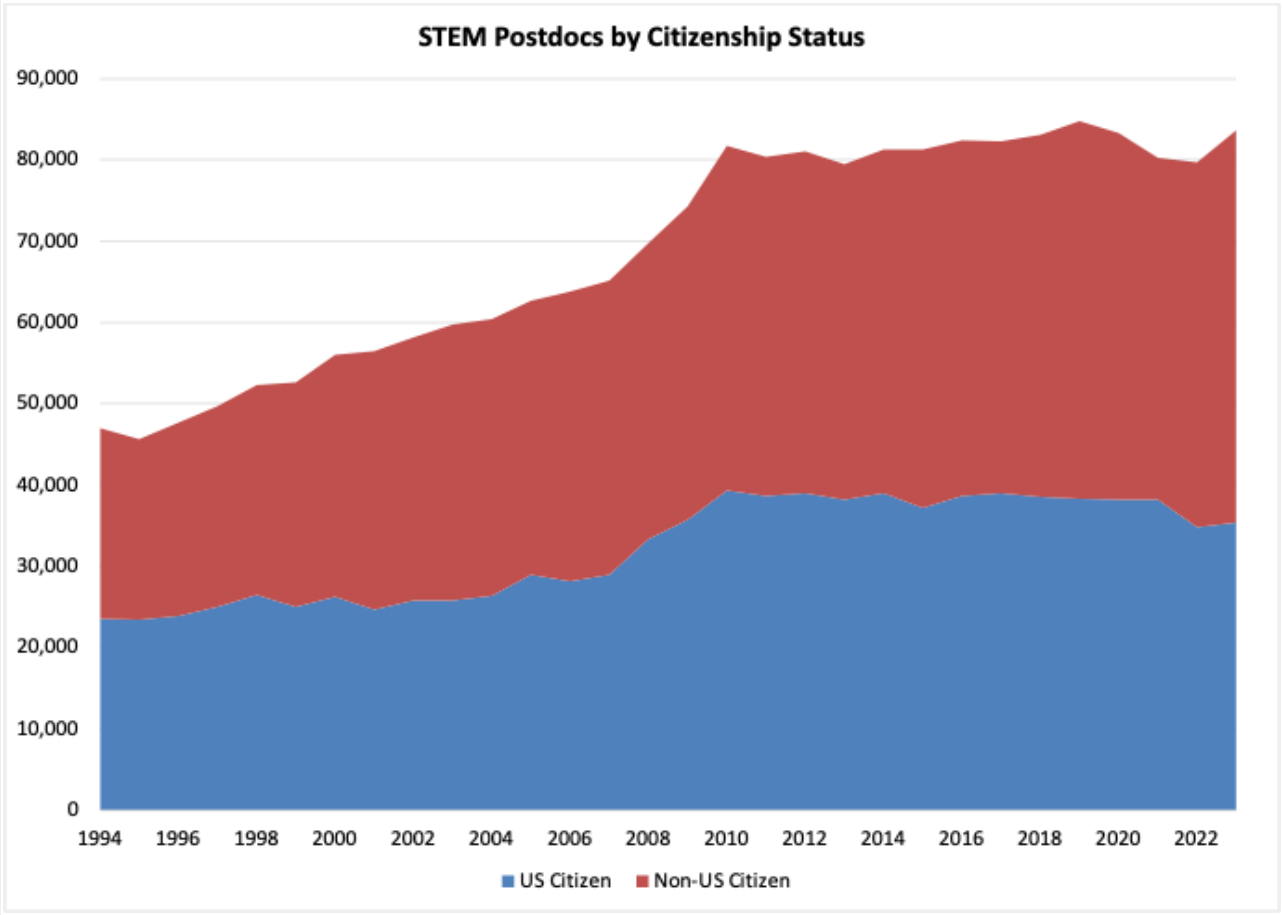
Postdocs as a Share of Doctorates Awarded

- In 1994 there were 2.7 postdocs per doctorate awarded in biomedicine. This peaked over 3 in 2004 and has trended downwards to 2.
- Chemistry postdocs per doctorate have also dropped.
- Engineering postdocs per doctorate have doubled.
- We may have passed "Peak Postdoc"



Immigrants as Share of Doctorates and Postdocs

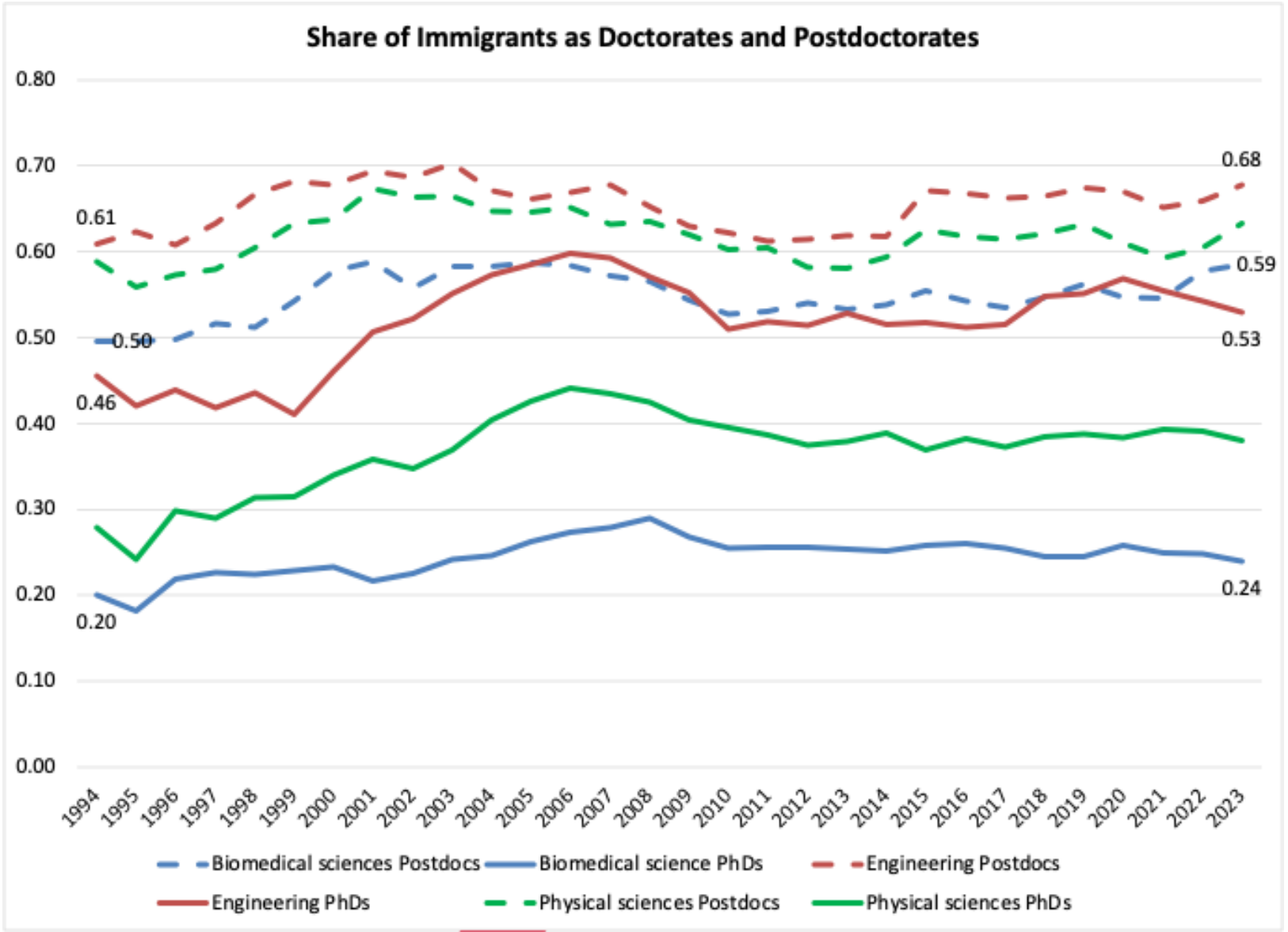




- Two thirds of STEM doctorates are awarded to US Citizens, but this varies by field. Non-US citizens are the majority of postdocs.

This is Not a New Phenomenon

- In 1994 on 20% of biomedical doctorates awarded went to non-citizens, but they made up 50% of postdocs.
- In engineering, over 50% of doctorates are awarded to non-citizens but close to 70% of postdocs are non-citizens.



Why are Postdocs Disproportionately non-Citizens?

- Postdoc pay has been very low and US citizens may have better outside options.
- The US has historically been at the cutting edge of science and attracts international PhDs.
- Non-citizens value US work experience and take postdocs as a way of obtaining more of that experience.
- US academic employers do not face the same visa caps as other types of employers.

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The Demand for STEM Doctorates

The Increasing Importance of Industry Employment

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Data Sources: The Survey of Doctorate Recipients

- Information on employment comes from the Survey of Doctorate Recipients (SDR)
  - This is a longitudinal panel that is a sample from the Survey of Earned Doctorates.
  - The SDR is a biennial survey of doctorate recipients that started in 1973.
  - The SDR was supposed to have been collected in 2025 but was postponed this year.
- Information that I am sharing with you may not be available in the future unless the SDR is collected.

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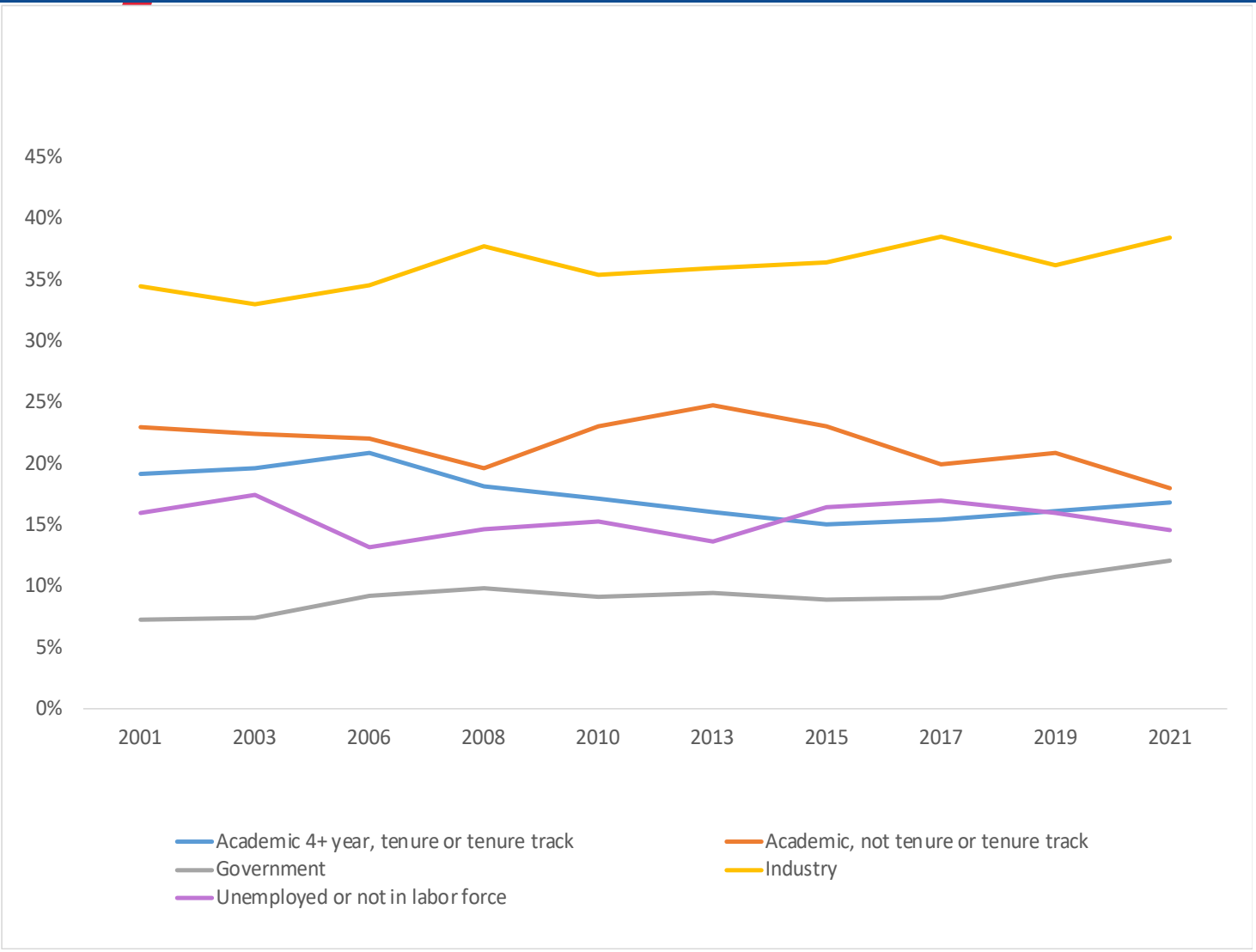
Data on Career Paths for Selected STEM Fields

- Following analysis based on a commissioned report on behalf of the American Society for Microbiology.
- Original analysis on additional fields was requested but not completed in time for this presentation.
- Trends in these fields are indicative of larger trends for other fields.

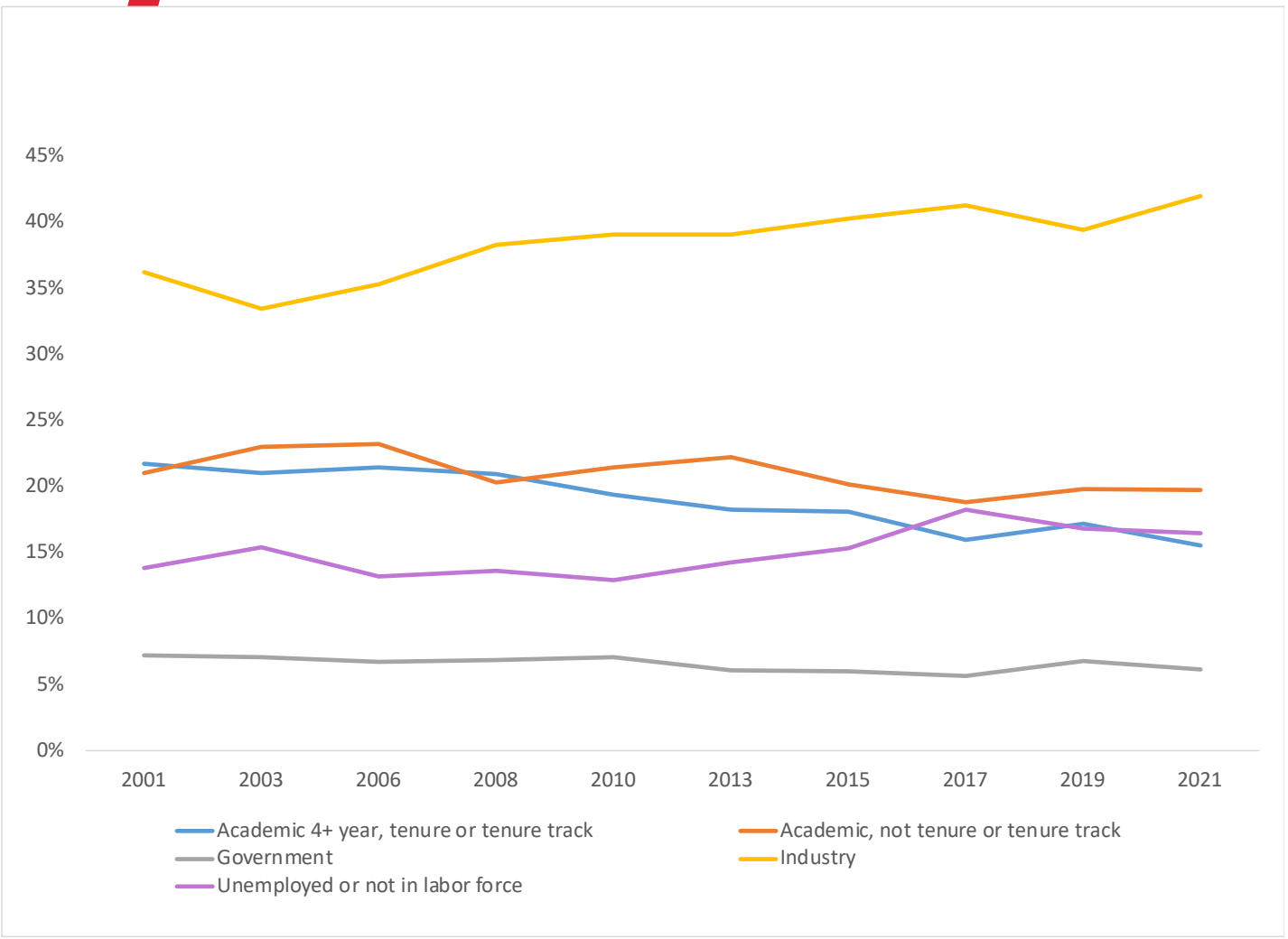
Microbiology Doctorate Employment by Sector



- Most Microbiologists are employed in industry (now 38%)
- Employment in Academia has declined.
  - From 19% to 16% Tenure Track
  - From 23% to 18% non-tenure track
- Inflection point at 2013: Industry employment grows while academic employment decreases.

Source: SDR

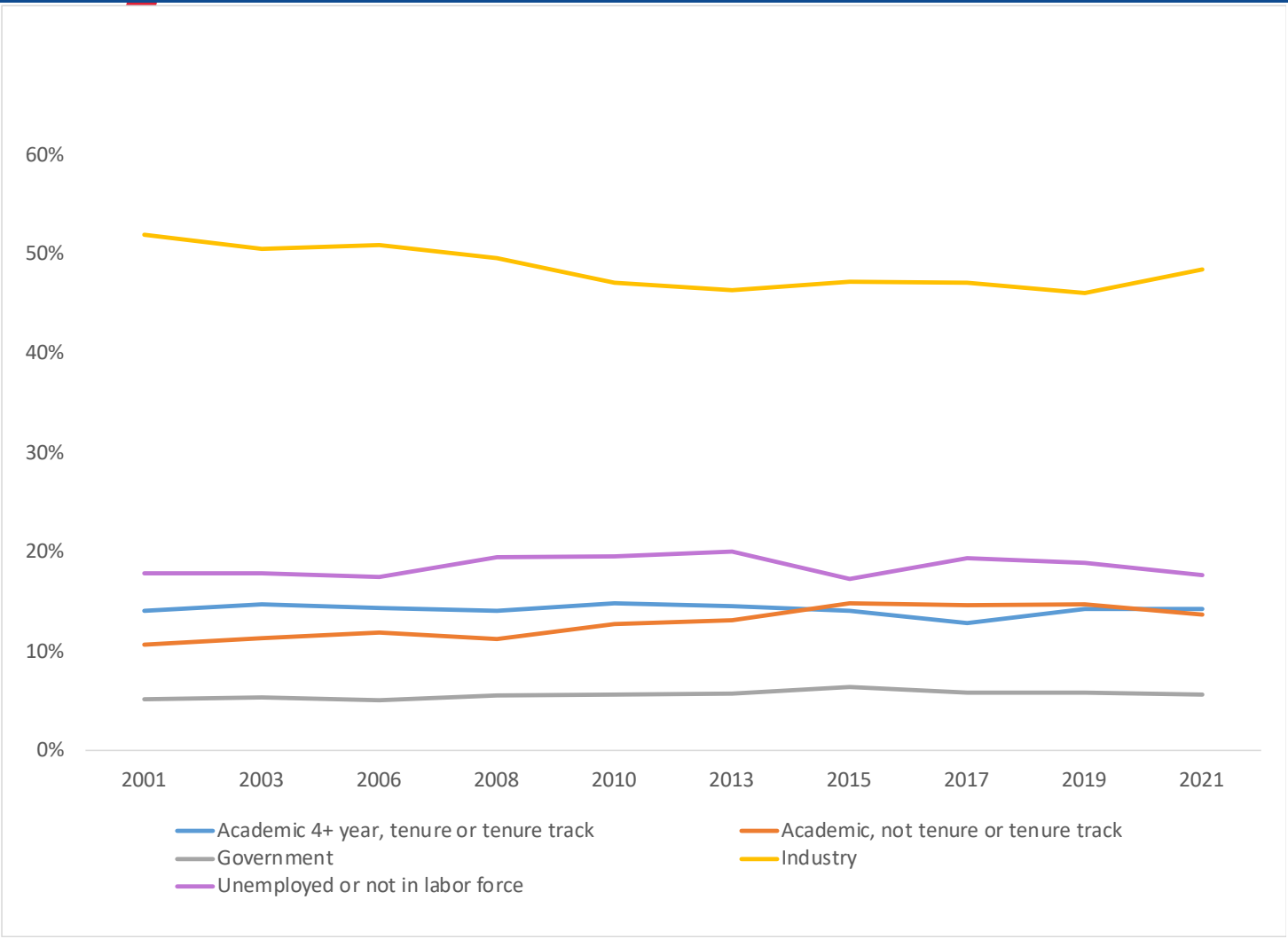
Biochemistry Doctorate Employment Sector



- Biochemistry doctorates are most likely to work in industry, and that has grown from 36% to 42%.
- Employment in Academia has declined.
  - From 22% to 16% Tenure Track
  - From 21% to 20% non-tenure track
- Inflection point at 2013 once again.

Source: SDR

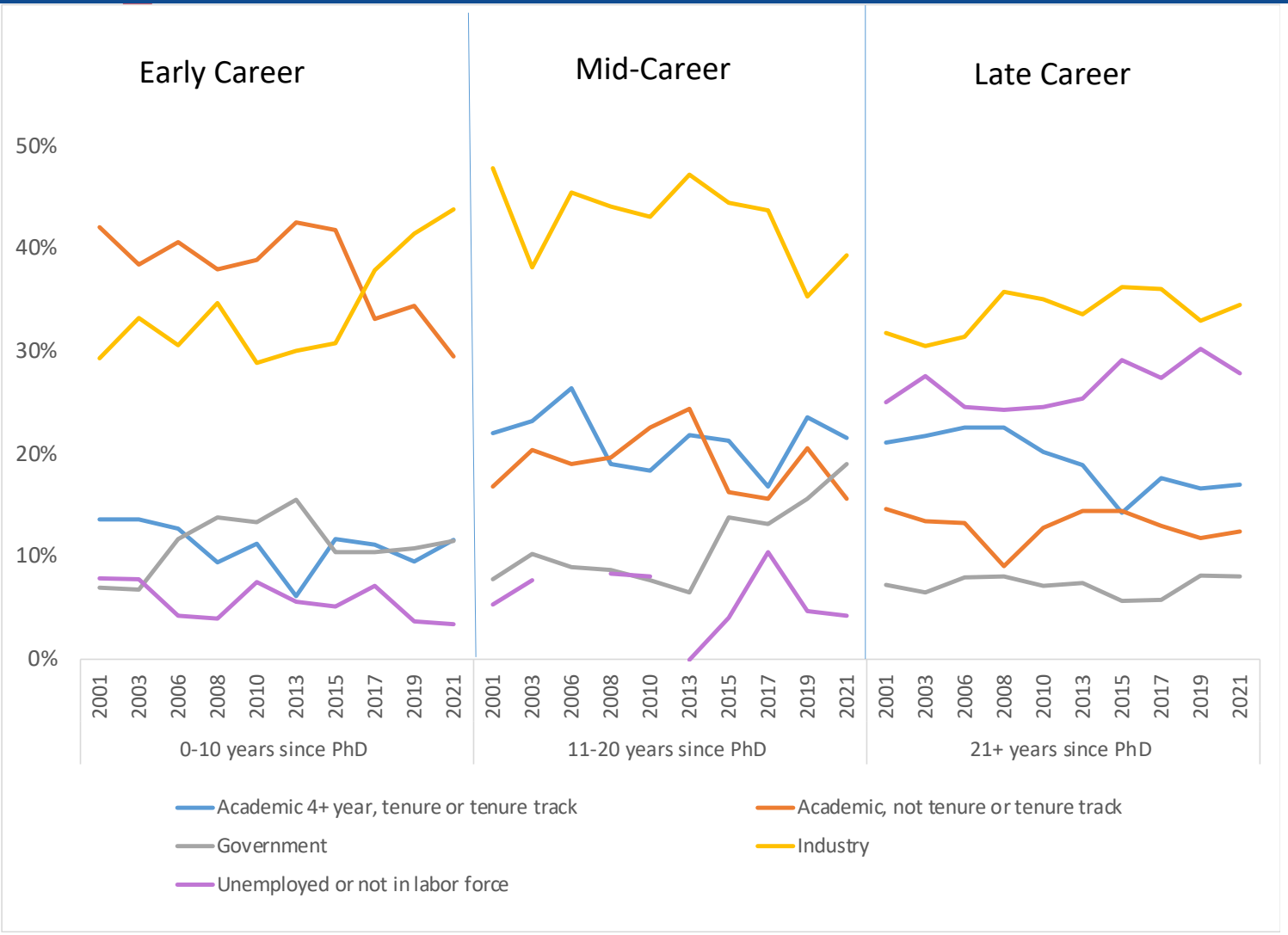
Chemistry Doctorate Employment Sector



- Employment trends are flat.
- 49% of Chemistry doctorates are employed in industry as of 2021.
- Academic Employment is flat (14% in each sector).

Source: SDR

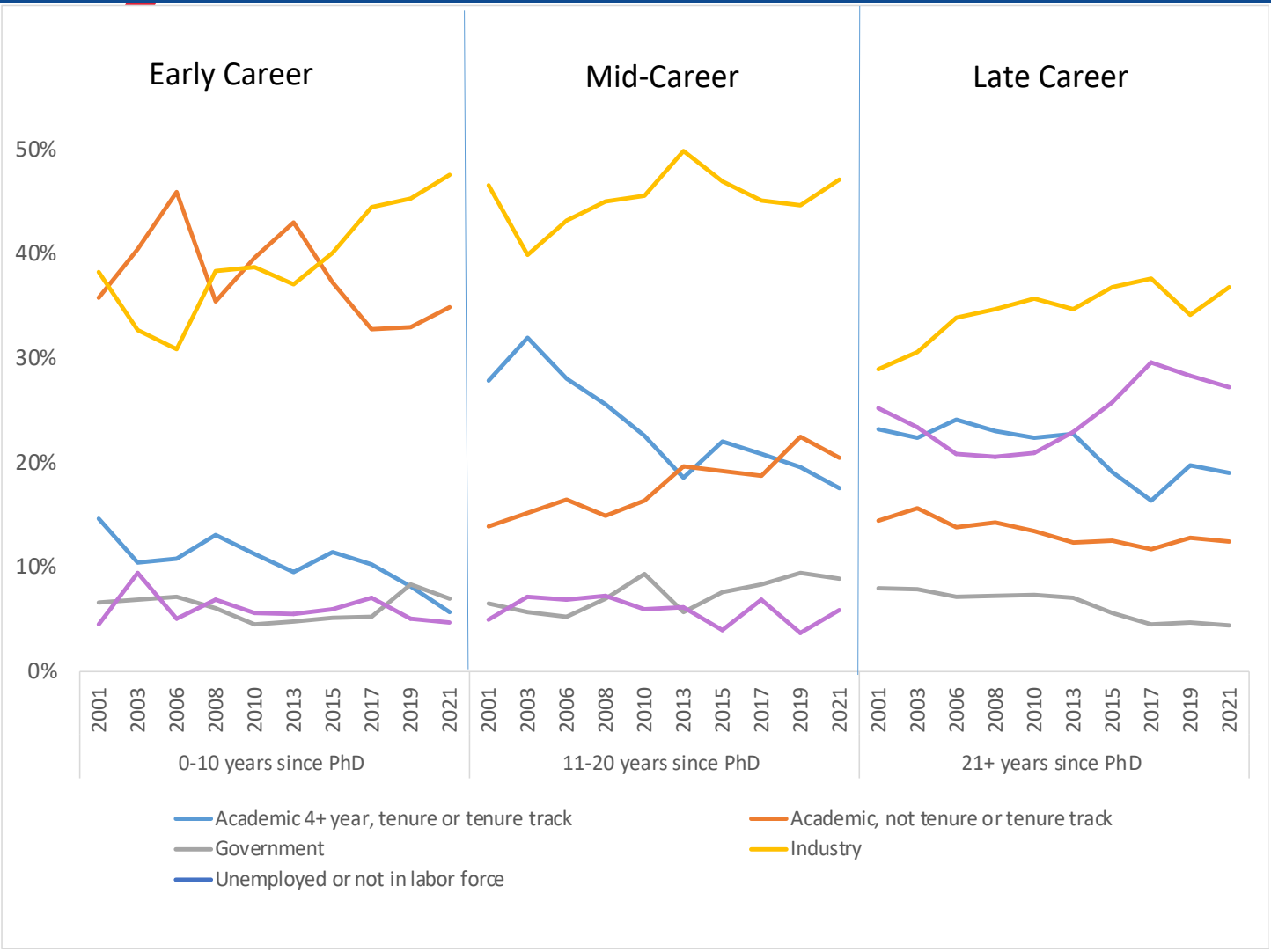
Microbiology Doctorate Employment Sector by Career Stage



- Significant drop in starting in academia:
  - This is a reduction in people taking postdocs.
- Increase in starting in industry and remaining in industry throughout career.
- Government employment increasing in mid-career.

Source: SDR

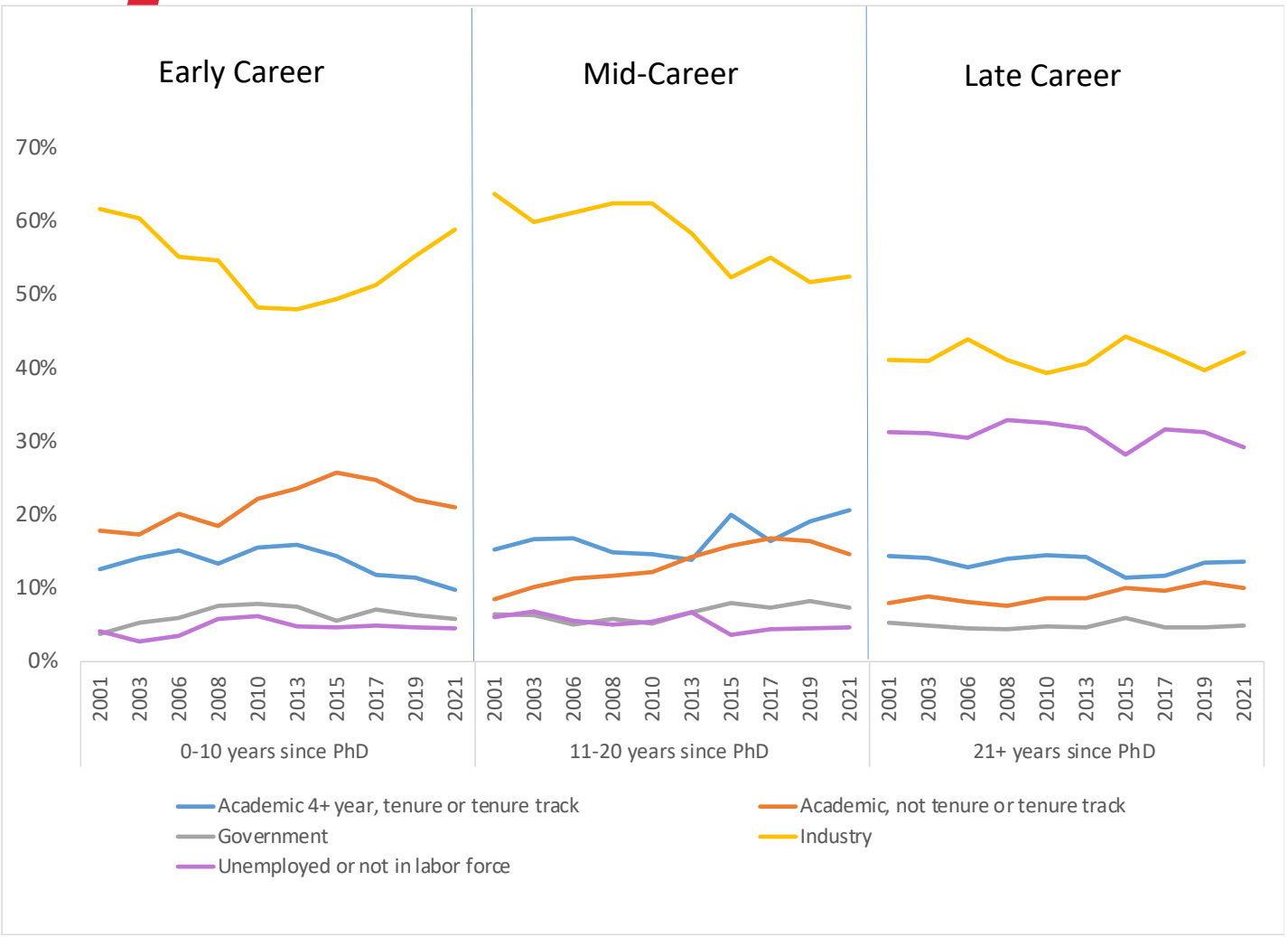
Biochemistry Doctorate Employment Sector by Career Stage



- Similar to Microbiology, there is a significant drop in starting in academia:
  - This is a reduction in people taking postdocs.
- Academic tenure track employment has dropped for mid- and late-career biochemists & biophysicists for more-recent cohorts.

Source: SDR

Chemistry Doctorate Employment Sector by Career Stage



- Industry employment for younger doctorates shows a U-shape between 2001—2021.
- Academic employment increased for mid-career workers over these decades.
- One-third of chemists are retired at 21+ years of experience.

Source: SDR

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Research on Early Career Scientists

What is the Impact of the Postdoc and Team Size on Career Outcomes?

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The Economic Return on Postdoctoral Research

CAREERS AND RECRUITMENT

Nature Biotechnology 2017. 35(1): 90-94.

The impact of postdoctoral training on early careers in biomedicine

Shulamit Kahn & Donna K Ginther

While postdocs are necessary for entry into tenure-track jobs, they do not enhance salaries in other job sectors over time.

The Economics of the Postdoc

- Postdoc is defined as a temporary period of advanced training
  - Economists call this an investment in human capital.
  - Human capital investments should yield a positive return.
- Or is the postdoc some kind of signal, tournament or queue?
- Our results suggest that Postdocs are a “Rat Race” where individuals sacrifice to signal productivity.

Data and Methods

- Use the 1980-2013 waves of the Survey of Doctorate Recipients (SDR) matched to the Survey of Earned Doctorates (SED).
  - SED: Census of all PhDs awarded in the US.
    - Field of study, start in a postdoc
  - SDR: Sampled from PhD. Followed every two years. Detailed information on:
    - Demographics (race, gender, nativity, marital status)
    - Industry, sector, academic careers.
- Sample includes biomedical PhDs where > 60% take postdocs.

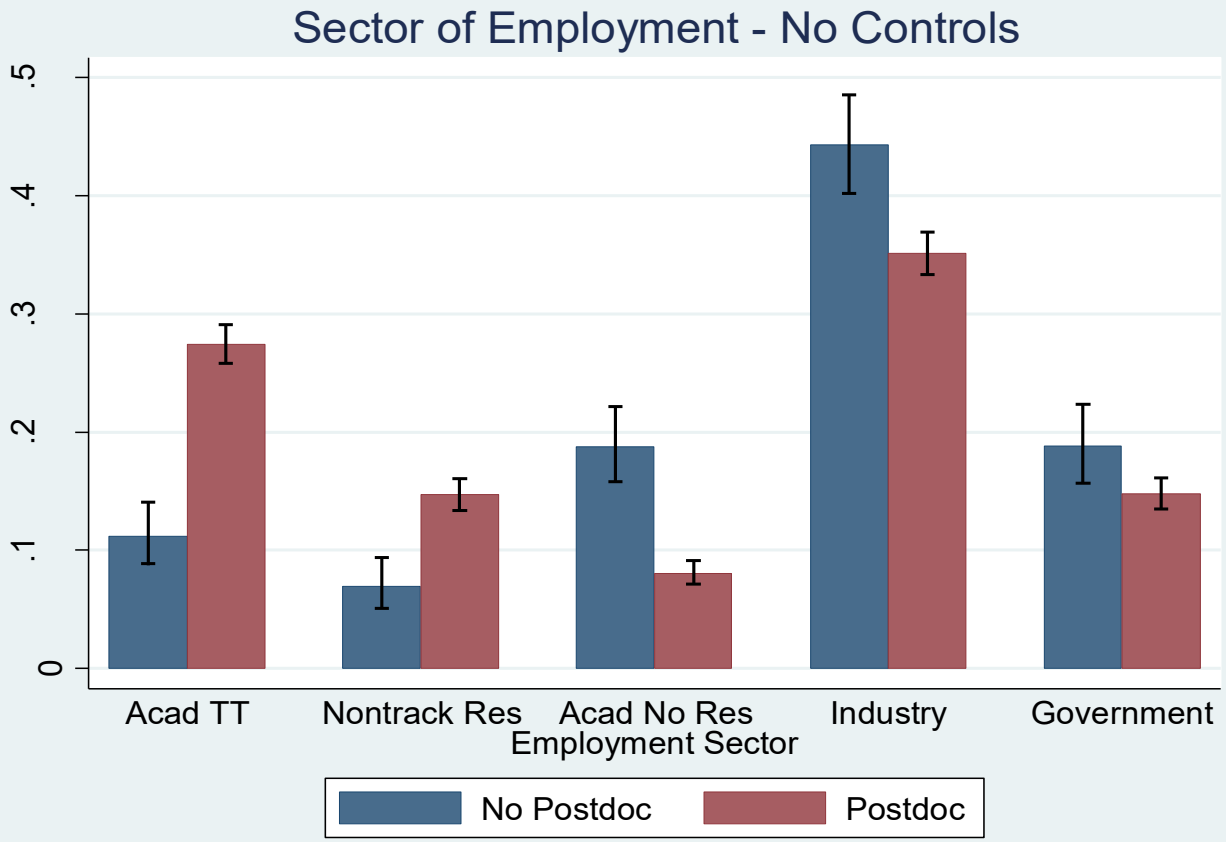
Data and Methods

- Use the Survey of Doctorate Recipients (SDR) matched to the Survey of Earned Doctorates (SED) to identify:
  - Incidence and duration of postdocs
  - Subsequent career outcomes 10 years Post PhD
    - Academic Tenure Track Research
    - Academic Non-track research
    - Academic Non-research
    - Government/Non-profit
    - Industry

Starting in a Postdoc & Duration

- Approximately 80% of biomedical PhDs start in a postdoc
  - Model indicates few factors influence that decision.
- Conventional wisdom: Postdoc durations have increased
  - No evidence of that within the last 10 years. However, that may have changed.
- Postdocs are positively selected. Former RAs and those from top ranked programs are more likely to do a postdoc.

Postdoc Status & Employment Sector 10 Years Post PhD

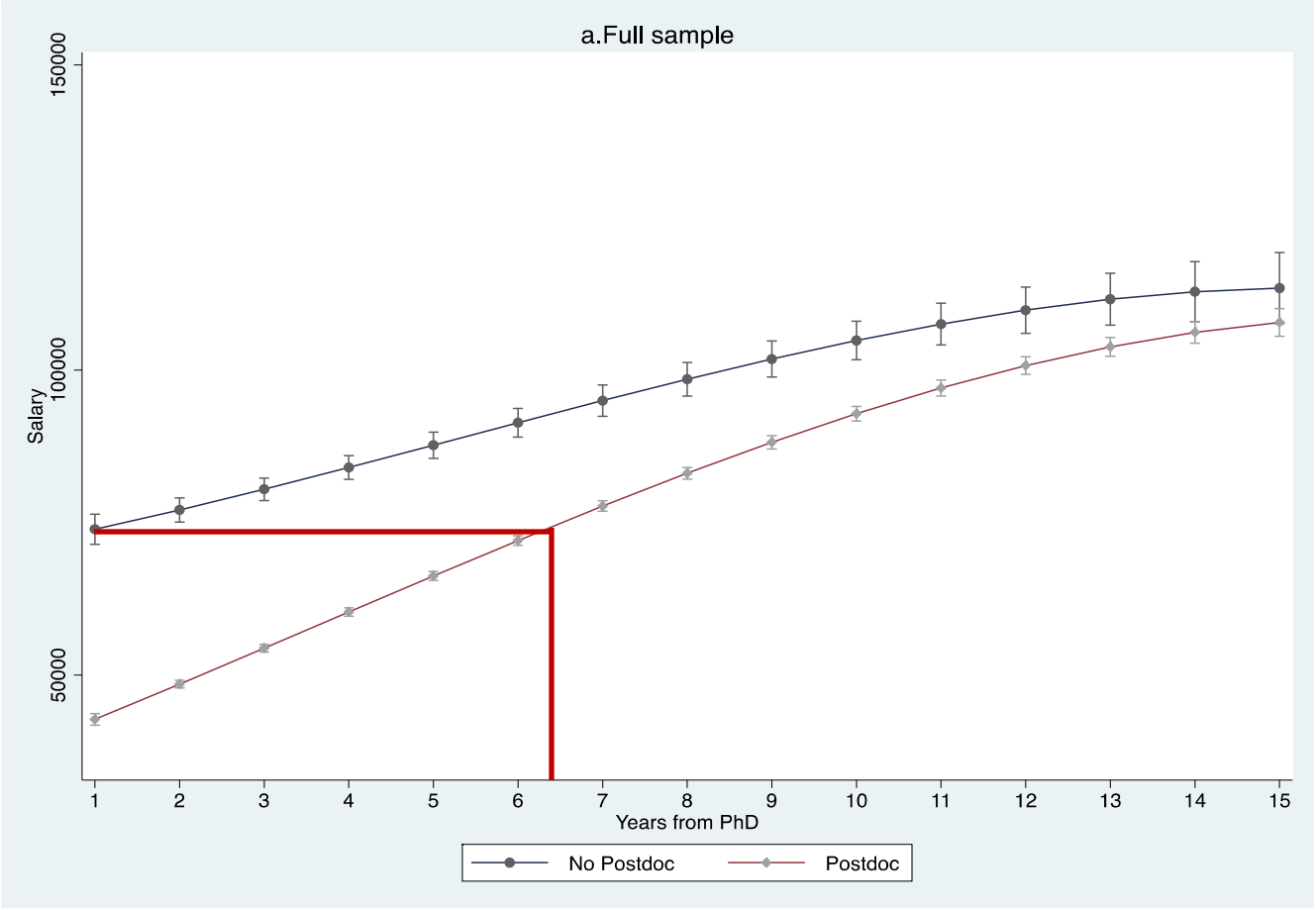


Postdocs are more likely to work in academia.

Postdocs less likely to work in industry and teaching intensive academia.

Postdocs equally likely to work in government as non-postdocs.

Effect of Postdoc on Earnings



- Postdocs earn 17% less than those who skip the postdoc.
- They do not catch up in earnings even after 15 years.
- A postdoc on average earns the same salary as an industry position after 6 years.

Effect of Postdoc on Earnings

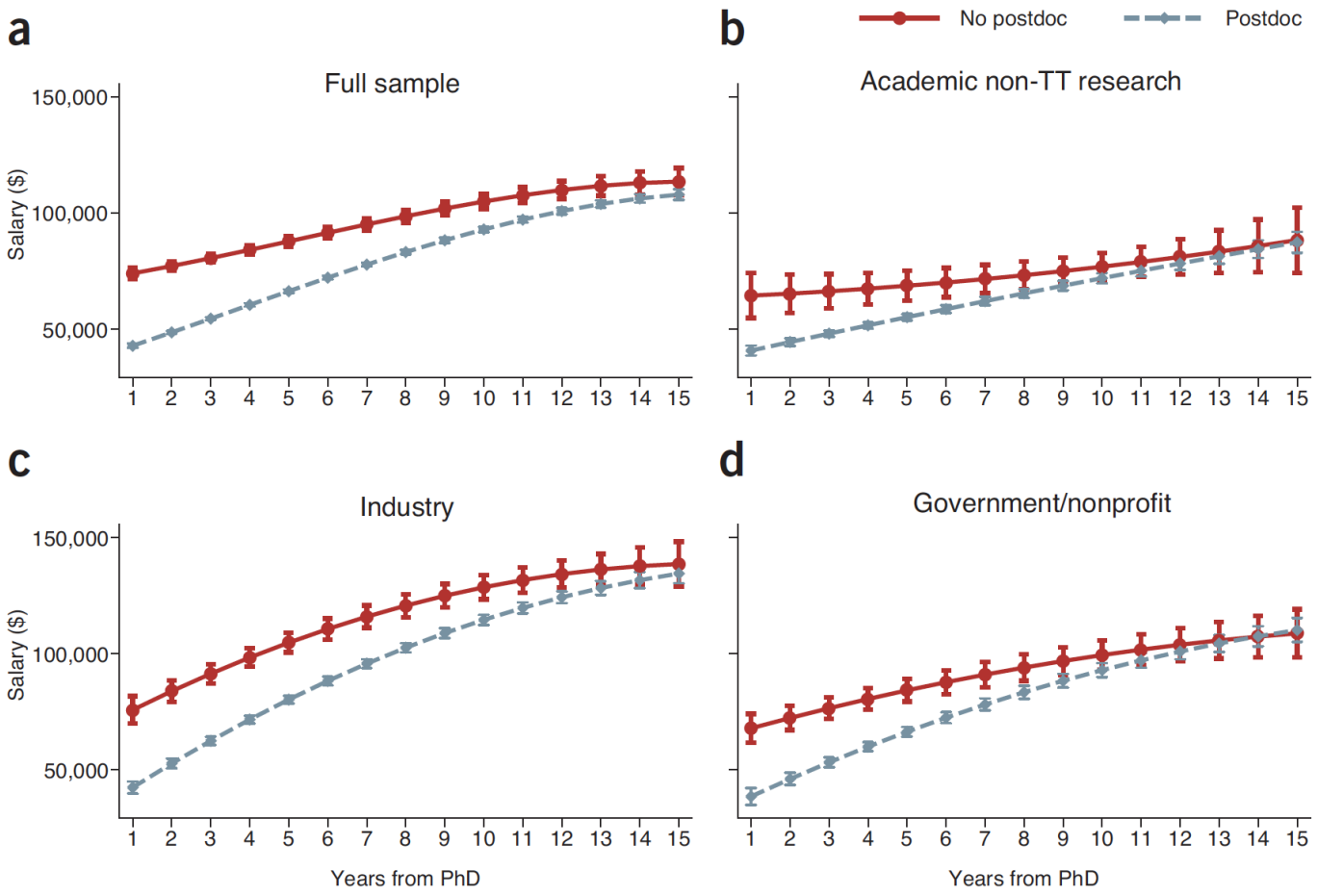


Figure 5 Predicted inflation-adjusted salary (2013 dollars) 1–15 years after PhD completion. (**a**–**d**) Salaries shown for those with and without postdoc experience by 10-year sector (**a**), academic non-TT research (**b**), industry (**c**), and government/nonprofit (**d**). Shown with 95% confidence intervals.

- Postdoc penalty:
  - 17% in non-tenure track research
  - 21% in industry
  - 17% in government.

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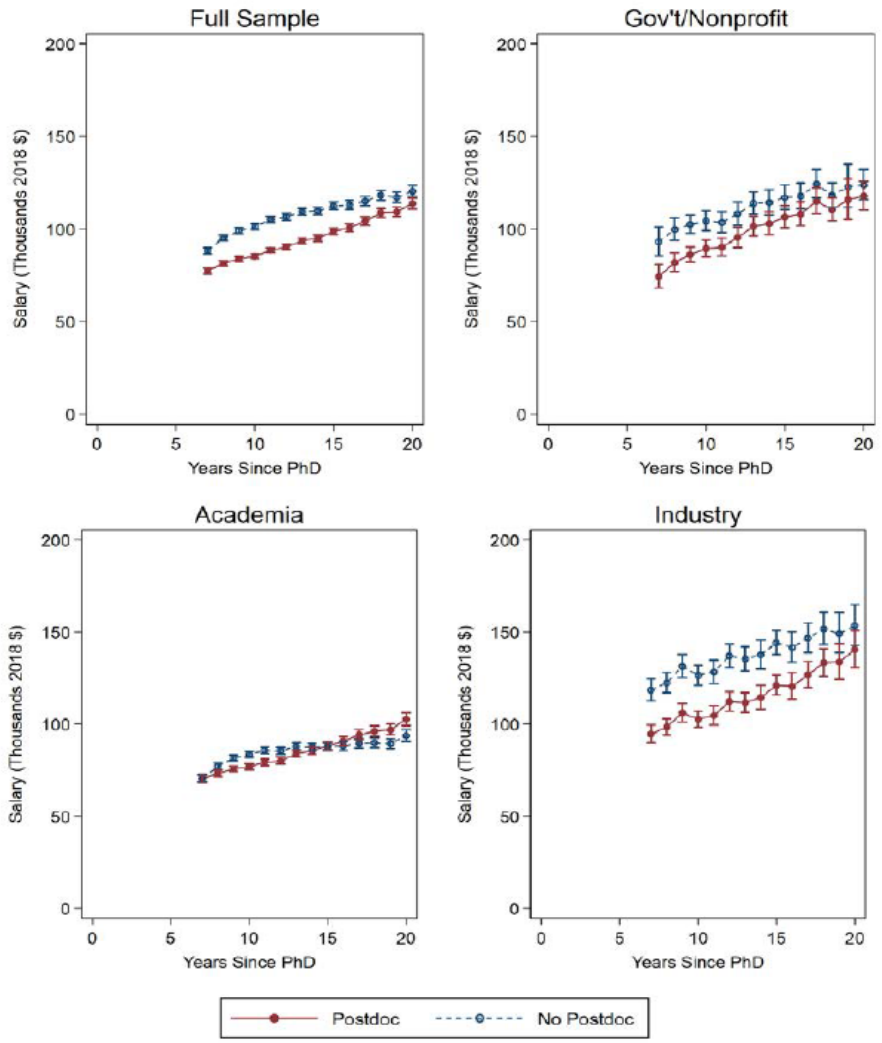
Diethorn & Marschke (Forthcoming)

Figure 3: Average Predicted After-Postdoc Salary Over Career by Postdoc-Trained Status: Postdoc Training as Experience, Postdoc Salary Observations Excluded



- Using the SDR data 1993-2017 and a different econometric approach, Diethorn & Marschke (2023) conclude:
  - Like Kahn and Ginther (2017), whose analysis of biomedical postdoc training is also based on this database, we find that the earnings of biomedical doctorates with postdoctoral training are lower than those of doctorates who skipped training and that earnings differences vary substantially by employment sector. On average, postdoc-trained doctorates earn about 12% less annually compared to non-postdoc-trained doctorates.

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Conclusions

- Multiple papers indicate that the postdoc has no discernible economic value to new PhDs besides improving a researcher's chance of obtaining elusive and dwindling academic positions.
- Based on these findings, the majority of PhDs would be better off skipping the postdoc.

Introduction

Careers & recruitment

Career feature

https://doi.org/10.1038/s41587-024-02351-8

The rise of teamwork and career prospects in academic science

Check for updates

The rise in team size in academic science has generated an unintended side effect: junior scientists are less likely to secure research funding or obtain tenure and are more likely to leave academia.

- Andalon, de Fontenay, Ginther & Lim

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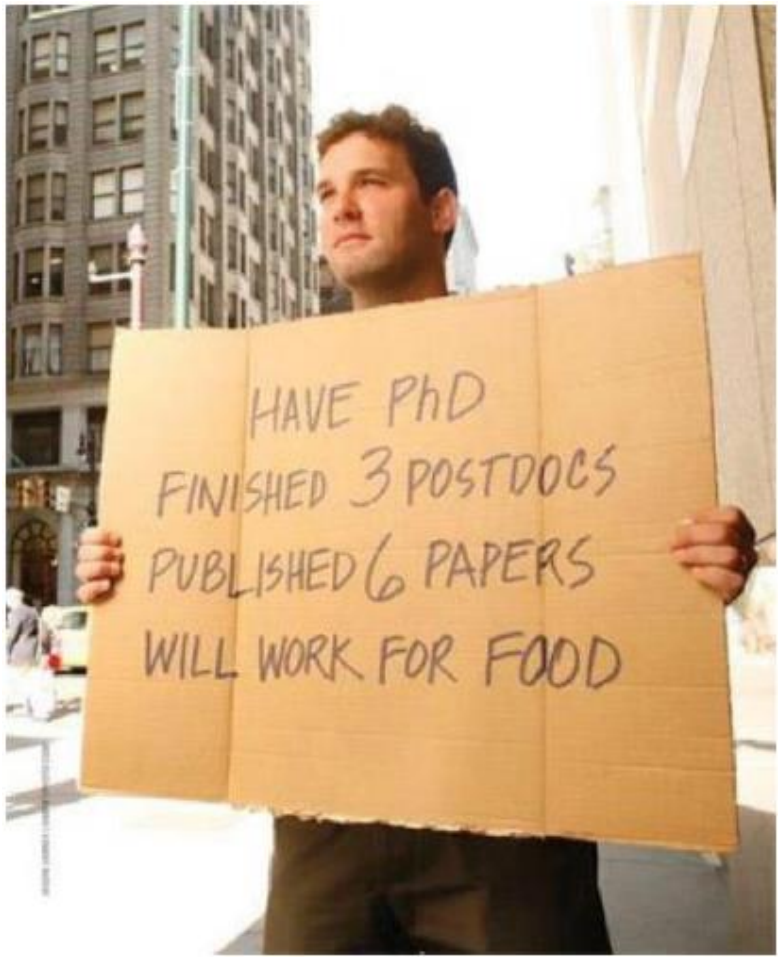
Career Prospects in Academic Science Have Worsened



Ginther (2015)
Only about 20% of biomedical PhDs will achieve tenure track appointments within 10 years of PhD

Kahn & Ginther (2017) Postdocs in biomedicine are only good for obtaining these diminishing academic jobs.

Postdocs also have the same starting salaries as graduates who skip the postdoc.

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Exit from science not only weak scientists

The New York Times

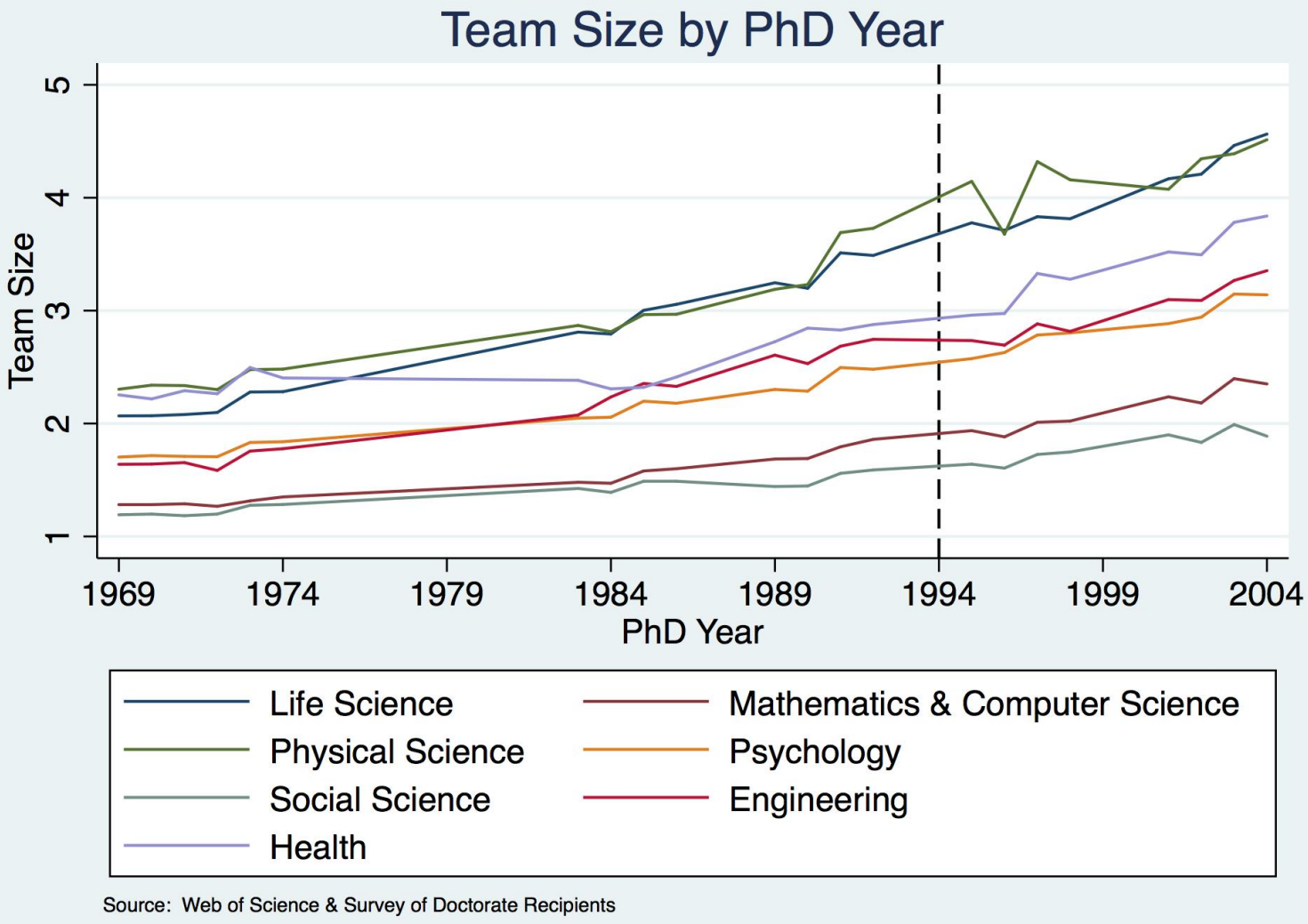
Man Who Set Stage for a Nobel Now Lives a Life Outside Science

Douglas Prasher, who discovered the glowing jellyfish protein used in research that won a Nobel Prize, now drives a courtesy van for a car dealer in Huntsville, Ala.

By Kenneth Chang

Oct. 16, 2008

Team Size in Science has Grown



Team size highest in physical science, followed by life science and health.

1994--the end of mandatory retirement.

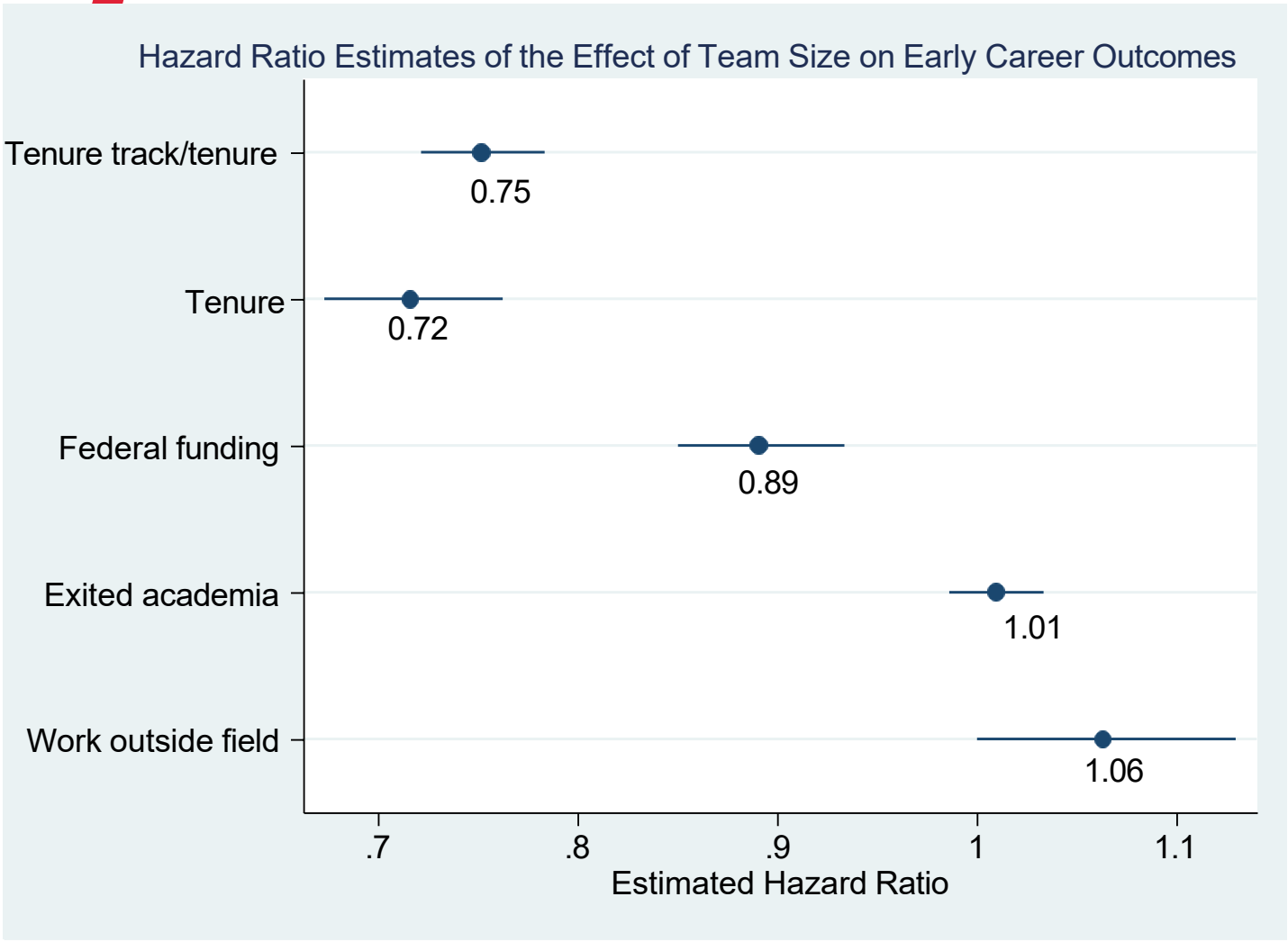
No change in trend of team size after 1994

Theory (de Fontenay et al, 2018)

- Credit sharing:
  - Some information in being first and last author: who put in the most hours; who funded the research and authorized the choice of project
  - Less information on the contribution of intermediate authors
  - Author order doesn't indicate who had the valuable insights

- Larger teams provide noisier signals of quality of a researcher to universities and funding agencies.
- We test this theory with the Survey of Doctorate Recipients

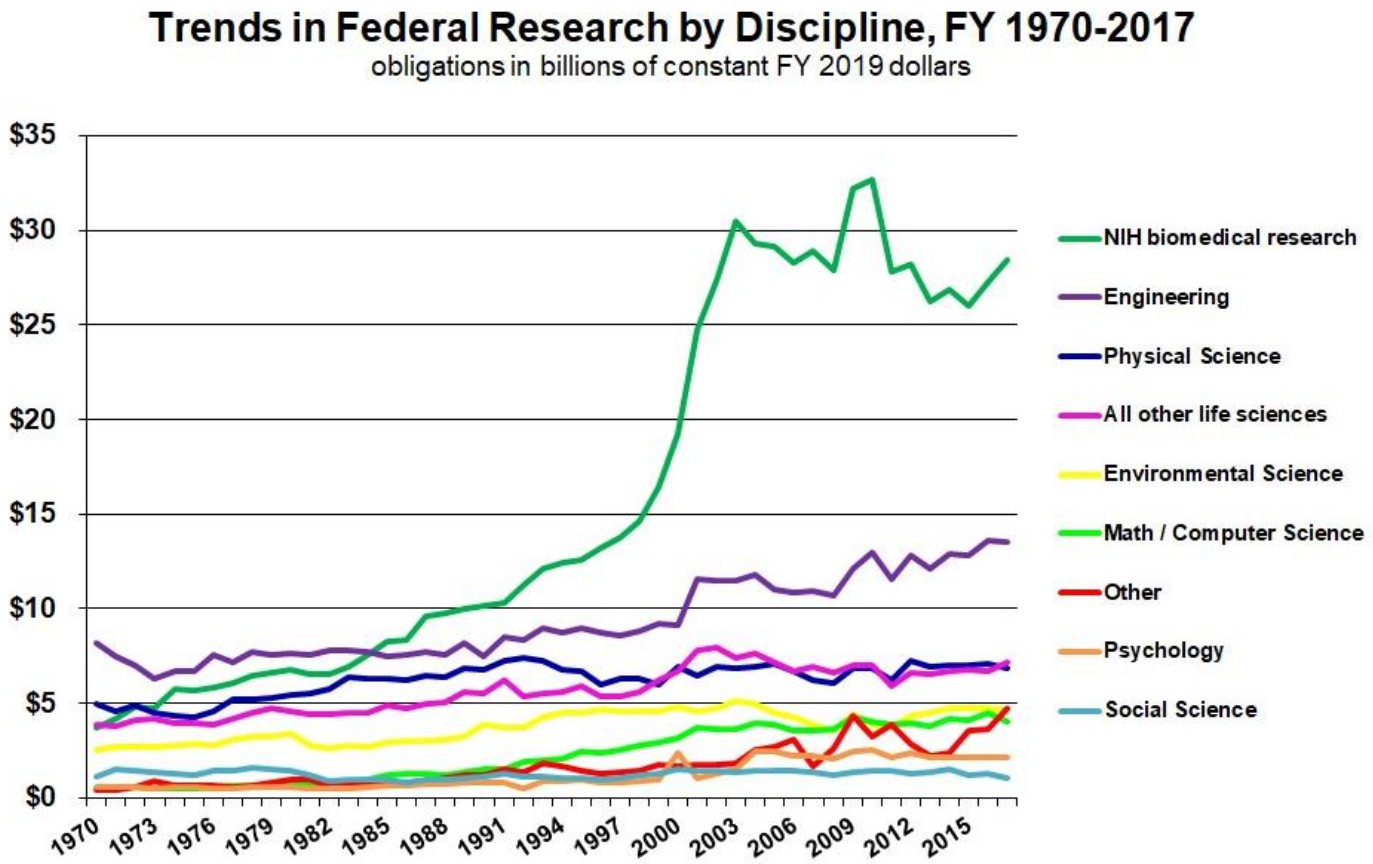
Effect of Team Size on Career Outcomes



Team size reduces tenure track jobs, tenure, and federal funding.

Team size associated with exiting academia and working outside of field.

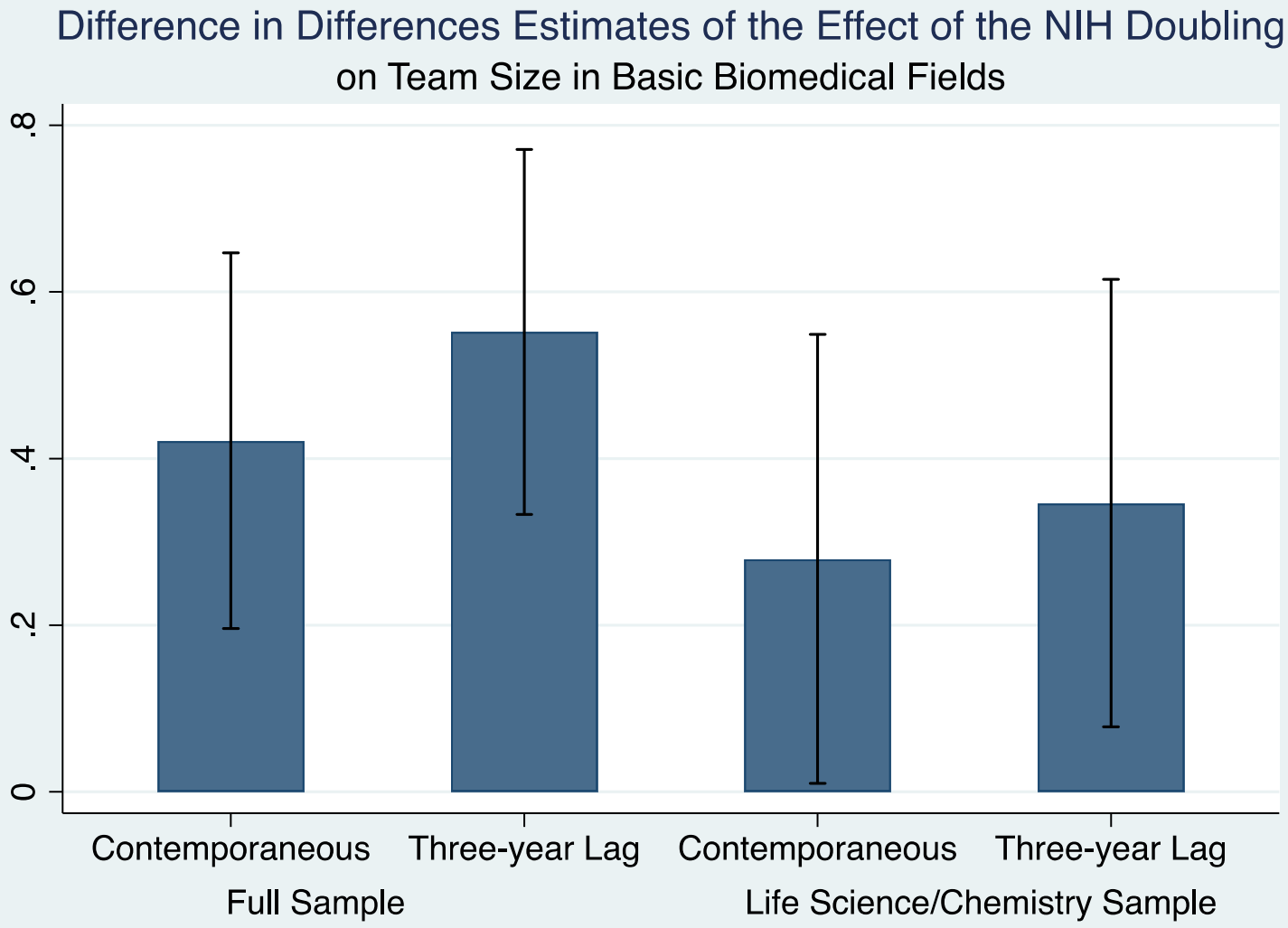
Federal Research by Discipline



"Other" includes research not classified (includes basic research and applied research; excludes development and R&D facilities). Life sciences are split into NIH support for biomedical research and all other agencies' support for life sciences.

Between 1998-2003, the NIH Budget doubled and other science agency budgets were flat.

Does Science Funding Affect Team Size?



Team size significantly increased in basic biomedical fields relative to other science fields after the NIH doubling.

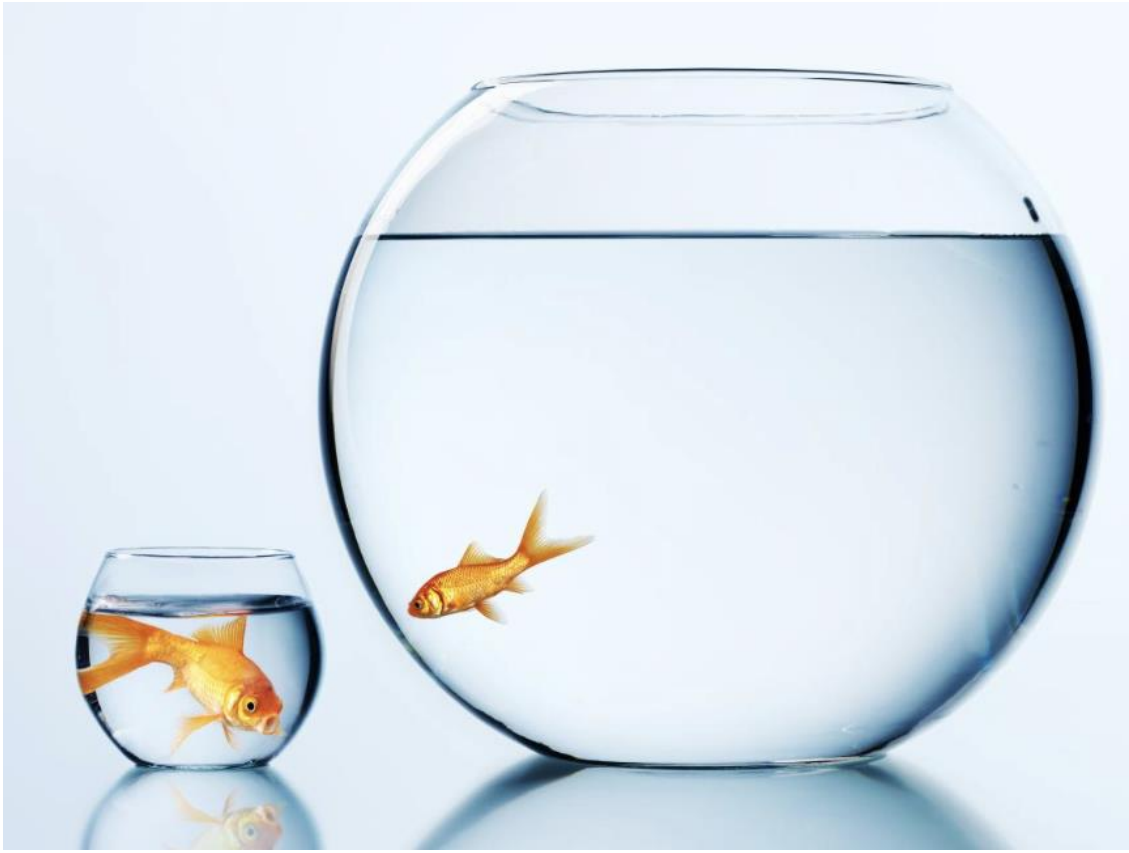
The team size increase ranged between .3 - .55.

Team Size Conclusions

- Economic theory suggests that increases in team size make it more difficult to determine individual contributions to teamwork.
- Our estimates confirm the theoretical prediction that the increase in team size disadvantages young scientists in academic careers.
  - This is not explained by mandatory retirement.
- The Doubling of the NIH budget contributed to the relative increase in team size.

Implications for Careers

- Choose your adviser wisely. There are advantages to working in smaller labs and to being a bigger fish in a smaller pond.
- There is a huge payoff to persistence.
- Given the unequal allocation of credit, do not chase shiny objects.
  - Forge your own path instead of following the crowd.



Findings from the Literature: Funding

- Type and timing of funding matters:
  - Babina, He, Howell, Perlman & Staudt (2023) found that federal funding reduces patenting and decreases the likelihood of working in industry.
  - Cheng, Perlman, Staudt & Tham (2024) found that gaps in federal research funding decreased lab size and lowered research productivity.
  - Shvadron, Zhang, Flemming & Gross (2025) found that "increasing government-funded PhD trainees increases PhD production roughly one-for-one."

Findings from the Literature: Mentors and International Postdocs

- Mentors matter:
  - Lerchenmueller, Schmallenbach & Hoisl (2025) found that having a female NIH mentor resulted in a citation discount of 10% on the average paper published by women- relative to men-mentored protégés.
  - Patsali, Pezzoni, and Visentin (2024) found that doctoral students who had research topics independent from their PhD supervisor were more likely to be employed in academia in France.
- International Postdocs are disadvantaged
  - Kahn & MacGarvie (2024) found that international postdocs received less support for independent research, were paid less and more closely monitored than their US citizen counterparts.

Findings from the Literature: Unions

- Impact of Unions:
  - Preliminary work by Ganguli & Goroff-Murciano (2025) find that graduate student unions increase stipends
    - But they reduce the demand for graduate students and postdocs
  - Graduate student unions also reduce the time to completion.

Early-career scientists rise up

For decades, graduate students and post-docs have complained about low pay and poor working conditions. Their frustration took center stage over the past year as early-career scientists banded together to demand changes in the system.

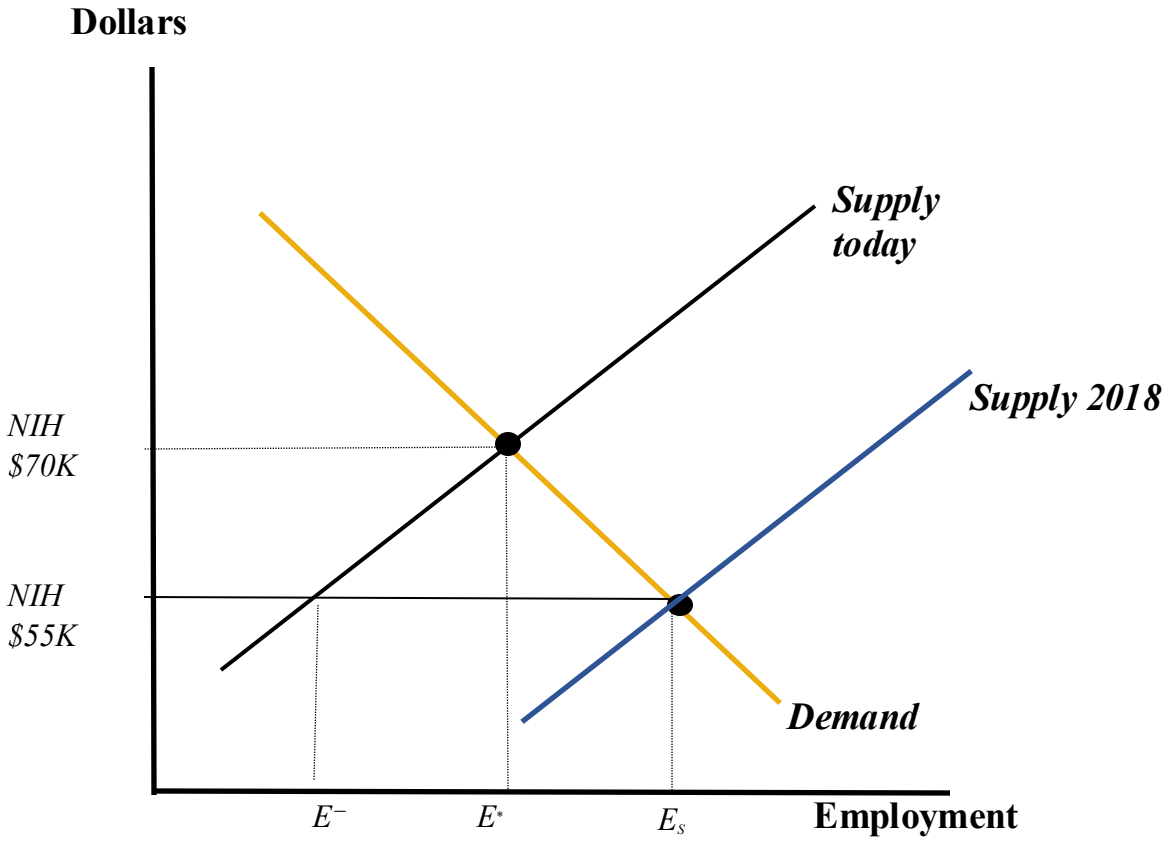
Last winter, 48,000 academic workers in the University of California (UC) system staged the largest academic strike in U.S. history, winning sizable pay increases for graduate students and postdocs. Such collective action has been especially pronounced in the United States, but in Canada, thousands of academic work-ers across the country engaged in a mass 1-day protest in May to demand increased federal funding for gradua postdocs. And in Germany researchers campaigned fo postdoc contracts.

In the U.S., the unioniza activity has forced many u agree to increases in pay a efits, including child care a improved workplace haras "We're doing this for us, bu doing this for the people t after us," says Álvaro Cuest molecular biologist at Colu and an executive board me that negotiated a new cont versity's postdocs and asso ers. "We need to provide b for the future generation c Early-career scienti put pressure on univ changes by voti feet and leavi tirely. An incr

ILLUSTRATION: DANIELVILLENEUVE/ISTOCK.COM

2023 BREAKTHROUGH OF THE YEAR | RUNNERS-UP

Implications of the Increased NIH Stipend



- With NIH Stipends below the Market wage, the number of postdocs demanded exceeds the number supplied.
  - Increasing the stipend should increase the supply and lower the demand of postdocs.

On Being a Scientist During Challenging Times

Keeping the Faith

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Things are Bad

Trump education officials investigate UC-Berkeley over foreign funding

The Education Department cited 2023 media reports that UC-Berkeley had not reported “hundreds of millions of dollars” in foreign government funding.

Trump’s first-term pick to run the National Science Foundation quits: ‘I have done all I can’

White House Cancels $400 Million in Grants and Contracts to Columbia

The Trump administration blamed the university’s failure to protect Jewish students from harassment during protests last year over the war in Gaza.

Beyond Ivy League, RFK Jr.’s NIH slashed science funding across states that backed Trump

Harvard’s Decision to Resist Trump Is ‘of Momentous Significance’

But a fight with the nation’s oldest, richest and most elite university is a battle that President Trump and his powerful aide, Stephen Miller, want to have.

Federal Funding is at Serious Risk

SCIENCEINSIDER | FUNDING

Trump proposes massive NIH budget cut and reorganization

Will Republican-led Congress support a 44% decrease for world's largest medical research funder?

17 APR 2025 · 4:20 PM ET · BY MEREDITH WADMAN

OUT

NSF director resigns amid 55% budget cut, mass layoffs from Trump admin

The director did not state a reason for the resignation.

BETH MOLE – APR 24, 2025 12:48 PM | 110

Entrance of The National Science Foundation (NSF) in Alexandria, Virginia Credit: Getty | JHVEPhoto

Supply Shocks

- The Trump Administration has moved to restrict international students. This will reduce the supply of graduate students and postdocs.

Demand Shocks

- Reports suggest that 30 universities have reduced or suspended graduate admissions
- Additional reports of hiring freezes/chills at 40 universities.
- Hard data is difficult to come by because of the disaggregated nature of job postings.
- From the American Economic Association:
  - Unfortunately, this past job market season was a challenging one for candidates. In the second half of 2024, the total number of job openings listed on JOE was down 4.6 percent relative to the same period in 2023, and down 22.8 percent relative to the same period in 2022. Demand has remained weak in the first half of 2025, with the number of job listings on JOE down 14.4 percent relative to the same period in 2024, and down 39 percent relative to the same period in 2023.

Science Magazine, Commentary
July 18, 2025


CAREERS | WORKING LIFE

My academic job offer was rescinded. I'll keep going—but U.S. researchers are running out of road

18 JUL 2025 · 1:43 PM ET · BY NA ZHAO

What Do Scientists Do?

- According to the Science Council:
  - A scientist is someone who systematically gathers and uses research and evidence, to make hypotheses and test them, to gain and share understanding and knowledge.

- According to the New York Times 4/29/25:

In Breakneck 2nd Term, Trump Turns to Falsehoods to Justify His Agenda

The president's dizzying efforts to reconfigure the global economy, reshape the federal government and restrict immigration have been undergirded by a nonstop distortion of facts.

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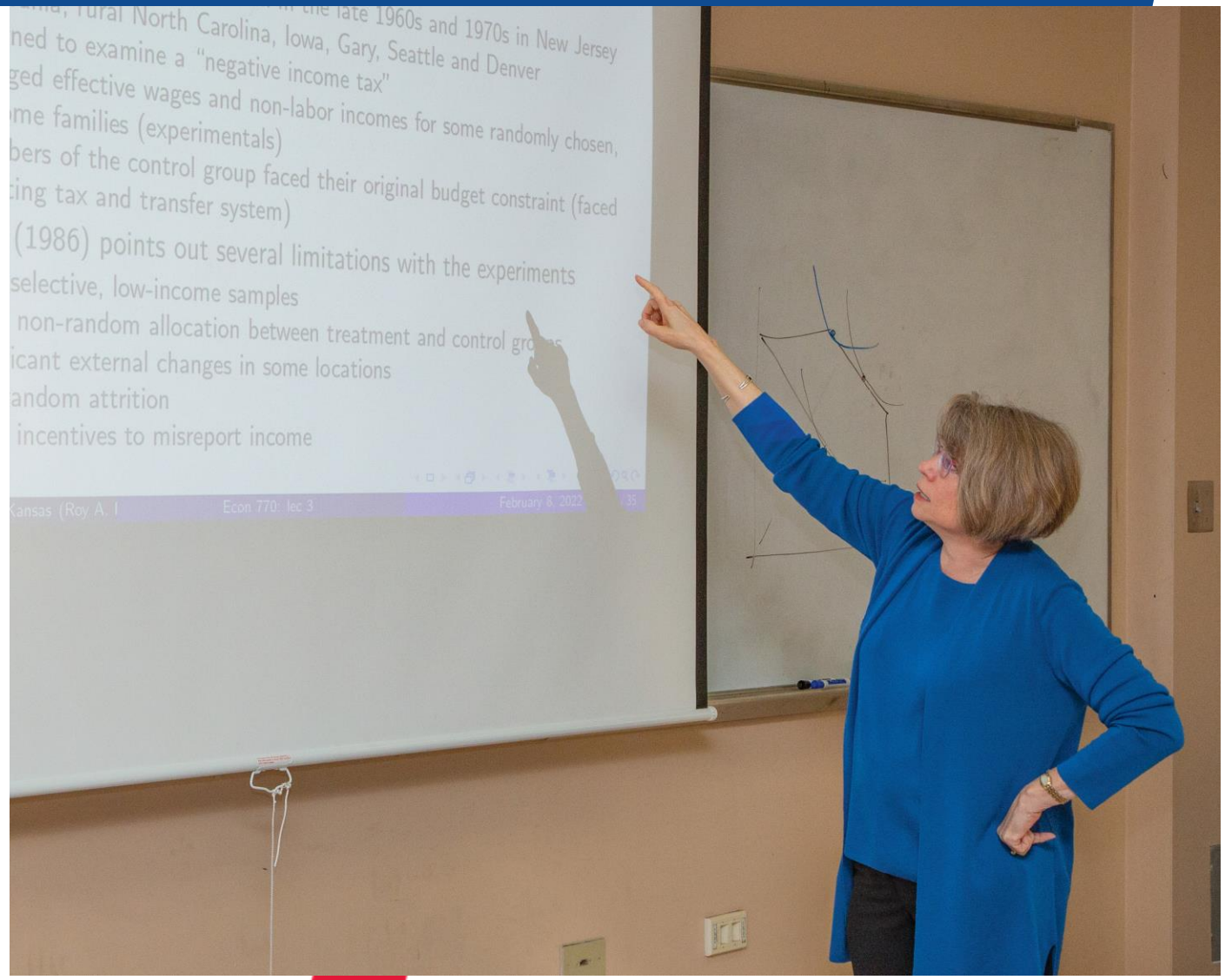
What Do Academics Do?

- Teaching
  - We educate the next generation of the workforce as well as future leaders.
- Research
  - We ask important questions and seek evidence-based answers.
- Service
  - We support the mission of our universities, states, and the nation.

This is a Teachable Moment

- As scientists, we need to do what we do best:
  - Generate knowledge
  - Communicate our knowledge to our students, the public, and policymakers.
  - Use our knowledge to advocate for our science and university.



Strategies for the Current Situation

- Be proactive: understand your professional risks and seek advice about how to manage them.
- Advocate: Tell people the story of your science.
  - Who does your science affect?
  - What are you doing in the lab?
  - Where is your science taking place—e.g. the context?
  - When will your science lead to change?
  - How do you do your science?
- *Email or call your Congressional leaders and tell them how the current situation affects you.*

Strategies for the Current Situation

- Engage with the media—they can help you tell your story
  - I recommend focusing on your science and expertise when doing so.
- Faculty:
  - Support your students and postdocs. Check in with them.
- Act collectively through your professional organizations
- Support one another.

Acknowledgements

Shulamit Kahn

Catherine de Fontenay

Mabel Andalon

Kwanghui Lim

- Thanks to my great collaborators!
- The use of NSF data does not suggest NSF endorsement of the findings that were just presented.

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Thank You!

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