What's Another Year?
The Lengthening Training and Career Paths of Scientists

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Abstract

Lengthening doctorate and post-doctorate training allow STEM Ph.Ds. to persist in high-intensity academic research environments at the cost of significant lifetime earnings. Using the National Science Foundation (NSF)'s Survey of Earned Doctorates (SED) linked to the 1993-2015 longitudinal waves of the Survey of Doctorate Recipients (SDR), I construct career paths for 156,089 research doctorate holders over six job types - postdoctoral resercher, tenure-track academic, non-tenure track academic, for-profit industry, non-profit, and government - and two employment statuses - unemployed and out of the labor force. Examining Ph.D. cohorts in four major science, technology, engineering, and mathematics (STEM) fields from 1950 to the present, I find evidence that the increasingly prevalent postdoctoral position allow STEM Ph.Ds. to remain in high-intensity academic research positions, albeit not necessarily on the tenure-track. Since the 1960's, a STEM Ph.D.'s probability of obtaining a tenure-track position has droppeed from 42.8% to 25.2%. Remaining in longer doctoral and postdoctoral appointments does not significantly improve one's chances at a tenure-track position but does increase one's chances of a permanent position at a research-intensive university. However, these research opportunities come at a cost of an approximately $3,700 deduction in undiscounted average of lifetime earnings. Taken together, STEM Ph.Ds. must weigh the non-pecuniary costs of remaining in academic research with this earnings loss to determine if postdoctoral positions are a worthwhile investment.

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1 Introduction

Over the past fifty years, the average time spent in graduate school for a science, technology, engineering, and mathematics (STEM) Ph.D. has increased by two years. At the same time, the probability of ever obtaining an academic tenure-track position has been nearly cut in half: compared to 43 percent of 1960-1980 graduating cohorts, only a quarter of STEM Ph.D. graduates today ever move into these positions. Despite the lengthening graduate training and the low probability of entering the tenure track, a growing 40 percent of STEM Ph.Ds. pursue postdoctoral positions. Postdoctoral positions do not improve one's chances at obtaining a tenure-track position: approximately 18 percent of STEM Ph.Ds. transition from their last postdoctoral appointment into tenure-track positions, compared to 22 percent of STEM Ph.Ds. who transition directly from graduate school. Rather, this paper finds evidence that postdoctoral positions allow STEM Ph.Ds. to remain in high-intensity academic research positions, albeit not necessarily on the tenure track: 79 percent of postdoctoral positions are at Carnegie-Classified very high research activity (R1) institutions, and postdoctoral researchers who remain in academia are approximately 20 percentage points more likely to transition to R1 universities than those transitioning directly from graduate school.[1] However, these research opportunities come with a significant earnings loss: although postdoctoral researchers eventually transition into equal or higher salary jobs as their non-postdoctoral peers, each additional year is postdoctoral positions is associated with an approximately $3,700 deduction in undiscounted average of lifetime earnings.

The scientific community has long been concerned with the lengthening training of STEM Ph.Ds. for a shrinking number of academic tenure-track positions.(*Bridges to Independence: Fostering the Independence of New Investigators in Biomedical Research* 2005) However, limited research has focused on doctorate and post-doctorate stages of the STEM pipeline - especially outside of the biomedical fields.(Balsmeier and Pellens 2014; Mathur et al. 2018; Mishagina 2009; Roach and Sauermann 2016; *Science and Engineering Indicators* 2018; Stephan 2012; Zolas et al. 2015)[2] This paper systematically examines the long-term trends of STEM Ph.D. career paths. Using the National Science Foundation (NSF)'s Survey of Earned Doctorates (SED) linked to the 1993-2015 longitudinal waves of the Survey of Doctorate Recipients (SDR), I create

[1] The Carnegie Classification groups universities by the number of doctoral degrees conferred and amount of research funding utilized each year. A R1 "very high research activity" university (e.g. Harvard University, Stony Brook University) confers at least fifty doctoral degrees each year and has at least $40 million in federal research support.

[2] A larger literature has focused on STEM persistence at the pre-doctorate level (e.g. Blotnicky et al. 2018; Boudreau and Marx 2019; Evans 2017; Shu 2015; Tai et al. 2006) or alternatively among established scientists (e.g. Azoulay, Ganguli, and Zivin 2017; M. Levitt and J. Levitt 2017). This is due to limited data particularly on postdoctoral researchers, which have historically been poorly tracked.(*Biomedical Workforce Working Group Report* 2012) There has only recently been a push for universities to collect the long-term career outcomes of their graduate students and postdoctoral researchers.(*Coalition of Next Generation Life Sciences* n.d.; Silva, Mejía, and Watkins 2019)

detailed career profiles for 156,089 research doctorate holders across ten STEM fields. Expanding Ginther and Kahn (2017)'s methodology for estimating postdoctoral incidence, I identify each post-Ph.D. year that an individual spends any portion of the year working in six job types - postdoctoral researcher, academic tenure-track, academic non-tenure track, for-profit industry, non-profit, and government - and in two employment statuses - unemployed and out of the labor force. I compare how these career paths and job characteristics change across 1950-2013 Ph.D. graduation cohorts.

I find that the average time spent in graduate programs between finishing the Bachelor's degree and completing the Ph.D. has increased from 5.8 years (s.d. = 2.1) among 1960-1980 STEM Ph.D. cohorts to 8.0 years (s.d. = 4.1) among 2000-2013 cohorts.[3] The probability of ever obtaining an academic tenure-track position has plummeted from 42.8% of 1960-1980 STEM Ph.Ds. to 25.2% of 2000-2013 cohorts. Despite this decline in probability, more STEM Ph.Ds. are pursuing postdoctoral positions each year: 40.2% of 2000-2013 cohorts are ever observed in postdoctoral positions, compared to 28.9% of 1960-1980 STEM Ph.Ds. The average STEM Ph.D. spends 2.7 years (s.d. = 2.3) in these postdoctoral positions. There is no evidence to suggest that this additional training improves a STEM Ph.D.'s chances at obtaining a tenure-track job: 18.4% of 2000-2013 cohorts with postdoctoral experience transition to tenure-track jobs after their last appointment, compared to 21.8% transitioning directly from their Ph.D. graduation.

Rather, the benefit of postdoctoral positions is that they provide a higher likelihood of remaining in high-intensity academic research, albeit not necessarily on the tenure track, than transitioning directly from graduate school. Because of their temporary nature, postdoctoral positions allow flexibility in the transition to a permanent job sector. Non-postdoctoral positions are absorbing states: approximately 80 percent of individuals who take on a permanent academic or for-profit industry job remain in the same job sector for the remainder of their career paths, compared to 13 percent of postdoctoral researchers. STEM Ph.Ds. who take on postdoctoral positions spend longer in high-intensity academic research than those who transition to permanent positions directly from their Ph.D. Among 2000-2013 STEM Ph.D. cohorts, 23.9% of STEM postdoctoral researchers transition to academic non-tenure track positions, compared to 8.7% of STEM Ph.Ds. directly from graduation. Postdoctoral researchers who remain in academia are approximately 20 percentage points more likely to transition from their last appointment to a Carnegie-Classified "very high research activity" university than Ph.Ds. who take on academic positions directly from graduate school.

Consistent with the average STEM Ph.D.'s preference for academic research over industry positions established in the literature, I find evidence of a compensating differential for remaining in academia - particularly at research-intensive universities.(Agarwal and Ohyama 2013; Conti and Visentin 2015; Ganguli

[3]This measure combines time spent in both Master's and Doctorate degree programs, subtracting time out of school during this period.

and Gaulé 2018; Janger and Nowotny 2016; Stern 2004) Remaining in low-paying postdoctoral positions comes with a significant loss in lifetime earnings. Although postdoctoral researchers transition into positions with equal or higher starting salaries as those who transition directly from graduate school, this does not compensate for the lower postdoctoral wages early in their careers. Over a thirty year post-Ph.D. career, each additional postdoctoral year is associated with a $3,730 deduction in undiscounted average of lifetime earnings, rather than a typical education premium. From a salary perspective, the opportunity cost of pursuing postdoctoral experience is greater than the real market interest rate. This indicates that the non-pecuniary benefits of remaining in high-intensity academic research are likely a greater driver in the growth of individuals pursuing postdoctoral positions than skills investment.

Taken all together, postdoctoral appointments allow STEM Ph.Ds. to persist longer in high-intensity academic research, albeit not necessrily on the tenure track. As the number of postdoctoral researchers becomes more commonplace and the number of tenure-track positions declines, postdoctoral experience does not improve a STEM Ph.D.'s chances of obtaining a tenure-track position. Rather, postdoctoral researchers spend more time at very high research universities than those transitioning directly from graduate school. The temporary nature of postdoctoral appointments give STEM Ph.Ds. greater flexibility to transition into these high-intensity academic research positions over other permanent positions. However, this greater research opportunity comes at significant cost: low postdoctoral pay is not offset by higher earnings later in the career, leading to lower overall lifetime earnings compared to transitioning directly from graduate school. Thus, STEM Ph.Ds. considering a postdoctoral position must weigh the non-pecuniary costs of remaining in academic research with this earnings loss to determine if it is a worthwhile investment.

The remainder of this paper is organized as follows: Section 2 describes the NSF SED-SDR dataset and its advantages in constructing STEM Ph.D. career paths. Section 3 summarizes the construction of post-Ph.D. career paths and provides summary statistics. Section 4 presents trends across 1950-2013 Ph.D. cohorts and gives evidence of how postdoctoral positions provide opportunities for preferred high-intensity research activities at the cost of significant lifetime earnings. Section 5 discusses potential avenues for future research and concludes.

2 Data: NSF Survey of Earned Doctorates (SED) Linked to Survey of Doctorate Recipients (SDR)

This paper draws on the National Science Foundation (NSF)'s Survey of Earned Doctorates (SED) linked to the 1993-2015 waves of the NSF Survey of Doctorate Recipients (SDR). This is the largest, nationally representative sample of individuals receiving first-time research doctorates from accredited U.S. institutions in science, engineering, and health fields. Figure 1 gives the number of individuals in each Ph.D. graduation cohort that are represented by the SED-SDR data. The SED surveys individuals the year they apply for their Ph.D. graduation, then follows respondents on a roughly biennial basis in the SDR waves until they reach the age of 76, emigrate from the U.S.,[4] or are otherwise unable to respond.[5]

Each survey collects extensive information on the doctoral recipient's individual demographics, education, and job characteristics. From the SED, respondents provide information on their education through the doctorate and their immediate post-graduation plans. In each following SDR wave, respondents answer a wide range of questions about their current job such as their employment sector, most common work activities, and annual salary. Some questions also shed light on work experience in between surveys such as their current job's starting date and whether one has changed jobs since the last survey. Based on these responses, the SED-SDR paints a detailed picture of an individual's career over time.

One limitation of the SED-SDR is that the survey has limited information on ability proxies. A few survey waves (1995, 2001, 2003, and 2008) ask respondents about their five-year publication and patent rates; this question has since been discontinued. No question asks about cumulative number of publications or number of patents. Thus, I am limited to information at the academic institution level for an individual respondent's ability proxy. In particular, I use the Carnegie Classifications provided by the SED-SDR as a measure of educational prestige. Since 1970, the Carnegie Classification groups U.S. universities by the yearly number and types of degrees conferred and the amount of research expenditures as reported through the NSF Higher Education Research & Development (HERD) Survey.(*The Carnegie Classification of Institutions of Higher Education* n.d.)[6] These classifications are updated approximately every five years. The SED-SDR data provides Carnegie Classifications for the academic institutions from which an individual receives their Bachelor's, Master's, and Doctorate degrees. If an individual works at an academic institution after their Ph.D. graduation, I further merge on the institution's Carnegie Classification at the time of employment.

Overall, the response rate for a SDR wave is approximately 70 percent.(Foley 2015) Individuals who do not respond to a specific SDR wave remain in the sample and continue to be contacted for future waves until

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[4]Starting in 2010, the survey expanded to include U.S. research doctorate earners residing outside of the U.S. through the International SDR (ISDR). However, given limited data on expats, this project focuses on individuals who obtained their Ph.Ds. in the U.S. and remain in the U.S.

[5]This consists of individuals who are known to be deceased, terminally ill, incapacitated, or permanently institutionalized in a correctional or health care facility.

[6]This paper focuses on the doctoral university classifications: "R1 - very high research" awards at least fifty doctoral degrees per year and have at least $40 million in federal research support (e.g. Harvard University, Stony Brook University); "R2 - high research" awards at least fifty doctoral degrees per year and have between $15.5 - $40 million in federal research support (e.g. American University, Eastern Michigan University); "D1 - doctoral I" awards at least fifty doctoral degrees per year and has less than $15.5 million in federal research support (e.g. Drake University, Indiana State University); and "D2 - doctoral II" awards between ten to forty doctoral degrees per year (discontinued from classification system in 2000; e.g. Loma Linda University, University of Alabama in Huntsville).

they are no longer eligible (as defined by the conditions in Footnote 5). Thus, it is possible for individuals to miss multiple waves but respond later. For the 1993-2015 SDR waves, Table 1 gives a comparison between the number of waves an individual is expected to have responded to the SDR - based on their Ph.D. graduation year and age - to the actual number of waves an individual is observed in the SDR. The fewer waves contributed to the SDR, the less complete of a career path can be constructed.

3 Methodology: Tracking STEM Ph.D. Careers

For all individuals in the 1993-2015 SDR waves, I construct career paths that measure their experience in six job types - postdoctoral researcher, academic tenure-track, academic non-tenure track, for-profit industry, non-profit, and government - and two employment statuses - unemployed and not in the labor force. This construction is an expansion of Ginther and Kahn (2017)'s measurement of postdoctoral incidence: using the vast SED-SDR data, I identify each post-Ph.D. year in which a respondent spends any portion of the year working in the job type or employment status of interest. Appendix A.1 details this career path construction and gives a hypothetical example using this methodology. Figure 2 gives the number of jobs that are identified by this methodology in each year post-Ph.D. graduation for each decade of graduation cohorts.

There are considerable gaps in the data: 35.1% of individual-year cells do not have any employment information. This is to be expected, given that 68.3% of the sample graduated from their Ph.Ds. at least two years before the first available SDR wave in 1993 - thereby missing some portion of their career path - and the level of non-response to eligible SDR waves given in Table 1.

I perform limited interpolation on worker and job characteristics across non-survey years, as described in Appendix A.2. To examine the impact of postdoctoral experience on career earnings, I modify Bhuller, Mogstad, and Salvanes (2017)'s schooling regression to analyze thirty-year post-Ph.D. salary paths:

$$Y_a = \alpha_a + \beta_a P + \epsilon_a \tag{1}$$

where in each year post-Ph.D. graduation a, Y_a gives annual real salary (in 2015 dollars) and P gives years of postdoctoral experience. I include fixed effects for Ph.D. field of study, graduation year, and current job type. I then use the yearly postdoctoral coefficient estimates to compute the postdoctoral premium (or deduction) in undiscounted average of thirty-year post-Ph.D. lifetime earnings:

$$\bar{\beta} = \sum_{a=0}^{30} \frac{\beta_a}{30} \tag{2}$$

The full career paths dataset consists of 156,089 individuals holding 300,944 unique jobs. Limiting the sample to ten STEM fields of study gives 135,599 individuals holding 258,873 unique jobs. Table 2 gives the distribution of fields for the full sample and the STEM sample. For analysis, I focus on four major STEM fields of study: biological sciences, chemistry, engineering, and physics.[7] Table 3 gives summary statistics on Ph.D. demographics. Table 4 gives summary statistics on experience in each job type and employment sector. Table 5 gives summary statistics on job characteristics.

4 Results

4.1 Training Time Steadily Increasing

Over the past fifty years, mean time spent in graduate school has steadily increased by 2.2 years, from 5.8 years (s.d. = 2.1) among 1960-1980 STEM Ph.Ds. to 8.0 years (s.d. = 4.1) among 2000-2013 cohorts. For example, Figure 3 shows that time in biological science graduate school began a steady increase in the 1970's and has only recently stabilized.[8] This increase is not explained by individuals taking more time off between undergraduate and graduate school. Figure 4 demonstrates time out has remained relatively low over time: the average STEM trainee spends approximately 1.3 years (s.d. = 2.7) between their Bachelor's and their Ph.D. not in school. This increase is due to a shift rather than widening of the distribution: Figure 5 demonstrates that fewer individuals are completing Ph.Ds. in fewer than four years and more individuals are completing Ph.Ds. in more than eight years over time.

Despite the lengthening of time in graduate school, the percent of STEM PhD graduates pursuing postdoctoral appointsment grew from 28.9% of 1960-1980 graduating cohorts to 40.2% of 2000-2013 cohorts. This trend is especially prevalent in the biological sciences: Figure 6 illustrates that over 60 percent of 2000-2013 biological science Ph.D. graduates transition directly to postdoctoral positions, compared to only 20 percent of 1950's cohorts.[9] Time spent in postdoctoral positions has not varied significantly in this time period despite more individuals pursuing these positions. Conditional on any postdoctoral experience, the average time spent in postdoctoral positions across all STEM fields since 1970 is 2.7 years (s.d. = 2.3). As shown in Figure 7, the distribution of postdoctoral years among biological sciences Ph.Ds. with any postdoctoral experience is relatively stable over time. This suggests that the purpose of postdoctoral positions has not significantly changed over time. Unlike the concurrent lengthening of graduate school, which arguably stems

[7]Figures in the main text give results for biological sciences, the largest STEM field. Appendix B gives figures for chemistry, engineering, and physics.

[8]Similar increases are observed in chemistry, engineering, and physics. (See Appendix Figure B.1.)

[9]A near majority of chemistry and physics Ph.Ds. have also transitioned directly to postdoctoral positions since the 1980's. Engineering, which had almost no Ph.Ds. transition directly to postdoctoral positions in the 1960's, has also increased to approximately 20 percent of chorts moving into postdoctoral positions. (See Appendix Figure B.4.)

from requiring more time to build up a base of scientific knowledge, the rapid expansion of scientific literature in the last fifty years has not led to longer specialized training at the postdoctoral level. All together, between graduate and postdoctoral training, STEM Ph.Ds. now spend on average 9.1 years in specialized training before their first permanent position.

4.1.1 Trainees No Longer Transition to Tenure-Track But to Other Jobs

As doctoral training has lengthened and more STEM Ph.Ds. have pursued postdoctoral training, the probability of obtaining an academic tenure-track position has nearly halved over the past fifty years. Only 25.2% of 2000-2013 STEM Ph.D. graduating cohorts are ever observed in a tenure-track position, compared to 42.8% of 1960-1980 cohorts. As shown in Figure 8, after the post-World War II boom in scientific research during the 1950's, the percent ever observed in tenure-track positions has steadily declined since the mid-1960's.(Bush 1945)[10] Only 21.8% of 2000-2013 STEM Ph.D. cohorts transition into these positions directly from graduate school, despite the focus of doctoral programs on academic tenure-track careers.(Anderson 2019; Loriaux 2019)

Historically, postdoctoral experience improved one's competitiveness in obtaining a tenure-track position: 40.9% of 1960-1980 STEM Ph.D. cohorts with postdoctoral experience transitioned to tenure-track positions, compared to 37.2% of those graduating in the same years with no postdoctoral experience. However, comparing Figures 9 and 10, 2000-2013 graduating Ph.Ds. with postdoctoral experience are not significantly more likely to obtain tenure-track positions as those without postdoctoral experience.[11] 18.4% of STEM postdoctoral researchers who graduated between 2000-2013 transition to tenure-track jobs, compared to 21.8% directly from graduate school. Thus, there is no evidence to suggest that postdoctoral experience improves one's job prospects on the academic tenure track.

It is now more likely that STEM Ph.Ds. work in job sectors outside of tenure-track academia. Among individuals identified in job types ten years after their Ph.D. graduation, Figure 11 gives the fraction of each graduation cohort that are in each job type. Although 47.5% of 1960-1980 STEM Ph.Ds. were in tenure-track academic positions ten years after their Ph.D. graduation, 2000-2013 cohorts are almost evenly distributed across tenure-track (28.1%), industry (36.0%), non-tenure track (16.6%), and government or non-profits (15.7%). Moving away from the tenure track and into "alternative" job sectors occurs for both individuals transitioning directly from graduate school and those who transition from postdoctoral appointments. Figure

[10] Similar declines are observed in engineering and physics. Chemistry, which had the lowest tenure-track rates in the 1960's, experienced a small drop before stabilizing at approximately 20 percent since the 1980's. (See Appendix Figure B.6.)

[11] Chemistry and engineering, which have seen less drastic increases in the percent of graduate students pursuing postdoctoral appointments, have been relatively consistent in the percent of postdoctoral researchers transitioning to tenure-track. These percents are also similar to that of individuals transitioning directly from graduate school. (See Appendix Figures B.7 and B.8.)

12 gives the distribution of job types within two years of Ph.D. graduation for biological science Ph.Ds. with no postdoctoral experience. Figure 13 gives the distribution of job types that postdoctoral researchers take within two years of their last appointment. A growing percentage of STEM Ph.Ds. take for-profit industry jobs: compared to 17.9% of 1960-1980 cohorts, 22.8% of 2000-2013 cohorts transition to industry directly from graduate school.[12] Especially among postdoctoral researchers, academic non-tenure track positions have become increasingly popular. Among 2000-2013 STEM Ph.D. cohorts, 8.7% of new graduates and 23.9% of postdoctoral researchers transitioned into non-tenure track jobs.[13]

4.2 Postdocs as Opportunity for High-Intensity Academic Research

As a larger percent of postdoctoral researchers transition to academic non-tenure track jobs than new Ph.D. graduates, this may indicate that individuals with a higher preference for academic jobs - regardless of tenure status - are selecting into postdoctoral positions. Previous literature has documented researchers' willingness to trade off salary for greater research time.[14] Consistent with these results, many STEM Ph.Ds. pursue academic positions that have high research activities but low salaries compared to industry positions. Figure 14 gives the fraction of respondents holding each job type that state they spend the most hours on select work activities, and Figure 15 gives the average salary for each job type. STEM industry jobs have the least focus on research - with 2.3% spending the most time on basic research - but have the highest average salary at $127,469. Comparatively, 21.8% of tenure-track positions and 23.5% of non-tenure track positions spend the most time on basic research and have an average salary of $99,500 and $71,680 respectively.[15] Of all job types, postdoctoral positions performs the most basic research and have the lowest salary: 42.0% of all postdoctoral positions - increasing to 66.2% at very high research activity institutions - spend the most time on basic research at an average salary of $50,396.[16]

Given the limited number of permanent academic positions, a postdoctoral appointment may allow STEM Ph.Ds. the flexibility to wait for high research positions. As shown in Figure 16, the postdoctoral appointment is more transitive than the academic tenure-track, non-tenure track, for-profit-industry, government,

[12] Engineering, which already had a considerable percent of Ph.D. graduates transition directly to industry between 1960-1980, has also seen the percent transitioning to industry widen over time. (See Appendix Figure B.10.)

[13] This increase is also observed among engineering new graduates, engineering postdoctoral researchers, and chemistry postdoctoral researchers. (See Appendix Figures B.10 and B.11.)

[14] For example, Janger and Nowotny (2016)'s hypothetical choice survey find that early stage researchers are willing to pay approximately $2,000 for an additional contract year and $4,425 for a 25 percent increase in research autonomy. Using multiple job offers, Stern (2004) finds postdoctoral researchers are willing to take jobs with $16,000 lower salary that allow them to continue research.

[15] Carnegie-Classified "very high research activity" institutions are more likely to spend the most time on basic research at 35.1% for both tenure-track and non-tenure track positions respectively.

[16] The negative correlation between level of basic research and average salary persists across fields. (See Appendix Figures B.12 and B.13.)

and non-profit positions. Only 13.3% of STEM postdoctoral researchers remain in these positions for their entire observed career path. Permanent positions act as absorbing states: at least fifty percent in non-postdoctoral job sectors are never observed switching to any other job type.[17] Because individuals do not typically transition between absorbing states, an individual who moves out of academic research to another permanent job type is unlikely to ever return. By remaining in a transitory state like a postdoctoral position, STEM Ph.Ds. have more flexibility to move to any of the permanent job types.

STEM postdoctoral researchers also spend more time at research-intensive universities than individuals who transition directly from graduate school. 78.7% of first postdoctoral positions are at Carnegie-Classified R1 "very high research activity" institutions. Although postdoctoral researchers are not more likely to transition to any tenure-track position than new graduates, Table 6 demonstrates that those who are able to obtain a permanent academic position are more likely to be at very high research activity universities. Among new graduates transitioning to academic positions, 29.5% of tenure-track transitions and 49.5% of non-tenure track transitions are at R1 universities. Among postdoctoral researchers transitioning to academic positions, 51.2% of tenure-track transitions and 67.9% of non-tenure track transitions are at R1 universities. This indicates that individuals pursuing postdoctoral positions are not of lower ability than those who move directly into permanent positions; rather, they may have a higher threshold in the level of research activity they would accept for a permanent position.

4.3 Preferred Research Environment Comes at a Cost

Although postdoctoral researchers are more likely to transition to high-intensity academic research environments, this comes at a significant cost to their lifetime earnings. As postdoctoral researchers transition to permanent job types, they move into positions with equal or higher salaries as individuals who transition directly from graduate school. Figure 17 compares the salaries of postdoctoral researchers for the first thirty years after their last postdoctoral appointment to the thirty-year post-Ph.D. salaries of individuals transitioning directly from graduate school. In particular, a tenure-track position after postdoctoral experience has a $2,908 higher salary over the first three years compared to a tenure-track position directly after Ph.D. graduation.[18] This further indicates that postdoctoral researchers are not of lower research ability than those who transition directly from graduate school.

Although postdoctoral experience provides a small improvement in starting salary and growth over time, this does not offset the significant losses from taking a low-paying position early in the career. Figure 18 gives

[17] These values are especially high among academic tenure-track (81.5%), academic non-tenure track (76.0%), and for-profit industry (86.2%) positions. 63.1% of government and 55.6% of non-profit employees are never observed transitioning to other job types.

[18] Equal or higher tenure-track salary among postdoctoral transitions compared to graduate transitions is also observed among chemistry, engineering, and physics Ph.Ds. (See Appendix Figure B.14.)

the average thirty-year post-Ph.D. salaries for individuals who do and do not pursue postdoctoral experience. It can be interpreted as shifting the postdoctoral researchers in Figure 17 by the average number of years spent in postdoctoral positions. Over the first thirty years after their Ph.D. graduation, having postdoctoral experience is associated with a decrease of $5,333 (tenure-track), $10,626 (non-tenure track), and $13,549 (industry) in average yearly earnings.

To quantify the impact of postdoctoral experience on salary at each career stage, Figure 19 gives salary regression coefficients on years of postdoctoral experience for each of the first thirty years post-Ph.D. graduation, as calculated in Equation 1. The first few years show a large negative relationship due to the salary gap between postdoctoral appointments and permanent positions. This gap closes as postdoctoral researchers move into permanent positions, but the additional training does not improve their salaries enough to overcome this early loss. As given in Equation 2, the average of these yearly coefficients can be interpreted as the postdoctoral deduction in mean lifetime earnings. Rather than provide an education premium, each additional year of postdoctoral experience reduces average lifetime earnings by $3,730.

5 Discussion & Future Work

In this paper, I examine how trends in the STEM labor market have changed over the past fifty years. Using the NSF Survey of Earned Doctorates (SED) linked to the 1993-2015 waves of the NSF Survey of Doctorate Recipients (SDR), I construct career paths for 156,089 U.S. doctoral recipients from 1960-2013 graduation cohorts across six job types - postdoctoral researcher, academic tenure-track, academic non-tenure track, for-profit industry, non-profit, and government - and two employment statuses - unemployed and out of the labor force. This paper contributes to the literature on persistence in STEM academic research, particularly at the postdoctoral level. Due to limited tracking of Ph.D. and postdoctoral outcomes, there has been little previous research on long-term career trends of STEM Ph.Ds.(*Biomedical Workforce Working Group Report* 2012; *Coalition of Next Generation Life Sciences* n.d.; Silva, Mejía, and Watkins 2019) Using the largest longitudinal survey of U.S. doctoral recipients, this paper creates a comprehensive picture of STEM Ph.D. career paths over time. In doing so, I identify key trends that span multiple Ph.D. fields of study.

Across STEM fields, I find that training time has increased significantly since the 1960's. At the same time, postdoctoral positions are becoming more commonplace even in fields with strong industry ties like engineering. This is despite the declining probability of ever obtaining a tenure-track position in the same time period, ranging from an approximately 14 percentage point decline in chemistry to as much as 36 percentage points in the biological sciences. In recent years, having postdoctoral experience does not significantly improve one's chances of obtaining a tenure-track job: among 2000-2013 cohorts, fewer than 20 percent of both new graduates and postdoctoral researchers transition to these positions.

Rather, I find evidence that postdoctoral positions allow STEM Ph.Ds. to stay longer in high-intensity academic research jobs - but not necessarily ones on the tenure track. Compared to the absorbing states of permanent job types, in which individuals are unlikely to change job sectors, temporary postdoctoral appointments provide STEM Ph.Ds. more flexibility to transition into a new job sector. Although postdoctoral researchers are not more likely to enter a tenure-track position than new Ph.D. graduates, they are 15 percentage points more likely to transition to non-tenure track positions. Like tenure-track positions, more than 20 percent of non-tenure track positions spend the most work hours on basic research, which prior literature finds is a preferred work activity of STEM Ph.Ds.(Agarwal and Ohyama 2013; Conti and Visentin 2015; Ganguli and Gaulé 2018; Janger and Nowotny 2016; Stern 2004) Conditional on transitioning to a permanent academic position, postdoctoral researchers are approximately 20 percentage points more likely to take a position at a Carnegie-Classified "very high research activity" institution compared to those who transition directly from graduate school. This indicates that those pursuing postdoctoral positions are not of lower research ability than those transitioning directly from graduate school; rather, they may have a higher preference for academic research jobs. With approximately 79% of postdoctoral positions at very high research activity universities, postdoctoral positions allow individuals to remain in these high-intensity research environments longer.

However, this research opportunity comes at a significant cost in lifetime earnings. Although postdoctoral researchers transition into permanent positions with equal or higher starting salaries as individuals who transition directly from graduate school, their thirty-year salary growth is not large enough to compensate for the low postdoctoral pay early in their careers. Rather than provide an education premium, each additional postdoctoral year is associated with a $3,730 decrease in undiscounted average of lifetime earnings. This negative salary effect must thus be weighed against the non-pecuniary benefits of postdoctoral positions, in particular the preference for high-intensity academic research, to determine whether it is a worthwhile investment.

Despite the lengthening training and declining probability of ever obtaining a tenure-track position, recent STEM Ph.D. cohorts are more likely to pursue postdoctoral positions than their predecessors. Although these postdoctoral positions do not improve salary over time, they allow STEM Ph.Ds. to remain in preferred high-intensity academic research positions. One potential test for this mechanism is whether the decision to pursue a postdoctoral appointment changes in response to hypothetical or actual shocks to the availability of positions at very high research activity universities. This can be explored in future research using hypothetical choice surveys or labor market shocks. The postdoctoral deduction in lifetime earnings also begs the question of which types of STEM Ph.Ds. are able to afford this cost to pursue the non-pecuniary benefits. Concurrent work examines how certain time and financial constraints - in particular, women raising children at crucial transitional periods on the academic ladder - may differentially affect the academic persistence of STEM Ph.Ds.(Cheng 2021) If these constraints limit who is able to pursue postdoctoral positions and thus remain in high-intensity academic research environments, it may explain diversity gaps in the STEM pipeline. Examining the factors that drive individuals to pursue postdoctoral positions allows policymakers to better understand the mechanisms driving the STEM labor market. Continuing this work can identify possibilities for improving STEM training programs, encouraging persistence in scientific research across a diverse workforce, and preparing STEM Ph.Ds. for the wide range of career paths they can pursue today.

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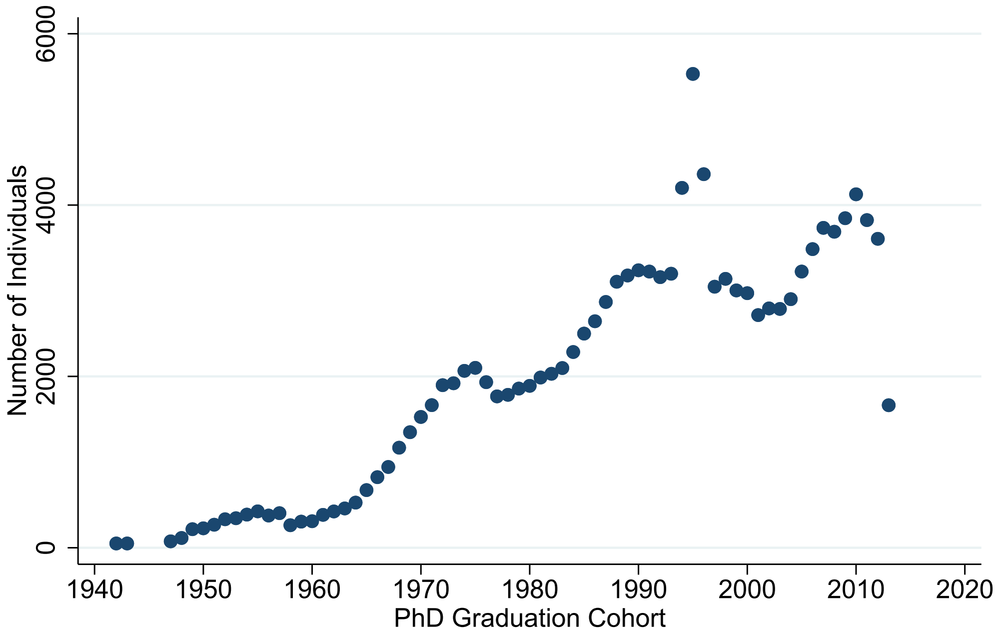
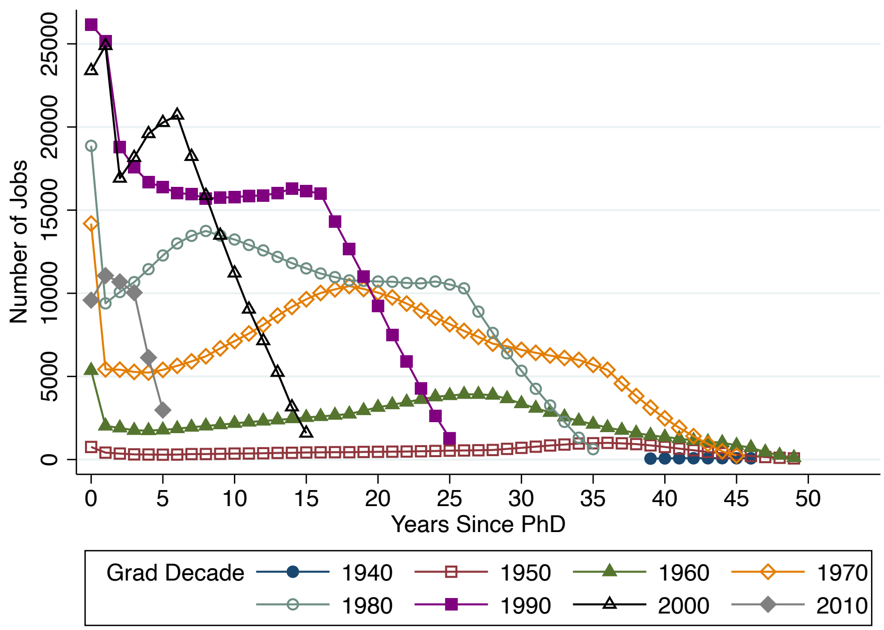
6 Figures

Figure 1: Number of Individuals in Each Ph.D. Graduation Cohort



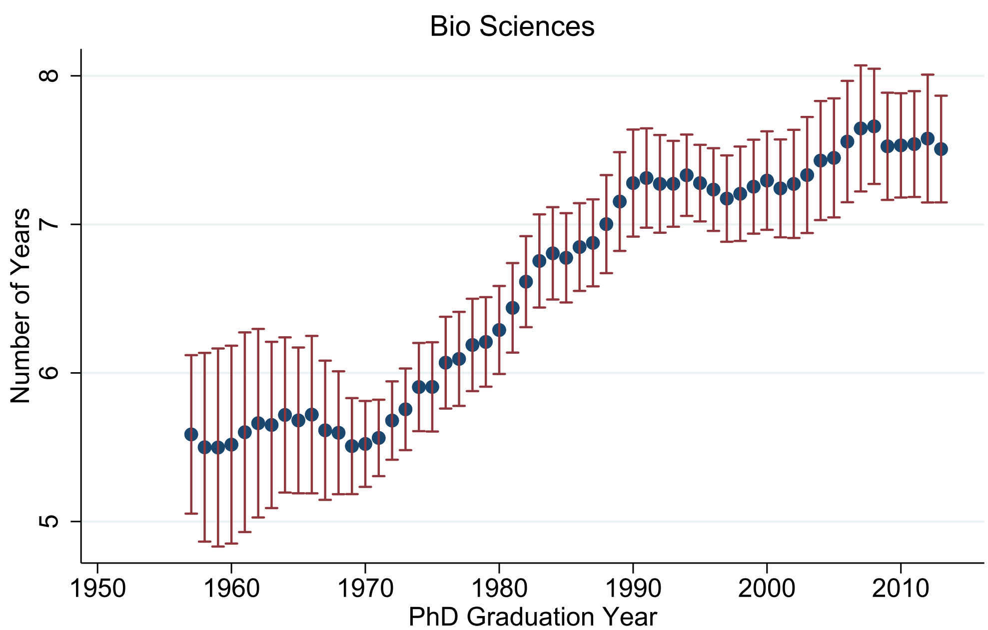
Notes: This graph gives the number of individuals in each Ph.D. graduation cohort represented by the SED-SDR data. For disclosure purposes, only cohorts with at least fifty individuals are shown.

Figure 2: Number of Jobs Represented in Each Year Since Ph.D. Graduation



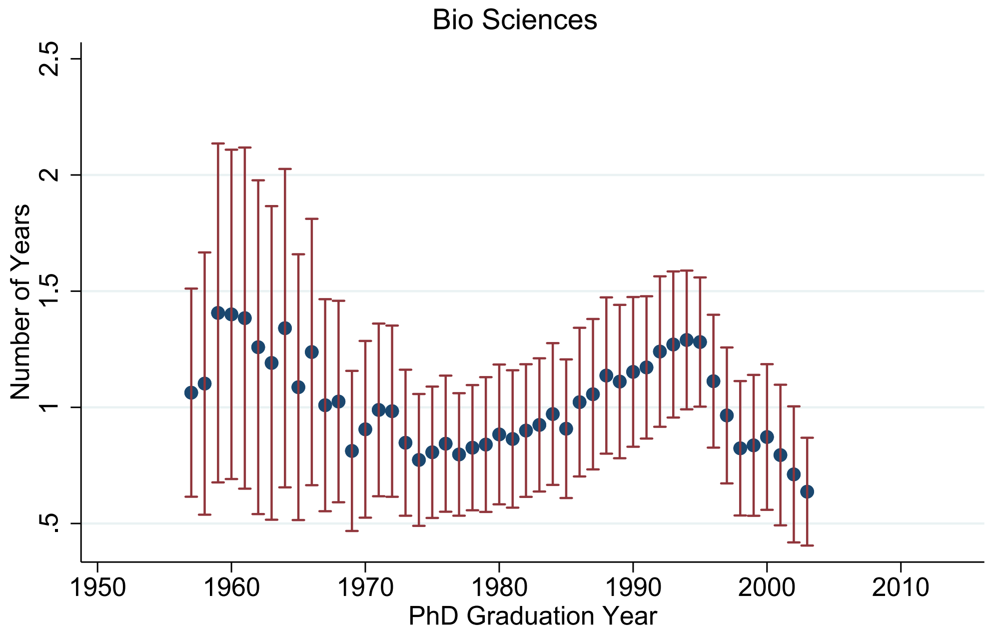
Notes: This graph gives the number of jobs identified in each year since Ph.D. graduation, grouping individuals by the decade during which they graduated. For disclosure purposes, only groups representing at least fifty jobs are shown.

Figure 3: Mean Years in Graduate School by Ph.D. Cohort



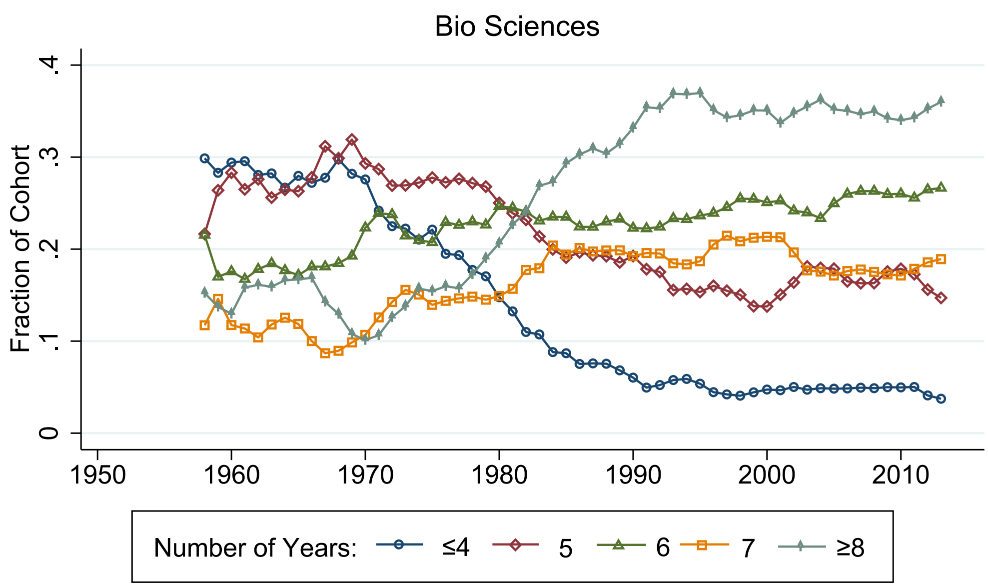
Notes: This graph gives the three-year moving 95% confidence intervals for the mean years biological sciences Ph.Ds. spend in graduate school, defined as Ph.D. graduation year minus Bachelor's graduation year and time spent out of school during these years, for each Ph.D. graduation cohort. For disclosure purposes, only cohorts with at least fifty individuals are shown.

Figure 4: Mean Time Out of Graduate School by Ph.D. Cohort



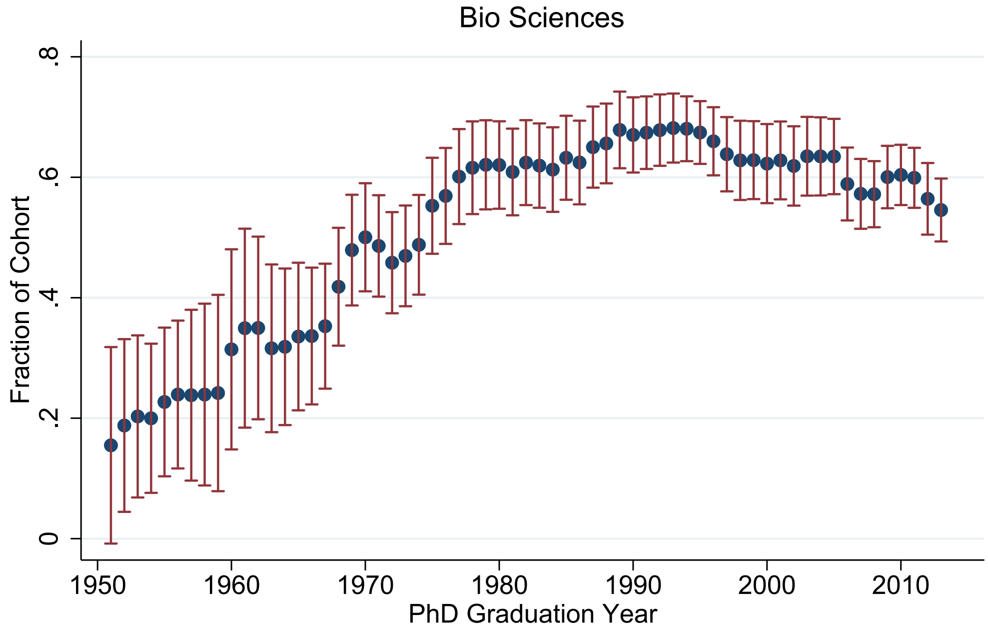
Notes: This graph gives the three-year moving 95% confidence intervals for the mean time out between Bachelor's and Ph.D. graduation years for biological science Ph.Ds. For disclosure purposes, only cohorts with at least fifty individuals are shown.

Figure 5: Distribution of Years in Graduate School by Ph.D. Cohort



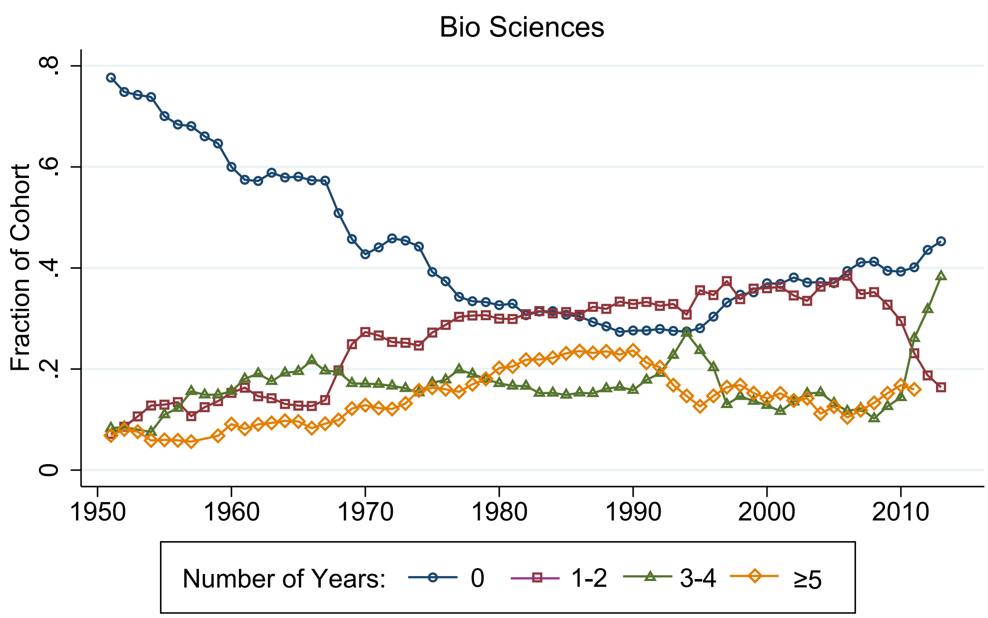
Notes: This graph gives the three-year moving distribution of biological science Ph.Ds.' years spent in graduate school, defined as the time between the Bachelor's and Ph.D. graduation year minus the number of years spent out of school during this time. Years are rounded down to the nearest integer. For disclosure purposes, only cohorts with at least fifty individuals and cells with at least five individuals are shown; some years are combined or suppressed due to low counts.

Figure 6: Early Postdoctoral Takeup by Ph.D. Cohort



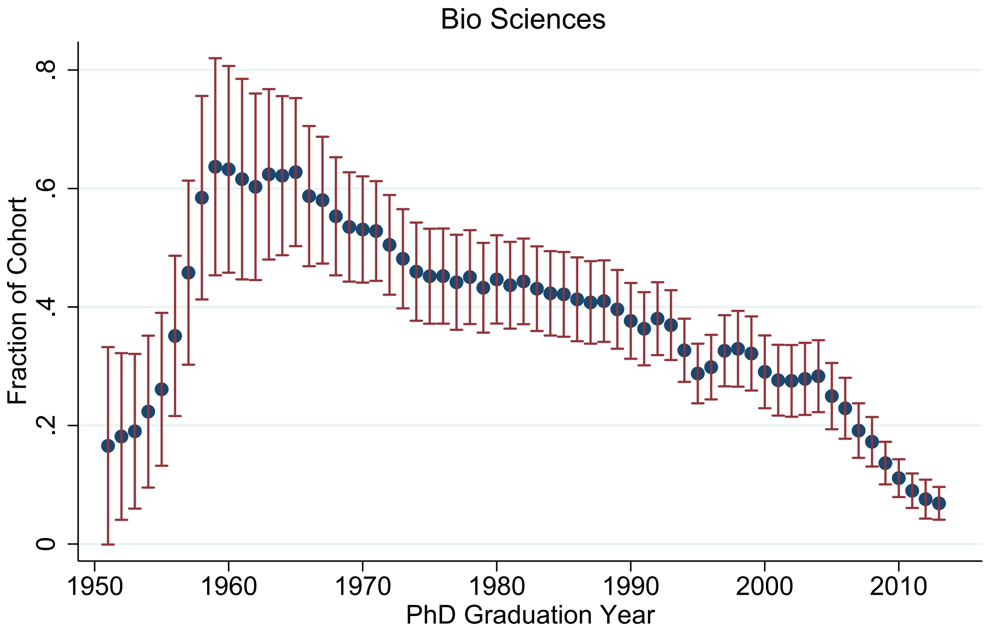
Notes: This graph gives the three-year moving 95% confidence intervals for the fraction of each biological science Ph.D. cohort that take on postdoctoral positions within two years of graduation. For disclosure purposes, only cohorts with at least fifty individuals and cells with at least five individuals are shown.

Figure 7: Distribution of Postdoctoral Years by Ph.D. Cohort



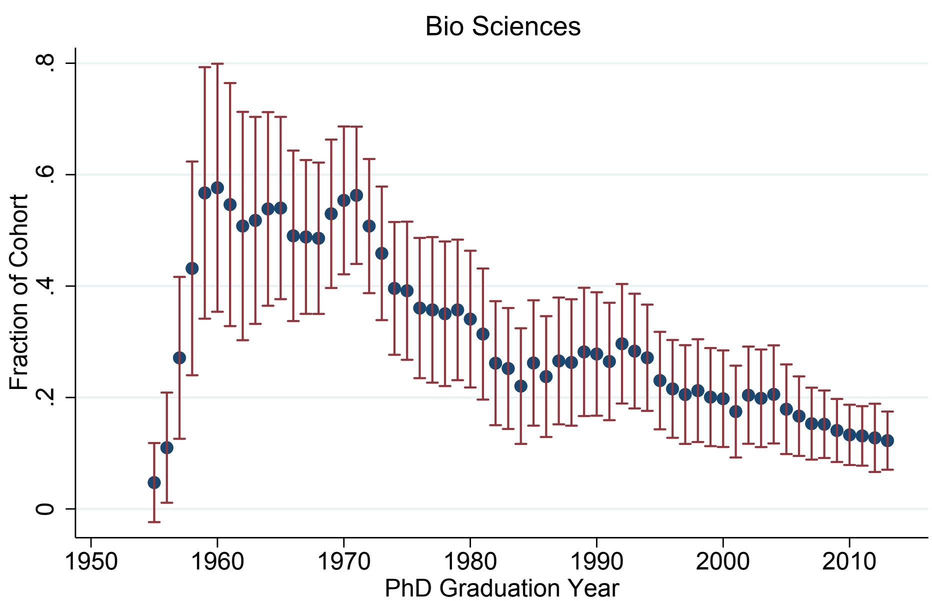
Notes: This graph gives the three-year moving distribution of biological science Ph.Ds.' years observed in postdoctoral positions for each Ph.D. cohort. Half-years spent in postdoctoral positions are rounded down. For disclosure purposes, only cohorts with at least fifty individuals and cells with at least five individuals are shown; some years are combined or suppressed due to low counts.

Figure 8: Fraction Ever Observed in an Academic Tenure-Track Position by Ph.D. Cohort



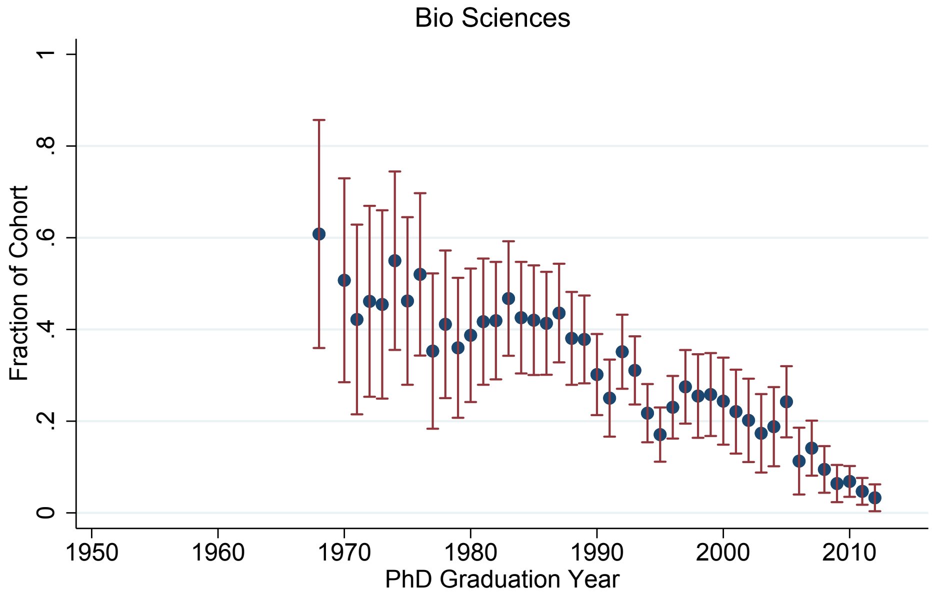
Notes: This graph gives the three-year moving 95% confidence intervals for the percent of each biological science Ph.D. cohort that is ever observed in an academic tenure-track position. For disclosure purposes, only cohorts with at least fifty individuals and cells with at least five individuals are shown.

Figure 9: Fraction Observed in an Academic Tenure-Track Position with No Postdoctoral Experience by Ph.D. Cohort



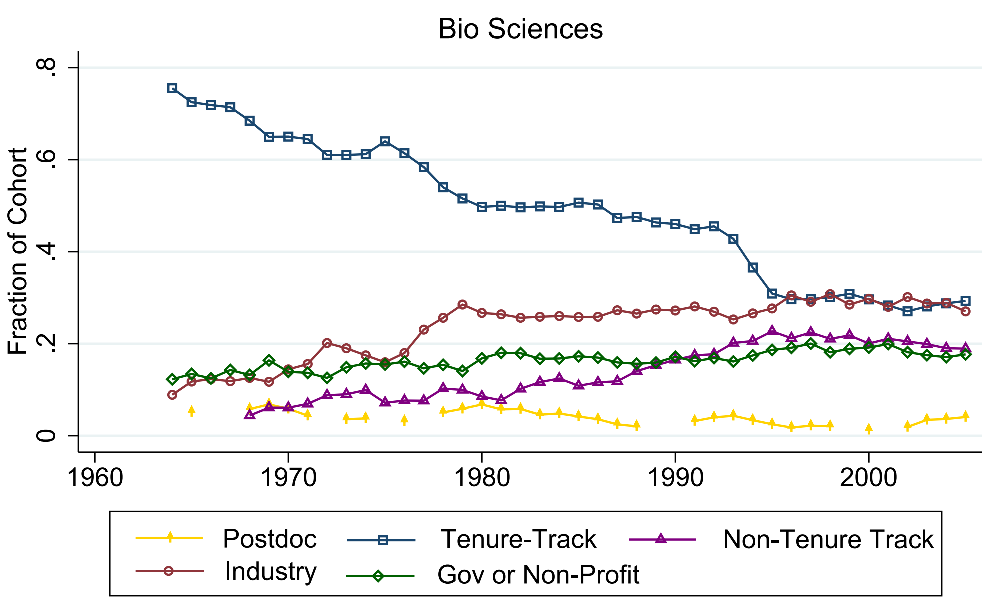
Notes: This graph gives the three-year moving 95% confidence intervals for the fraction of each biological science Ph.D. cohort observed in an academic tenure-track position within two years of their Ph.D. graduation without any postdoctoral experience. For disclosure purposes, only cohorts with at least fifty individuals and cells with at least five individuals are shown.

Figure 10: Fraction Transition from Postdoctoral Position to an Academic Tenure-Track Position by Ph.D. Cohort



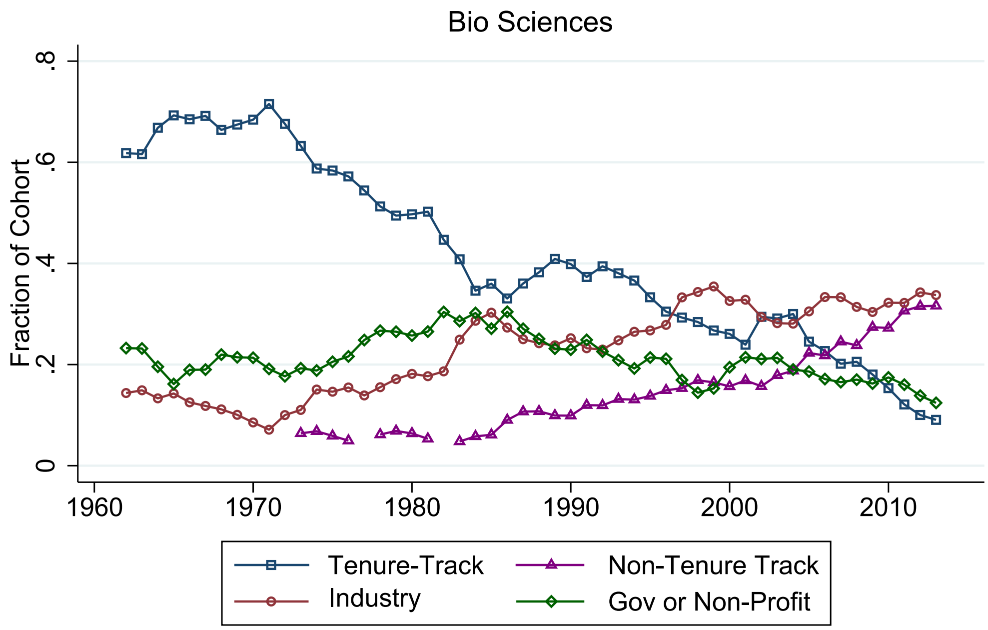
Notes: This graph gives the three-year moving 95% confidence intervals for the percent of postdoctoral researchers from each biological science Ph.D. cohort who transition to a tenure-track, academic position within two years of their last postdoctoral position. For disclosure purposes, only cohorts with at least fifty individuals and cells with at least five individuals are shown.

Figure 11: Job Distributions Ten Years Post-Ph.D. Graduation



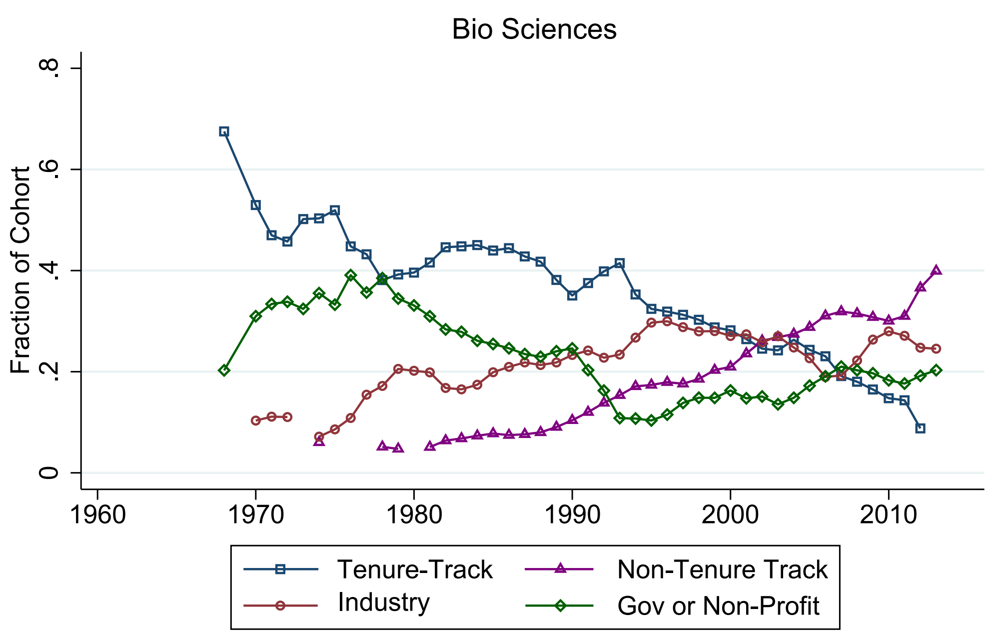
Notes: This graph gives the three-year moving fraction of each biological science Ph.D. cohort working ten years post-Ph.D. graduation in each job type. Individuals who are not working or do not have data ten years post-Ph.D. are not included. For disclosure purposes, only cohorts with at least fifty individuals and cells with at least five individuals are shown.

Figure 12: Distribution of Non-Postdoc Job Transitions After Ph.D. Graduation by Ph.D. Cohort



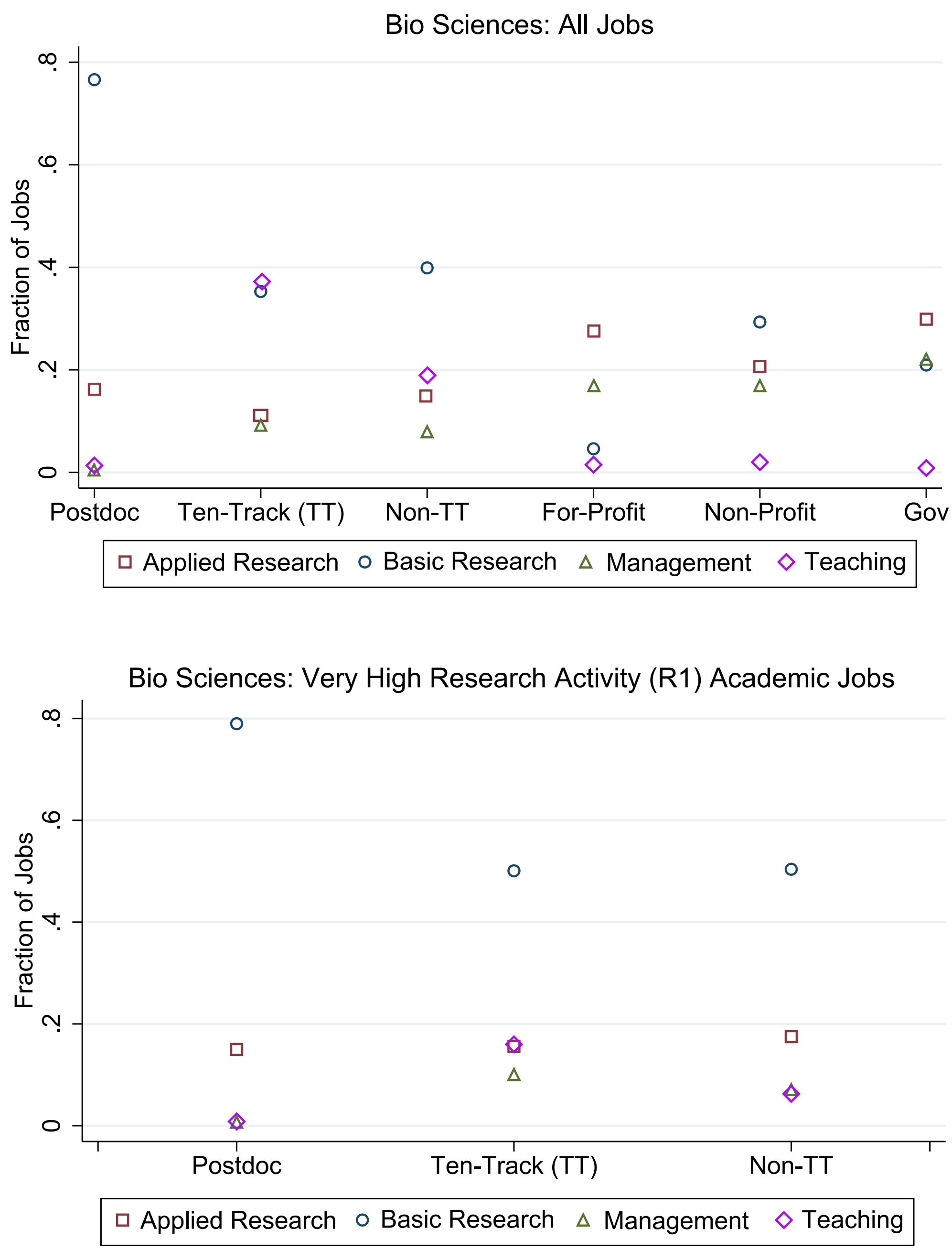
Notes: This graph gives the three-year moving fraction of each biological science Ph.D. cohort who do not have postdoctoral experience that transition into each non-postdoc job type within two years of their graduation. For disclosure purposes, only cohorts with at least fifty individuals and cells with at least five individuals are shown; some job types are combined or suppressed due to low counts.

Figure 13: Distribution of Job Transitions After Last Postdoctoral Appointment by Ph.D. Cohort



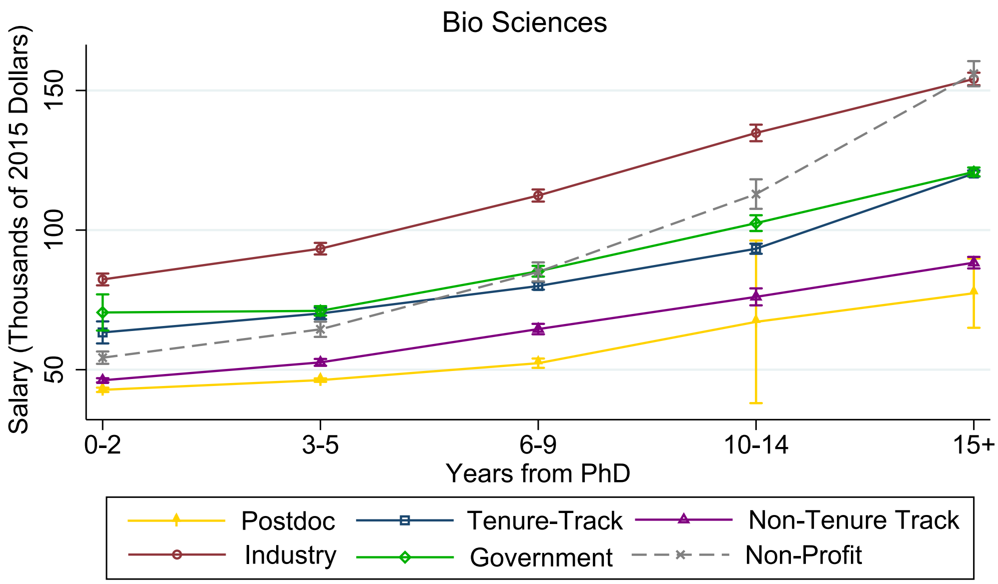
Notes: This graph gives the three-year moving fraction of each biological science Ph.D. cohort who have postdoctoral experience that transition into each non-postdoctoral job types within two years of their last postdoctoral position. For disclosure purposes, only cohorts with at least fifty individuals and cells with at least five individuals are shown; some job types are combined or suppressed due to low counts.

Figure 14: Most Common Work Activity by Job Type



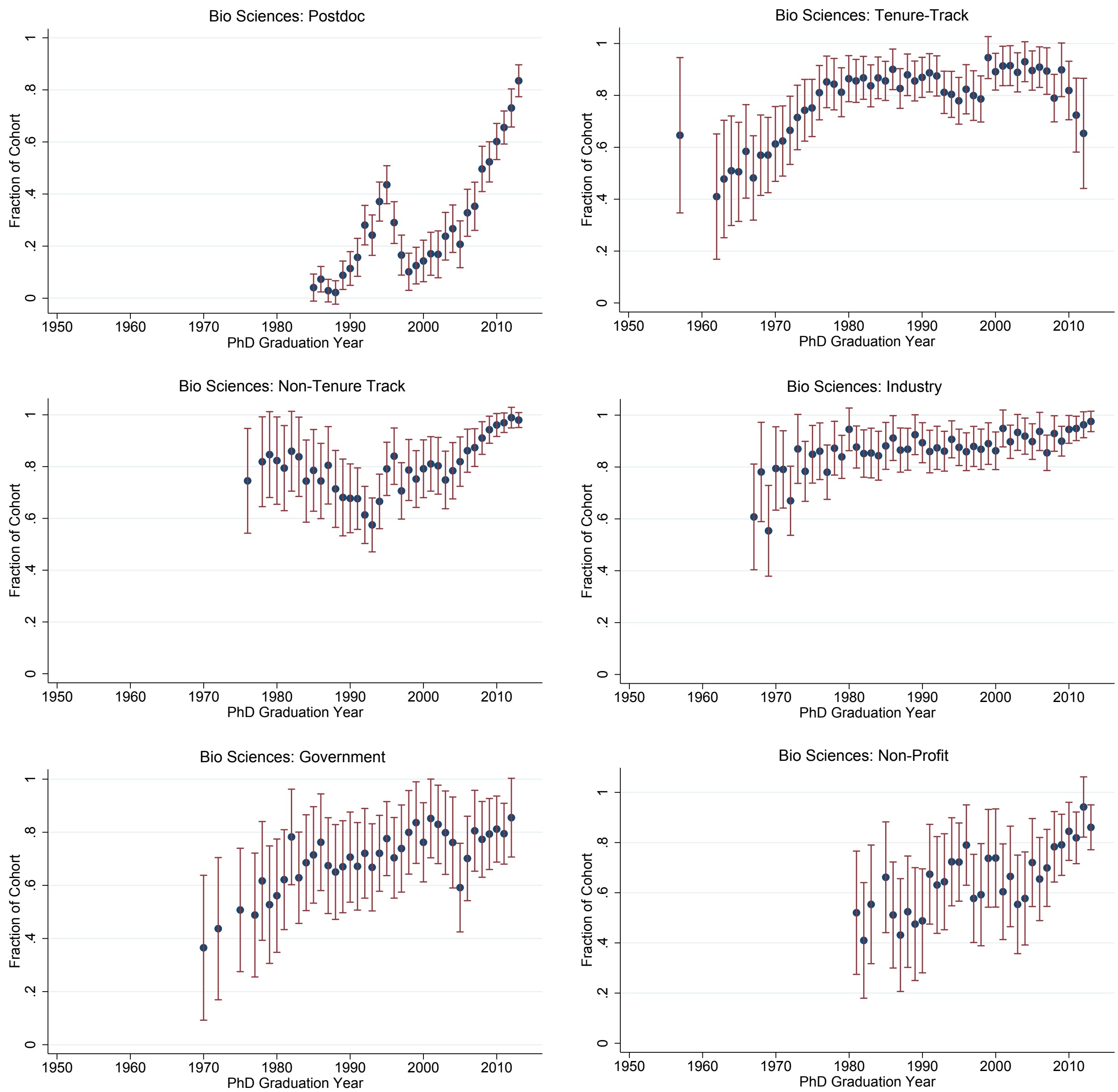
Notes: These graphs give the fraction of biological science Ph.Ds. holding each job type during the survey period (1993-2015) that state they spend the most work hours on applied research, basic research, management, or teaching. Bottom graph limits to academic sector jobs (postdoctoral, tenure-track, non-tenure track) at Carnegie-Classified R1 "very high research activity" universities.

Figure 15: Average Salary by Job Type and Career Stage



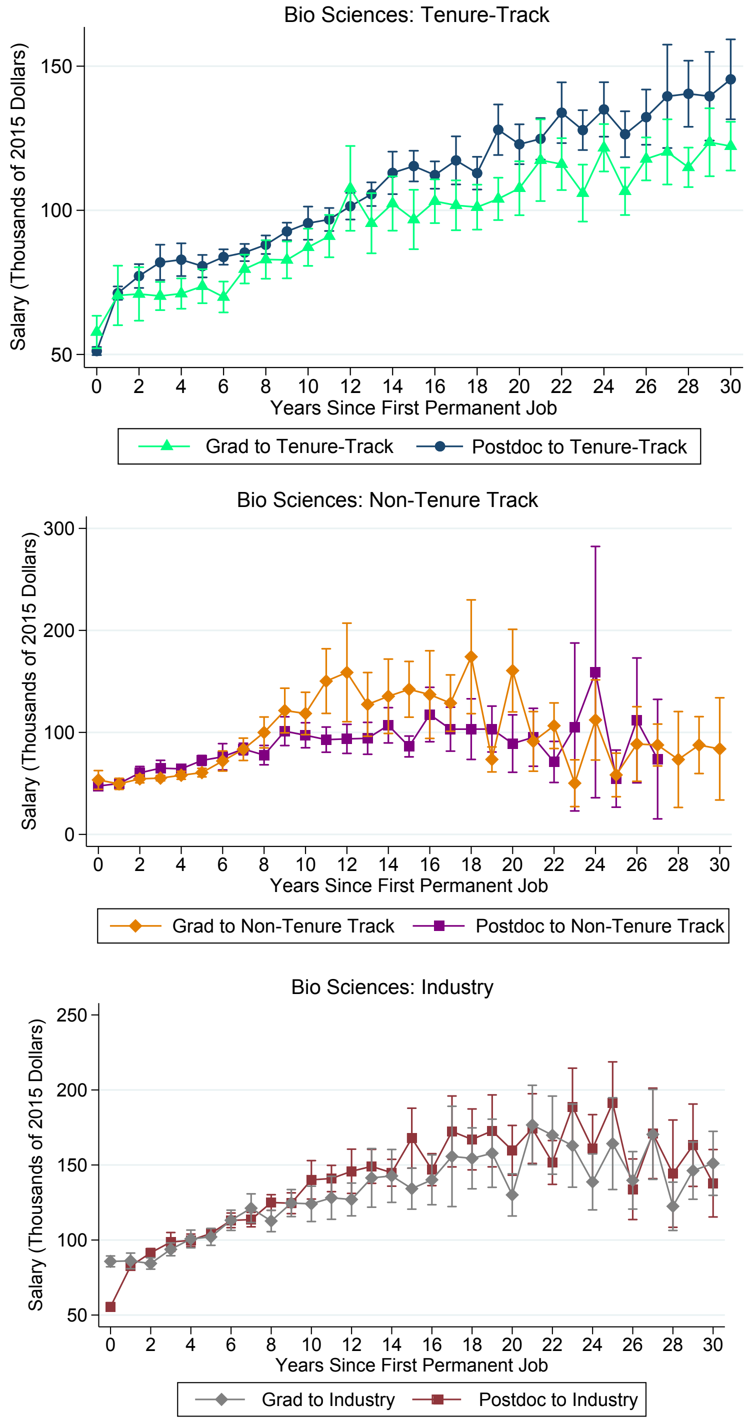
Notes: This graph gives 95% confidence intervals for the inflation-adjusted salary during the survey period (1993-2015) of biological science Ph.Ds. in six job types - postdoctoral researcher, academic tenure-track, academic non-tenure track, for-profit industry, non-profit, and government - grouped by years since Ph.D. graduation.

Figure 16: Fraction of Individuals Remaining in Same Job Type by Ph.D. Cohort



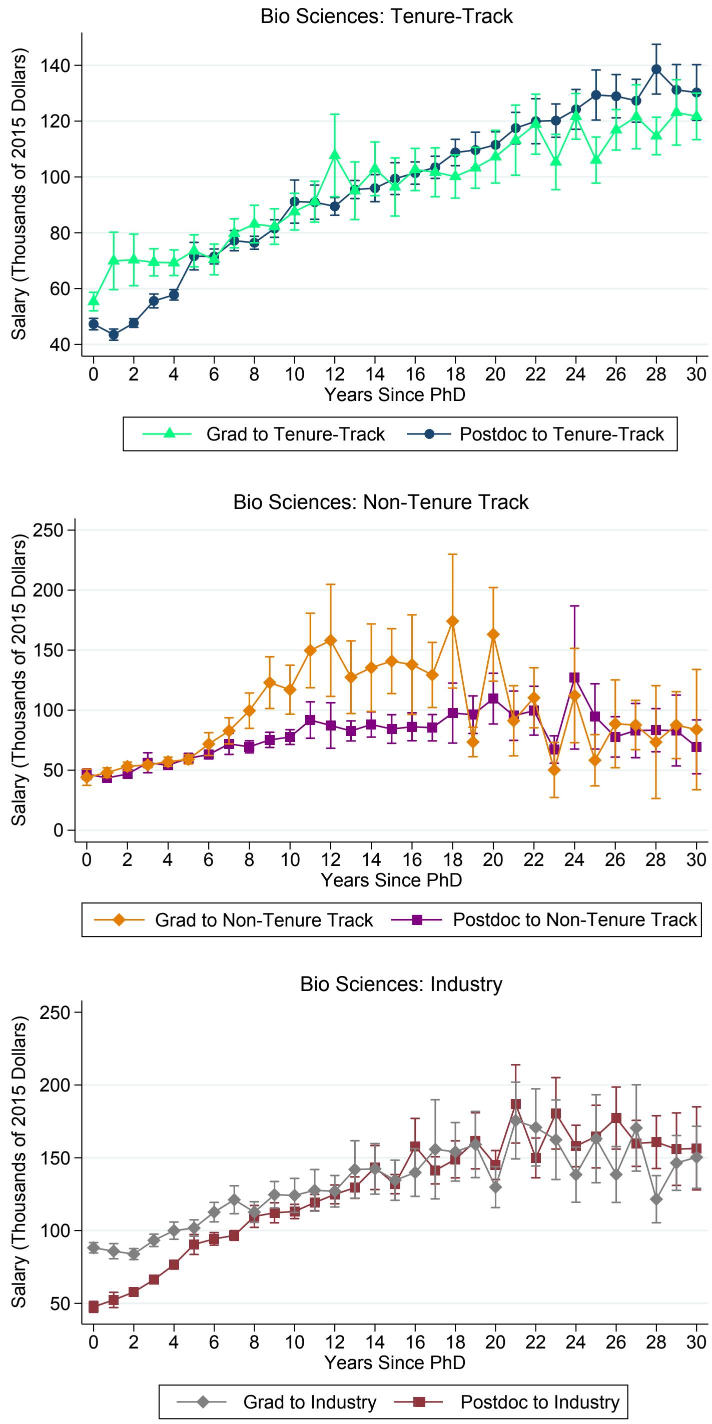
Notes: These graphs give the three-year moving fraction of each biological Ph.D. cohort observed in each job type that remain in this job type throughout their last observation in the SDR, as a measure of how much the job type is an "absorbing state." Each graph gives the analysis for a different job type: postdoctoral researcher (top left), academic tenure-track (top right), academic non-tenure track (middle left), for-profit industry (middle right), government (bottom left), and non-profit (bottom right). For disclosure purposes, only cohorts with at least 50 individuals and cells with at least 5 individuals are shown.

Figure 17: Average Salary in Each Year Since First Permanent Job by Postdoctoral Path



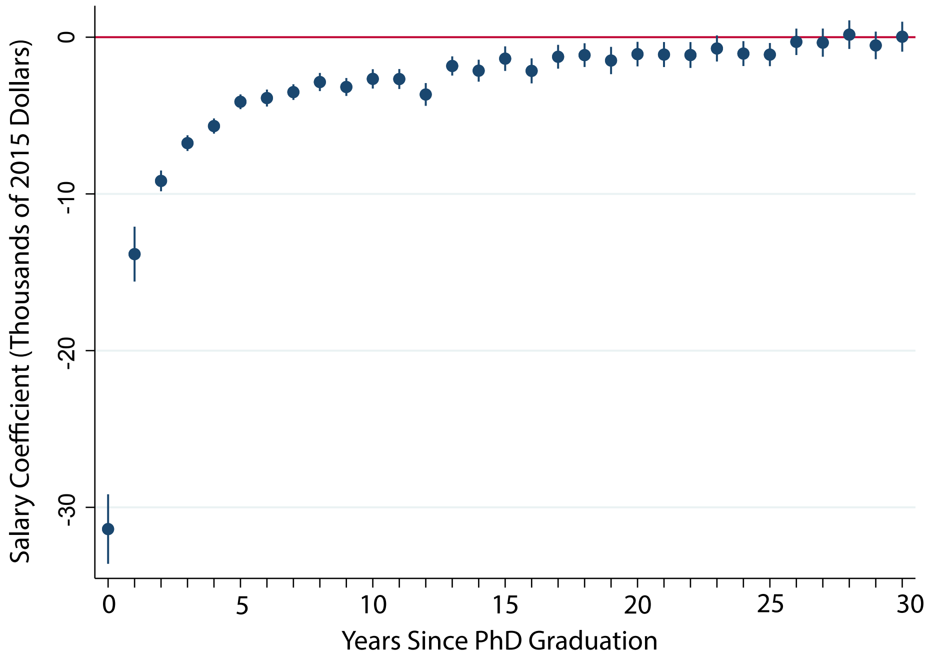
Notes: These graphs give the average salary in tenure-track (top), non-tenure track (middle), and industry (bottom) jobs for the first thirty years after starting a non-postdoctoral job type, grouped by whether the individual pursued any postdoctoral experience. The first permanent job year is the Ph.D. graduation year for individuals transitioning directly from graduate school and is the last postdoctoral appointment year for individuals transitioning from a postdoctoral position.

Figure 18: Average Salary in Each Year Since Ph.D. Graduation by Postdoctoral Path



Notes: These graphs give the average salary in tenure-track (top), non-tenure track (middle), and industry (bottom) jobs for the first thirty years after Ph.D. graduation, grouped by whether the individual pursued any postdoctoral experience.

Figure 19: Salary Regression Coefficients on Postdoctoral Experience in Each Year Post-Ph.D. Graduation



Notes: This graph gives the salary regression coeficients on years of postdoctoral experience for the first thirty since Ph.D. graduation. Regression includes fixed effects for Ph.D. field of study, graduation year, and job type (tenure-track, non-tenure track, or industry).

7 Tables

Table 1: Comparison of Number of Waves Expected in SDR vs. Actually in SDR

		Expected Waves										
		1	2	3	4	5	6	7	8	9	10	11
Actual Waves	0	31.8%	1.8%	5.6%	6.4%	6.6%	6.8%	6.4%	7.3%	12.8%	18.0%	7.6%
	1	68.2%	95.6%	79.3%	61.3%	57.9%	52.3%	49.1%	46.8%	42.4%	44.5%	42.7%
	2		2.7%	12.0%	18.0%	8.1%	7.3%	7.2%	6.2%	6.6%	6.9%	7.8%
	3			3.1%	11.4%	12.6%	8.7%	7.3%	7.7%	6.3%	4.9%	10.1%
	4				2.9%	11.0%	12.0%	6.5%	5.2%	4.9%	2.9%	3.9%
	5					3.8%	8.9%	11.0%	5.5%	4.0%	3.4%	3.2%
	6						4.1%	8.1%	9.8%	4.3%	2.8%	2.5%
	7							4.4%	8.2%	8.1%	3.3%	3.3%
	8								3.4%	6.4%	5.8%	2.7%
	9									4.3%	4.1%	4.4%
	10										3.4%	8.4%
	11											3.3%
	Total	534	10,794	9,601	9,097	11,870	7,803	7,832	8,246	10,597	12,764	66,716

Notes: This table compares a SDR individual's expected number of survey waves - defined as the number of surveys in which the SDR individual has graduated from their Ph.D. but less than 76 years after their given birth year - to the actual number of survey waves the individual is observed. Due to missing birth years, it is possible for individuals to be observed in more years than expected; however, those numbers are small and have been suppressed for disclosure purposes. Each cell of column m and row n gives the percentage of individuals expected in m waves that are observed n times. Perfect response rate would be a 100% on the diagonal. The final row gives the total number of individuals expected in m waves.

Table 2: Weighted Percentage of SDR Individuals Receiving First Doctorate in General Field of Study

Ph.D. General Field of Study	*Full SDR Sample* (1)	*STEM Sample* (2)
Agricultural Sciences/Natural Resources	4.2%	4.9%
Biological/Biomedical Sciences	20.5%	23.9%
Chemistry	9.1%	10.6%
Computer & Information Sciences	2.5%	2.9%
Economics	2.9%	-
Education	0.7%	-
Engineering	18.9%	22.0%
Health Sciences	4.4%	5.1%
Humanities	0.6%	-
Mathematics	4.4%	5.1%
Physics	5.4%	6.3%
Professional Fields	0.1%	-
Psychology	13.1%	15.4%
Other Physical Sciences	3.3%	3.9%
Other Social Sciences	9.7%	-

Notes: This table gives the weighted percentage of SDR individuals that received their first doctorate in each general field of study. Column 1 gives the full sample of 1993-2015 SDR individuals; Column 2 limits the sample to individuals in STEM fields.

Table 3: Ph.D. Individual Characteristics

	STEM (1)	Bio Sciences (2)	Chemistry (3)	Engineering (4)	Physics (5)
Male	69.9%	61.6%	77.3%	87.1%	89.4%
Race					
White	64.9%	68.7%	64.1%	47.2%	64.5%
Asian	25.4%	22.3%	27.1%	44.0%	28.6%
Underrepresented Minority	7.1%	6.6%	5.9%	6.4%	3.9%
At Ph.D. Graduation					
Age	32.0 (5.6)	31.5 (4.6)	29.9 (4.0)	31.6 (4.8)	30.5 (3.9)
Married	61.0%	59.5%	59.7%	63.1%	58.8%
Have Children	41.6%	37.3%	40.4%	45.3%	40.6%
US Native	65.8%	71.8%	68.3%	43.3%	61.1%
US Naturalized	4.0%	4.4%	3.1%	4.7%	3.6%
Ever Married	85.5%	84.5%	87.0%	88.9%	85.5%
Ever Have Children	63.4%	61.7%	62.8%	67.7%	61.9%
Research-Intensive					
Bachelor's	51.2%	50.8%	39.4%	65.9%	55.4%
Master's	68.4%	63.9%	67.4%	79.5%	78.5%
Doctorate	78.5%	78.9%	82.8%	84.3%	84.7%
Have Professional Degree	1.6%	4.4%	0.2%	0.2%	0.2%
Years in Graduate School	7.1 (3.2)	7.0 (2.7)	6.1 (2.3)	6.9 (3.0)	6.9 (2.5)
Total Number of Individuals	135,599	34,281	11,558	28,283	8,348

Notes: This table gives individual demographics - gender, race, age (standard deviation in parentheses), marital status, parental status, U.S. citizenship status, educational prestige as measured by the Carnegie Classification system, indicator for having a professional degree (e.g. M.D., J.D., M.B.A.) by Ph.D. graduation, and years in graduate school (standard deviation in parentheses) - for all STEM (column 1), bio sciences (column 2), chemistry (column 3), engineering (column 4), and physics (column 5) Ph.Ds.

Table 4: Ph.D. Experience in Job Types and Employment Sectors

	STEM (1)	Bio Sciences (2)	Chemistry (3)	Engineering (4)	Physics (5)
A. Percent Ever in Position					
Postdoc	37.0%	60.9%	45.9%	20.8%	48.2%
Tenure-Track	32.8%	32.7%	23.1%	25.6%	28.8%
Non-Tenure Track	17.7%	22.0%	14.0%	11.2%	17.7%
Industry	43.6%	30.1%	56.2%	62.1%	43.5%
Government	14.8%	13.8%	11.5%	12.5%	18.6%
Non-Profit	11.4%	12.5%	7.5%	8.3%	10.6%
Unemployed	3.6%	3.8%	5.5%	3.5%	4.1%
Not in Labor Market	14.9%	14.2%	21.7%	12.4%	17.4%
B. Average Conditional Years					
Postdoc	2.8 (2.5)	3.1 (2.6)	2.5 (2.2)	2.3 (2.0)	2.8 (2.4)
Tenure-Track	12.0 (11.2)	12.4 (10.8)	14.4 (12.4)	12.2 (11.3)	13.8 (12.1)
Non-Tenure Track	8.0 (7.4)	7.5 (7.0)	8.0 (7.7)	7.7 (7.5)	8.7 (8.4)
Industry	10.5 (8.8)	8.9 (7.8)	11.4 (9.3)	9.7 (8.5)	10.8 (9.2)
Government	8.1 (9.2)	8.3 (8.4)	8.5 (9.5)	7.5 (8.5)	9.2 (10.3)
Non-Profit	6.4 (7.5)	6.2 (6.5)	6.5 (8.2)	5.4 (7.7)	8.5 (9.9)
Unemployed	3.3 (2.6)	3.1 (2.3)	3.5 (2.8)	3.3 (2.6)	3.4 (2.6)
Not in Labor Market	7.6 (5.6)	7.2 (5.5)	8.7 (6.0)	7.8 (5.4)	7.7 (5.7)
Total Number of Individuals	135,599	34,281	11,558	28,283	8,348

Notes: Panel A of this table gives the percent of all STEM (column 1), biological sciences (column 2), chemistry (column 3), engineering (column 4), and physics (column 5) Ph.Ds. who ever hold a certain job type (postdoctoral researcher, tenure-track, non-tenure track, for-profit industry) or employment status (unemployed, not in labor force). Conditional on any experience in a certain job type or employment status, Panel B of this table gives the average number of years spent in these positions (standard deviations in parentheses).

Table 5: Job Characteristics Held by Ph.Ds.

	STEM (1)	Bio Sciences (2)	Chemistry (3)	Engineering (4)	Physics (5)
Job Tenure	5.9 (7.3)	5.3 (6.6)	5.9 (7.3)	5.9 (6.9)	6.2 (7.7)
Salary (2015 Dollars)	$105,737 ($70,640)	$100,801 ($77,643)	$110,042 ($70,105)	$121,365 ($72,254)	$112,497 ($67,799)
Benefits					
Health Insurance	87.9%	90.7%	90.4%	91.5%	90.2%
Pension	80.5%	80.2%	81.6%	82.5%	82.9%
Profit Sharing	20.9%	15.7%	28.4%	32.6%	22.2%
Vacation Time	81.8%	85.6%	84.8%	86.6%	85.0%
Hours Worked	45.9 (12.5)	48.6 (12.8)	46.5 (12.1)	46.3 (11.3)	46.1 (11.9)
Full Time ($\geq$35 Hours)	90.1%	92.8%	92.3%	93.5%	92.2%
Most Frequent Work Activity					
Applied Research	16.9%	24.0%	18.6%	12.5%	19.2%
Basic Research	18.1%	23.1%	18.0%	17.0%	17.3%
Management	13.2%	12.2%	15.2%	15.4%	11.9%
Teaching	18.4%	16.4%	17.1%	12.7%	16.3%
Total Number of Unique Jobs	258,873	69,770	24,028	50,206	16,355

Notes: This table gives select job characteristics - average time spent, salary (adjusted for inflation to 2015 dollars; standard deviation in parentheses), benefits, weekly hours (standard deviation in parentheses), and select work activities on which spend most time - for all STEM (column 1), biological sciences (column 2), chemistry (column 3), engineering (column 4), and physics (column 5) Ph.Ds.

Table 6: Distribution of Institutions' Carnegie Classifications by Transition Type

	STEM (1)	Bio Sciences (2)	Chemistry (3)	Engineering (4)	Physics (5)
A. Grad To Postdoc					
R1	78.7%	76.3%	80.5%	83.7%	84.4%
R2	6.6%	5.7%	8.0%	7.7%	5.8%
D1	1.6%	1.1%	2.4%	1.6%	2.5%
D2	1.5%	1.4%	1.6%	1.1%	1.6%
Total N	9,297	4,722	820	997	595
B. Grad to Tenure-Track					
R1	29.5%	23.6%	4.3%	44.2%	13.5%
R2	10.4%	5.0%	4.0%	13.9%	5.0%
D1	11.6%	7.6%	13.8%	11.6%	6.2%
D2	4.5%	3.5%	4.8%	4.3%	N/A
Total N	5,874	664	256	1,250	158
C. Postdoc to Tenure-Track					
R1	51.2%	50.5%	36.6%	63.4%	57.8%
R2	10.7%	8.4%	10.6%	15.1%	9.3%
D1	6.6%	4.8%	10.2%	6.0%	7.3%
D2	3.2%	3.3%	4.9%	3.7%	2.3%
Total N	5,369	2,083	483	631	312
D. Grad to Non-Tenure Track					
R1	49.5%	54.0%	42.0%	58.5%	58.9%
R2	10.3%	7.2%	7.8%	10.4%	11.1%
D1	5.5%	3.0%	9.2%	6.6%	-
D2	2.3%	2.2%	-	-	-
Total N	2,451	654	111	331	115
E. Postdoc to Non-Tenure Track					
R1	67.9%	65.9%	55.0%	82.1%	76.4%
R2	7.1%	6.4%	6.0%	5.9%	9.1%
D1	3.2%	2.2%	5.9%	2.5%	3.4%
D2	1.0%	0.9%	-	-	-
Total N	2,640	1,108	154	256	188

Notes: This table gives the distribution of known Carnegie Classification among individuals in the overall STEM sample (column 1), biological sciences (column 2), chemistry (column 3), engineering (column 4), and physics (column 5) who have transitioned from A) Ph.D. to postdoctoral appointment, B) Ph.D. directly to tenure-track, C) postdoctoral appointment directly to tenure-track, D) Ph.D. directly to non-tenure track, and E) postdoctoral appointment directly to non-tenure track. For disclosure purposes, only groups representing at least 50 individuals and cells representing at least 5 individuals are given.

"R1 - very high research" awards at least fifty doctoral degrees per year and have at least $40 million in federal research support (e.g. Harvard University, Stony Brook University); "R2 - high research" awards at least fifty doctoral degrees per year and have between $15.5 - $40 million in federal research support (e.g. American University, Eastern Michigan University); "D1 - doctoral I" awards at least fifty doctoral degrees per year and has less than $15.5 million in federal research support (e.g. Drake University, Indiana State University); and "D2 - doctoral II" awards between ten to forty doctoral degrees per year (discontinued from classification system in 2000; e.g. Loma Linda University, University of Alabama in Huntsville).

Appendices

A Tracking STEM Ph.D. Careers

A.1 Career Paths Construction

This appendix details the methodology used to identify a SED-SDR individual's career paths across six job types and two employment statuses. It performs the methodology on the example Ph.D. whose true career path is given in Appendix Table A.1. Based on this true path, the individual fills out the job-related variables from each SED or SDR survey in Appendix Table A.2. Note that this data has been constructed for example purposes and does not represent an actual individual in the SED-SDR data.

I start by identifying all individuals covered by the 1993-2015 SDR, matching to their SED responses using the variable *refid,* and using their first weight observation *wtsurvy.* For demographics that don't vary over time – race, gender, birth date, birthplace, native US citizenship, educational attainment prior to the Ph.D. (including years out of school), Ph.D. field of study, Ph.D. institution, and Ph.D. graduation year – I consider the individuals' SED responses to be the definitive source for these variables. I calculate the number of years each individual spends in graduate school by taking the difference between the year an individual receives their Ph.D. and the year they receive their Bachelor's degree, subtracting any time they spend out of school.

I identify six possible principal job types individuals can hold:

- **Postdoctoral Researcher (PD):** In the SED, the individual's postgraduation plans (given by the variable *pdocplan*) are a postdoctoral fellowship, a postdoctoral research associateship, a traineeship, or a clinical residency internship. In the SDR, the indicator for a postdoctoral principal job, *pdix*, equals one; alternatively, in the 1995 or 2006 SDR, the individual identifies this time period as a postdoctoral position through the retrospective questions on postdoctoral history (given by postdoctoral starting and ending years, *pd*syr* and *pd*eyr).*

- **Academic Tenure-Track (TT):** In the SED, the individual's postgraduation plan is not a postdoctoral position (as defined above) but is employment in a U.S. 4-year college or university, medical school, research institute, or university hospital. In the SDR, the individual is not in a postdoctoral position but is either tenured or on the tenure track (as given by the variables *facten* and *tensta*).

- **Academic Non-Tenure Track (NT):** In the SED, the individual's postgraduation plan is not a postdoctoral or tenure-track academic (as defined above) but is employment in a U.S. community college, U.S K-12, or a foreign educational institution. In the SDR, the individual is not in a postdoctoral or tenure-track academic position but is employed in an educational institution (as given by the employment sector variable *emsecdt*).

- **Industry (ID):** For both the SED and SDR, the individual is employed in the for-profit industry sector, for-profit business sector, or is self-employed.
- **Non-Profit (NP):** In the SED, the individual's postgraduation plan is a not-for-profit organization or international organization such as UN, UNESCO, or WHO. In the SDR, the individual is employed in a non-profit sector.
- **Government (GV):** In the SED, the individual's postgraduation plan is employment at a foreign government, U.S. federal government, U.S. state government, or U.S. local government. In the SDR, the individual is employed in the government sector.

I also examine if individuals are not employed and hold the following non-employed statuses:

- **Unemployed (UN):** There is no information on unemployment in the SED. In the SDR, an individual's labor force status is unemployed (as given by the variable *lfstat)*.
- **Not in Labor Force (NL):** In the SED, the individual's postgraduation status is not seeking employment (including being a housewife, writing a book, or no employment). In the SDR, the individual's labor force status is not in the labor force.

To construct the career paths, I modify Ginther and Kahn (2017)'s methodology for measuring postdoctoral incidence over time to expand to different employment sectors. From the SED, I identify STEM Ph.Ds.' immediate post-graduation status using the variables *pdocstat*. Individuals are considered to be in a particular job type the year of their graduation if they indicated they are returning to employment, have a signed contract, or are in negotiations for that job type. From the SDR, I utilize variables on their current job,[19] comparison to their previous job,[20] and retrospective postdoctoral experience asked of respondents in 1995

[19]Current job variables include *pdix* (indicator for postdoctoral principal job), *facten* (faculty rank and tenure status), *tensta* (tenure status), *emsecdt* (employer sector), and *lfstat* (labor force status).

[20]The variable *emsmi* asks if individual holds the same employer and/or same job as the last SDR survey, typically two to three years earlier.

and 2006.[21] Because some variables impart more information about one's job type than others, I use the following hierarchy to fill in indicators for each job type in each year from 1945-2015:

1. **New job:** Individual is starting a new job (given by start date) in that year. In the case of unemployed or out of labor force, the last year worked was the previous year.

2. **Postdoctoral retrospective:** Individual stated they were in a postdoctoral position in the retrospective 1995 and 2006 data, as given by the postdoctoral start and end dates. Fill indicators for all years between the start and end years.

3. **Current job:** Individual is currently in this job type; fill indicators for all years up through starting year. In the case of unemployed or out of labor force, fill indicators for all years just up to the year last worked.

4. **In same job type last survey:** Individual states they were either 1) in the same job and same employer, 2) in the same job but had a different employer, or 3) had the same employer but different job as the last survey. Denote these as case 4, case 4.1, and case 4.2 respectively. Fill indicators for current job type up to last survey year.

5. **Expected post-graduation job:** Fill in job type for an individual's graduation year from their expected post-graduation job type, as given by the SED.

6. **No other information, expected transition:** If steps 1-5 have not given any information on an individual's job type in a particular year but have given information in the previous year, assume that individuals were in the same job type as the year had information.

7. **No information expected:** For years before completing the Ph.D. and after the last year surveyed, the individual contributes no further information about their job type, so replace indicators with missing.

The example individual's indicators are given in Appendix Table A.3. I consider the highest step in the hierarchy as the most accurate representation of whether an individual was in that job type in that year.

[21] The 1995 and 2006 waves of the SDR included an additional module on retrospective postdoctoral employment. Individuals in the SDR sample for the 1995 and 2006 waves were asked how many postdoctoral appointments they had held; the start and end dates for their three most recent postdoctoral appointments; and their reasons for pursuing postdoctoral appointments. For this purposes of constructing career paths, I utilize start and end years for the three most recent postdoctoral appointments (given by *pd*syr* and *pd*eyr*).

Appendix Table A.4 gives the percent of indicators determined by each step. To estimate the number of years an individual is in a particular job type, I count one year for each year an indicator's most definitive step is steps 1-5 and a half year for each year an indicator's most definitive step is step 6. Transitions are defined by the new job type within two years of the last year spent in a different job type. As shown in Appendix Table A.3, the example individual is considered to have spent four years in a postdoctoral position, four and a half years in academic tenure-track, one year in non-tenure track, two years in non-profit, five and a half years in industry, two years not in labor force, and five and a half years in government. They have switched from postdoctoral to tenure track, tenure track to non-tenure track, non-tenure track to non-profit, non-profit to industry, industry to government, and not in labor force to government.

This methodology is able to capture the majority of the true career path; however, the example also illustrates limitations when individuals switch principal jobs between survey years or have employment gaps for a year or less. The 1999-2000 non-tenure track and the 2009-2012 government positions are underestimated, as the individual switched to a different job type in a non-survey year. The 2007 unemployment gap is missed due to being in a non-survey year. The 2004-2006 for-profit job is overestimated due to a lack of job type information in 2007. Since transitions are defined by the last time an individual is observed in a job type, this methodology also misses the transition from government to not in labor force (as the individual returns to government later on).

A.2 Individual and Job Characteristic Interpolation

Once I have constructed the full career path, I pull additional information on worker and job characteristics from the SDR data. I calculate age as the difference between the birth year given in the SED and the year of interest. I construct indicators for marital status; any children living in the household; US native citizen; and US naturalized citizen. I fill in between SDR survey years by assuming that if individuals have not changed their status for consecutive survey years, they kept that status. If they have changed status, I fill in the intervening year indicators with 0.25/0.75 to denote a transition a negative/positive transition respectively.[22] Between the SED and SDR years, I fill in the US naturalized citizenship indicator only if it does not change between the SED and their first SDR survey year; no other interpolation is done between the SED and SDR.

For job characteristics over time, the variables of interest include salary, work activity indicators, occupational codes, federal support indicators, location, educational institution (if in academic position), tenure

[22] 3.6% of observations change marital status; 7.1% change having children living with them; and less than 1% change US citzenship or residency status between surveys.

status (if in academic position), hours worked, indicator for full-time principal job, employer size, job benefits, and indicator for new business. Raw salaries have been converted to 2015 dollars using the CPI-U. If an individual is at a U.S. educational institution, I match to their institution's Carnegie Classification in that year. Occupational codes are matched to Ph.D. field of study using the key provided in Appendix Table A.5. For interpolation between survey years, I utilize the job indicators constructed in Appendix A.1 to determine years in the same job. For the same job, I assume that job field of work, occupation, location, educational institution (if in academic position) do not change and fill those characteristics in non-survey years. If a specific job is considered a new business, I allow this distinction for 5 years after the first time the individual first lists it as such. I do not interpolate other job characteristics across survey years.

Table A.1: Example Individual's True Career Path

refyr (1)	*PD* (2)	*TT* (3)	*NT* (4)	*ID* (5)	*NP* (6)	*GV* (7)	*UN* (8)	*NL* (9)
1990	X							
1991	Y							
1992	Y							
1993	Y							
1994		X						
1995		X						
1996		X						
1997		X						
1998		X						
1999			X					
2000			X		X			
2001					X			
2002				X				
2003				X				
2004				Y				
2005				Y				
2006				Y				
2007							X	
2008						X		
2009						Y		
2010						Y		
2011						Y		
2012						Y		X
2013								X
2014						X		
2015						X		

Notes: This table gives the true career path of a constructed SDR individual. Column 1 gives the reference year, *refyr*. Columns 2-9 give job types and employment statuses abbreviated as postdoctoral researcher (PD), academic tenure-track (TT), academic non-tenure track (NT), for-profit industry (ID), non-profit (NP), government (GV), unemployed (UN), and not in labor force (NL). A marked box denotes employment in that job type or employment status in that year; if an individual switches jobs but remains in the same job type, different jobs are denoted by switching the markings (X, Y, etc.). For example, the individual switches from one postdoctoral position to another in 1991, so the first postdoctoral job is denoted by X and the second is denoted by Y.

Table A.2: Example Individual's Responses to SED/SDR

Survey (1)	*refyr* (2)	*phdcy* (3)	*pdocstat* (4)	*pdocplan* (5)	*strtyr* (6)	*pdix* (7)	*lfstat* (8)	*emsecdt* (9)	*facten* (10)	*tensta* (11)	*emsmi* (12)	*lwyr* (13)	*pd1syr* (14)	*pd1eyr* (15)	*pd2syr* (16)	*pd2eyr* (17)
SED	1990	1990	2	0												
SDR	1993	1990			1991	1	1	11	4	5						
SDR	1995	1990			1994	0	1	11	1	4	4		1991	1993	1990	1990
SDR	1997	1990			1994	0	1	11	1	4	1					
SDR	1999	1991			1999	0	1	11	4	5	4					
SDR	2001	1990			2000	0	1	23			4					
SDR	2003	1990			2002	0	1	22			4					
SDR	2006	1990			2004	0	1	21			3		1991	1993	1990	1990
SDR	2008	1990			2008	0	1	32			4					
SDR	2010	1990			2008	0	1	32			2					
SDR	2013	1990				0	3					2012				
SDR	2015	1990			2014	0	1	32								

Notes: This table gives the constructed SDR individual's responses to the SED and the 1993-2015 SDR waves, based on their true career path in Table A.1. Column 1 gives the survey type (SED or SDR). Column 2 gives the reference year for the survey, *refyr*. Column 3 reports the Ph.D. graduation calendar year, *phdcy*; note that there is a typo in the 1999 SDR response. Columns 4-5 gives the individual's post-graduation status, *pdocstat*, and post-graduation planned employment, *pdocplan*, reported in the SED. Column 6 gives the starting year, *strtyr*, for the reported principal job. Column 7 is an indicator for whether the principal job is a postdoctoral position, *pdix*. Column 8 gives the labor force status, *lfstat*. Column 9 gives the employment sector, *emsecdt*. Columns 10-11 describe the faculty rank, *facten*, and tenure status, *tensta*, for employment in academic institutions. Column 12 describes whether the individual held the same job and/or employer during the last survey, *emsmi*. Column 13 gives the last year worked if unemployed or out of the labor force, *lwyr*. Columns 14-17 give retrospective start and end dates for the two most recent postdoctoral positions, *pd1syr*-*pd2eyr*; in this example individual, they did not have a third postdoctoral position, so *pd3syr* and *pd3eyr* are empty for all surveys.

Table A.3: Example Constructed Career Path

refyr (1)	*PD* (2)	*TT* (3)	*NT* (4)	*ID* (5)	*NP* (6)	*GV* (7)	*UN* (8)	*NL* (9)
1990	5, **2**							
1991	**1**, 2							
1992	3, **2**							
1993	3, **2**							
1994		**1**						
1995		**3**, 4						
1996		**3**, 4						
1997		**3**, 4						
1998		**6**						
1999			**1**					
2000			{}		**1**			
2001					**3**			
2002				**1**				
2003				**3**, 4.1				
2004				**1**, 4.1				
2005				**3**, 4.1				
2006				**3**, 4.1				
2007				{**6**}			{}	
2008						**1**, 4.2		
2009						**3**, 4.2		
2010						**3**, 4.2		
2011						**6**		
2012						{}		**1**
2013								**3**
2014						**1**		
2015						3		

Notes: This table gives the constructed career path based off survey responses in Table A.2. Column 1 gives the reference year, *refyr*. Columns 2-9 give job types and employment statuses abbreviated as postdoctoral researcher (PD), academic tenure-track (TT), academic non-tenure track (NT), for-profit industry (ID), non-profit (NP), government (GV), unemployed (UN), and not in labor force (NL). Boxes are marked with the steps of the hierarchy that the year satisfies: 1 denotes a new job; 2 denotes a postdoctoral position given by the retrospective module; 3 denotes a current job reaching back to its starting year; 4 denotes the same job and employer as the previous wave; 4.1 denotes the same job but different employer as the previous wave; 4.2 denotes the same employer but different job as the previous wave; 5 denotes the SED post-graduation plans; and 6 denotes an expected transition. The smallest number in each cell is bolded and used as the most accurate representation of whether the individual was in that job type in that year. Brackets denote differences from the true career path given in Table A.1.

Table A.4: Percent of Job Indicators Determined by Step Hierarchy, STEM Sample

Step	PD (1)	TT (2)	NT (3)	ID (4)	GV (5)	NP (6)	UN (7)	NL (8)
1: New Job	21.8%	7.7%	13.3%	12.9%	10.1%	11.8%	32.8%	15.6%
2: Postdoc Retrospective	32.0%							
3: Current Job	15.4%	86.0%	80.2%	78.6%	79.2%	76.1%	64.2%	83.7%
4: Same Job, Same Employer	0.2%	0.2%	0.7%	0.3%	0.3%	0.3%		
4.1: Same Job, Diff Employer	0.8%	0.4%	1.0%	1.1%	0.6%	1.2%		
4.2: Diff Job, Same Employer	1.4%	2.1%	2.1%	2.8%	2.7%	2.3%		
5: Expected Post-Grad Job	18.7%	2.8%	1.4%	2.4%	5.0%	6.1%		
6: No Info, Expect Transition	9.6%	1.0%	1.3%	2.0%	2.1%	2.3%	3.1%	0.7%
Total # Obs	144,296	514,238	176,576	503,858	155,971	86,002	14,894	129,310

Notes: This table gives the percentage of job type indicators for STEM doctorate holders that are determined by each step in the described hierarchy: 1 denotes a new job; 2 denotes a postdoctoral position given by the retrospective module; 3 denotes a current job reaching back to its starting year; 4 denotes the same job and employer as the previous wave; 4.1 denotes the same job but different employer as the previous wave; 4.2 denotes the same employer but different job as the previous wave; 5 denotes the SED post-graduation plans; and 6 denotes an expected transition. Each column gives a different job type or employment status: 1) PD: postdoctoral researcher, 2) TT: academic tenure-track, 3) NT: non-tenure track, 4) ID: for-profit industry, 5) GV: government, 6) NP: non-profit, 7) UN: unemployed, and 8) NL: not in labor force.

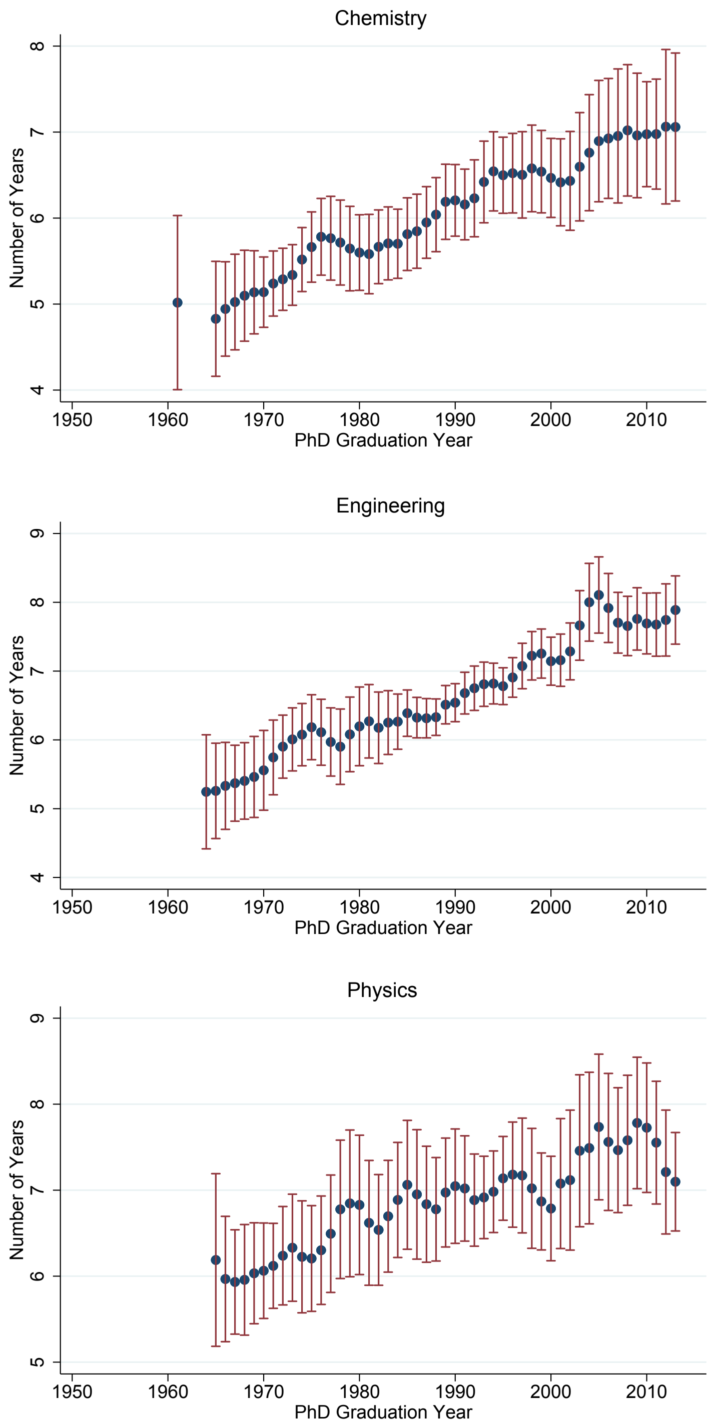
Table A.5: NSF Occupational Codes Matched to Ph.D. Field of Study

Ph.D. General Field of Study	Occupational Codes
Agricultural Sciences/Natural Resources	210000-219999, 282710
Biological/Biomedical Sciences	220000-229999, 282730
Chemistry	310000-319999, 382750
Computer & Information Sciences	110000-119999
Economics	412320, 482780
Education	632530-632540, 732510-742990
Engineering	510000-579999, 582800
Health Sciences	610000-611140, 612870
Mathematics	120000-129999, 182760, 182860
Physics	330000-339999, 382890
Professional Fields	711410-721530, 781200
Psychology	432360, 482910
Other Physical Sciences	320000-329999, 341980
Other Social Sciences	420000-452380, 482900-482980

Notes: This table matches NSF occupational codes to the closest Ph.D. general field of study. Note that postsecondary teachers are matched to their field of study (e.g. mathematics teacher is counted in mathematics), not education. Labels for NSF occupational codes are given at https://ncses.nsf.gov/pubs/nsf21320/table/A-2.

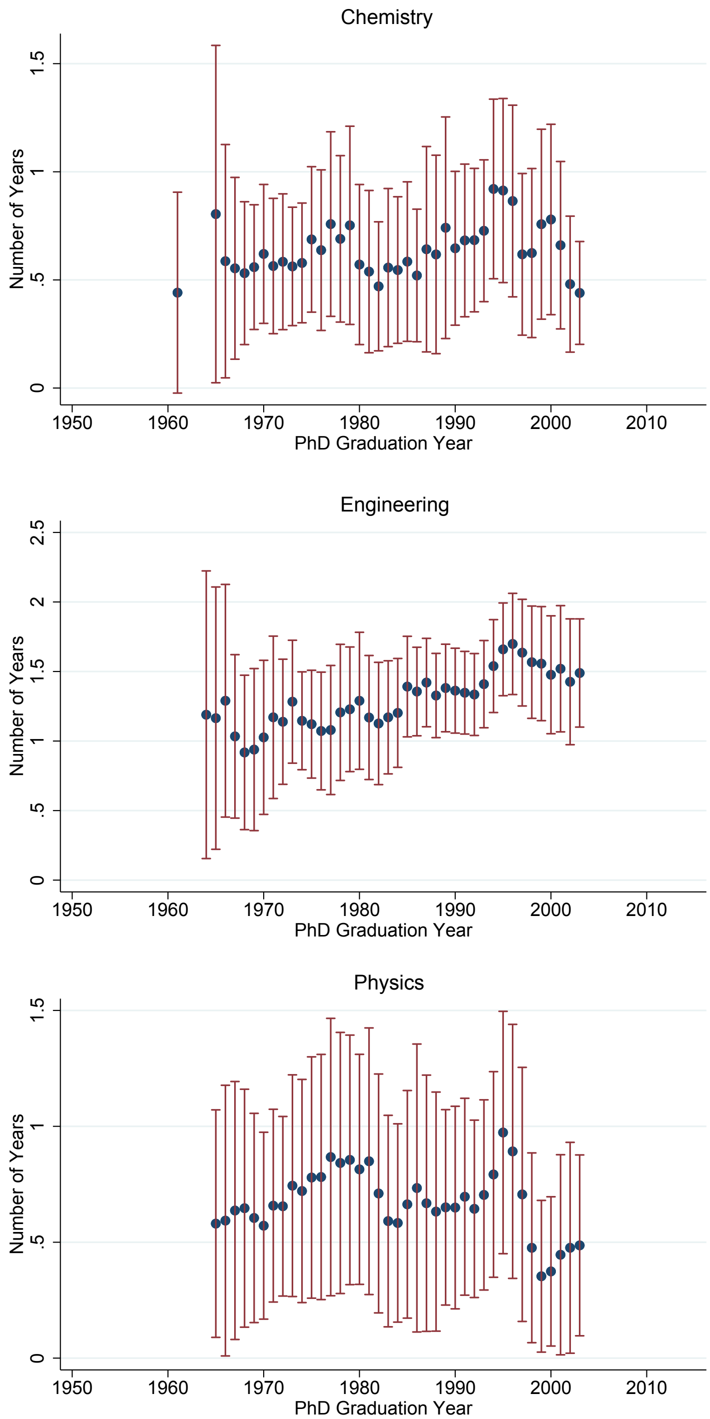
B Trends Across STEM Fields

Figure B.1: Mean Years in Graduate School by Ph.D. Cohort for Additional Fields



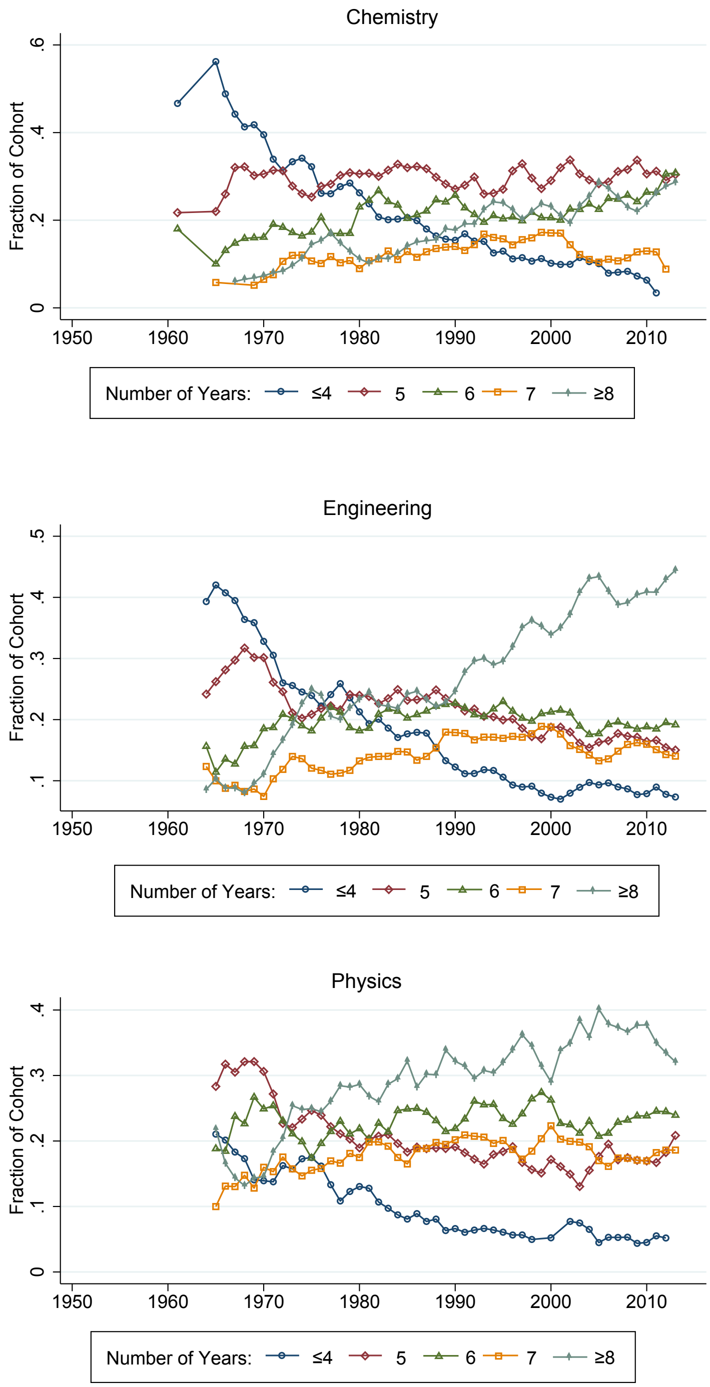
Notes: These graphs give the three-year moving 95% confidence intervals for the mean years chemistry (top), engineering (middle), and physics (bottom) Ph.Ds. spend in graduate school, defined as Ph.D. graduation year minus Bachelor's graduation year and time spent out of school during these years, for each Ph.D. graduation cohort. For disclosure purposes, only cohorts with at least fifty individuals are shown.

Figure B.2: Mean Time Out of Graduate School by Ph.D. Cohort for Additional Fields



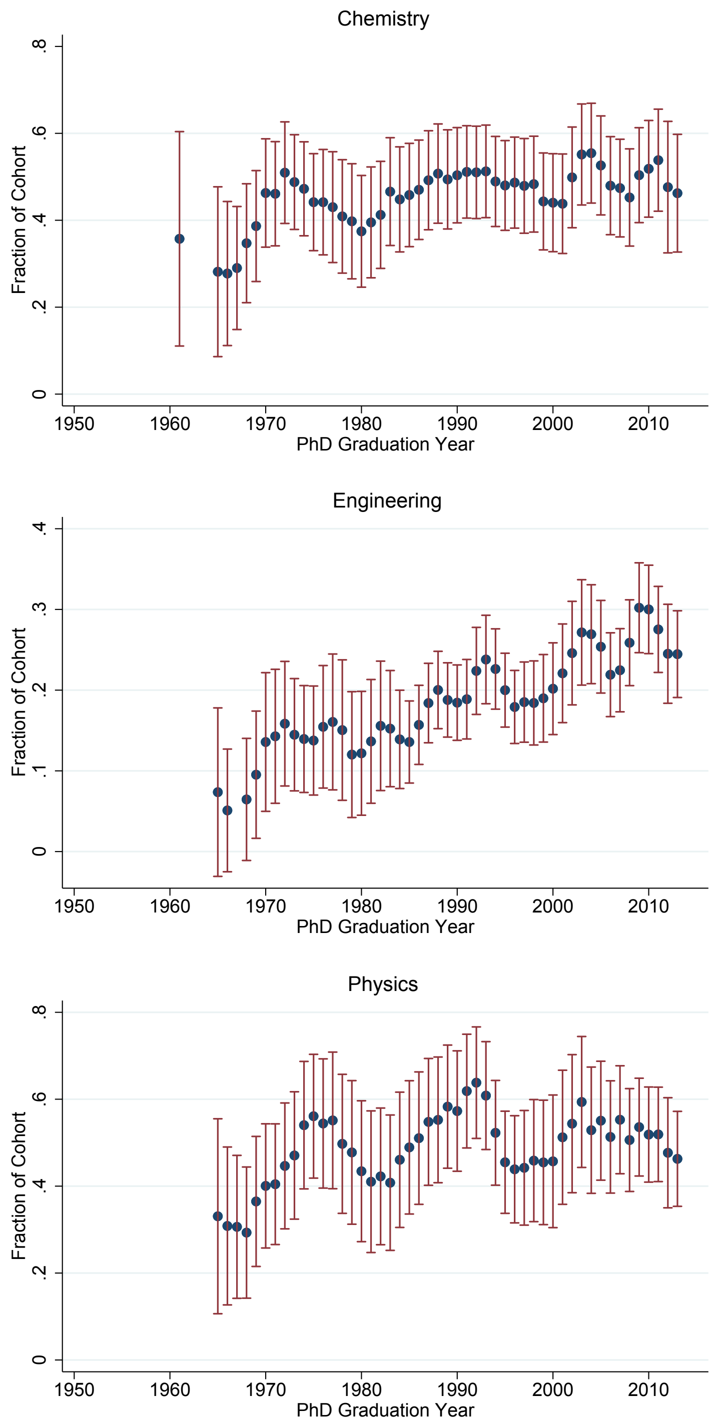
Notes: These graphs give the three-year moving 95% confidence intervals for the mean time out between Bachelor's and Ph.D. graduation years for chemistry (top), engineering (middle), and physics (bottom) Ph.Ds. For disclosure purposes, only cohorts with at least fifty individuals are shown.

Figure B.3: Distribution of Years in Graduate School by Ph.D. Cohort for Additional Fields



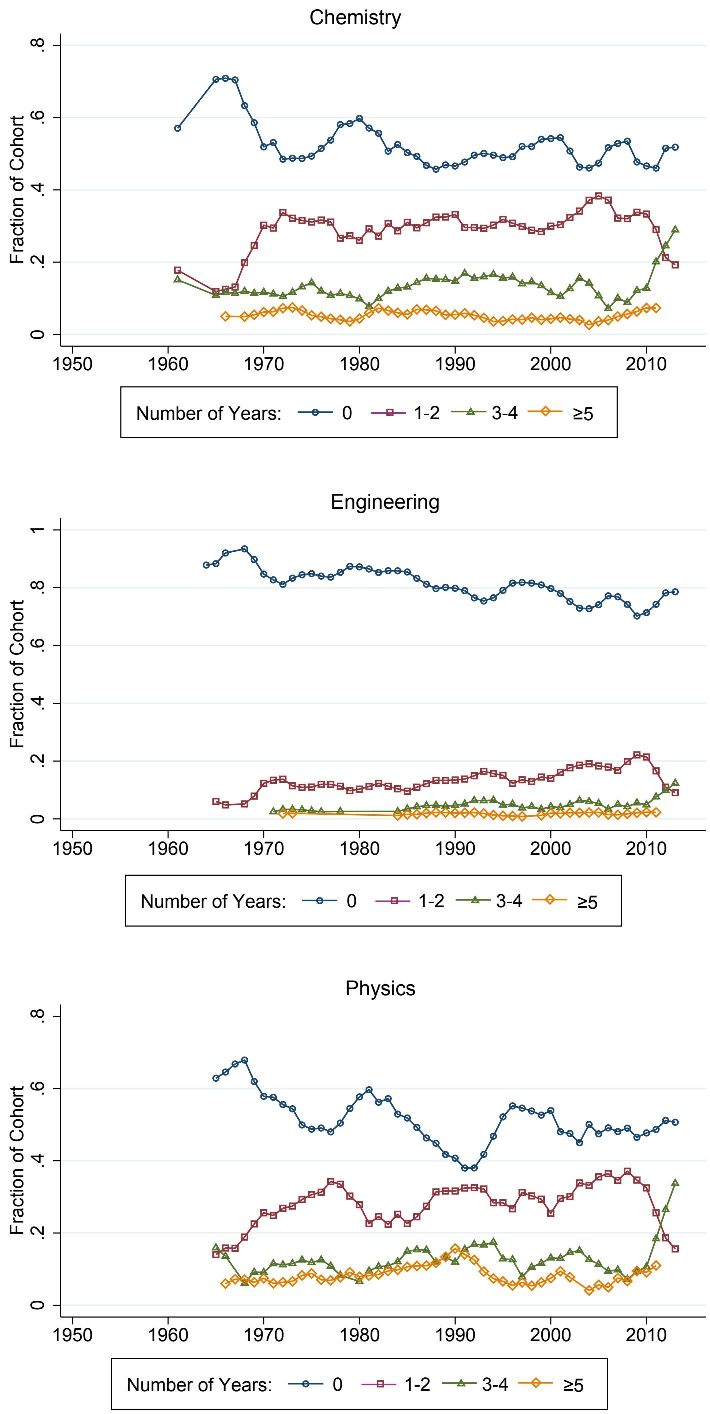
Notes: These graphs give the three-year moving distribution of chemistry (top), engineering (middle), and physics (bottom) Ph.Ds.' years spent in graduate school, defined as the time between the Bachelor's and Ph.D. graduation year minus the number of years spent out of school during this time. Years are rounded down to the nearest integer. For disclosure purposes, only cohorts with at least fifty individuals and cells with at least five individuals are shown; some years are combined or suppressed due to low counts.

Figure B.4: Fraction Early Postdoctoral Takeup by Ph.D. Cohort for Additional Fields



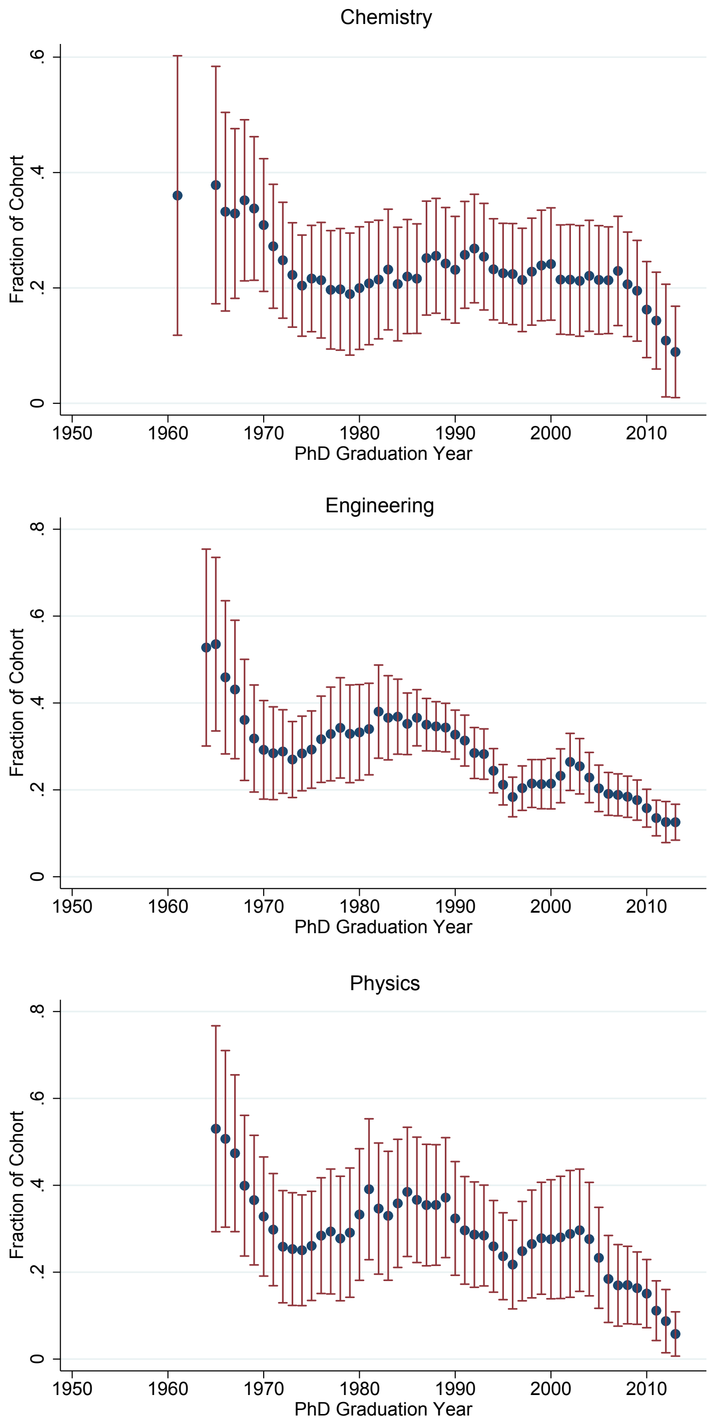
Notes: These graphs give the three-year moving 95% confidence intervals for the fraction of each chemistry (top), engineering (middle), and physics (bottom) Ph.D. cohort that take on postdoctoral positions within two years of graduation. For disclosure purposes, only cohorts with at least fifty individuals and cells with at least five individuals are shown.

Figure B.5: Distribution of Postdoctoral Years by Ph.D. Cohort for Additional Fields



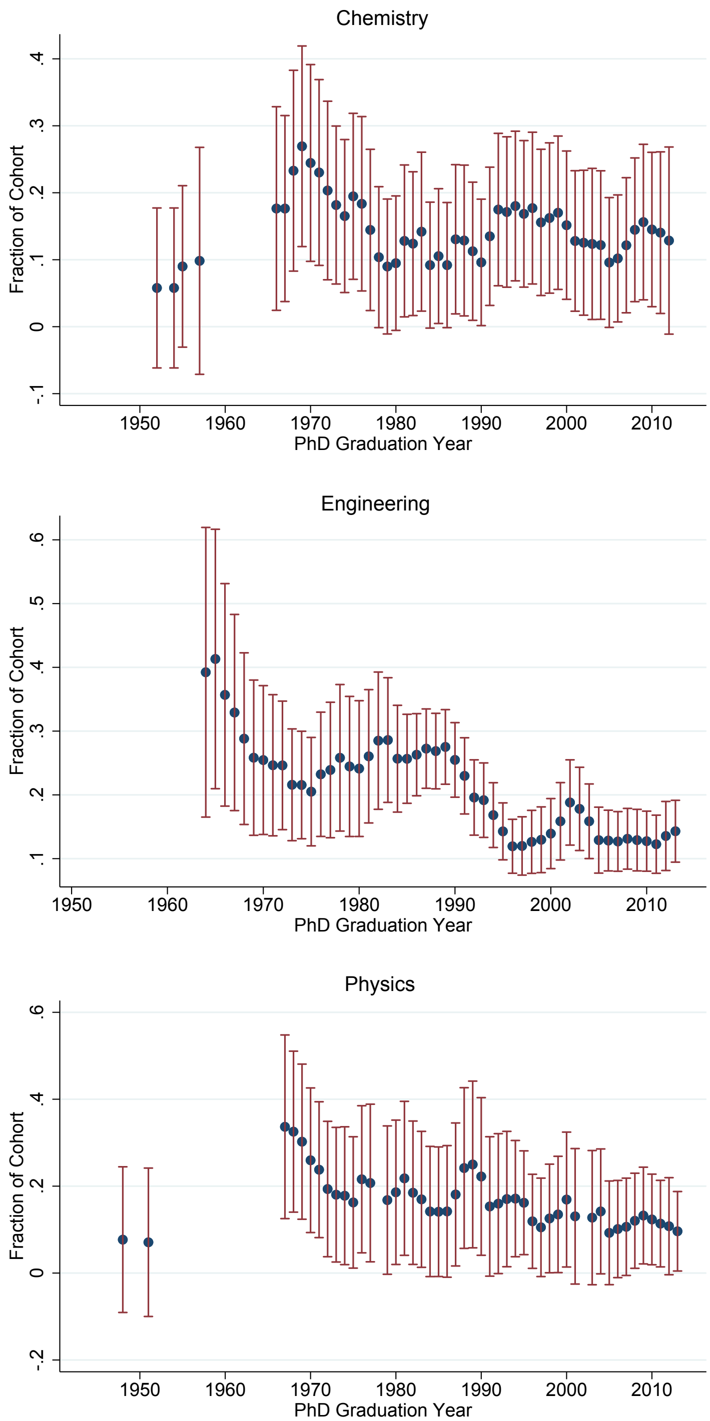
Notes: These graphs give the three-year moving distribution of chemistry (top), engineering (middle), and physics (bottom) Ph.Ds.' years observed in postdoctoral positions for each Ph.D. cohort. Half-years spent in postdoctoral positions are rounded down. For disclosure purposes, only cohorts with at least fifty individuals and cells with at least five individuals are shown; some years are combined or suppressed due to low counts.

Figure B.6: Fraction Ever Observed in an Academic Tenure-Track Position by Ph.D. Cohort for Additional Fields



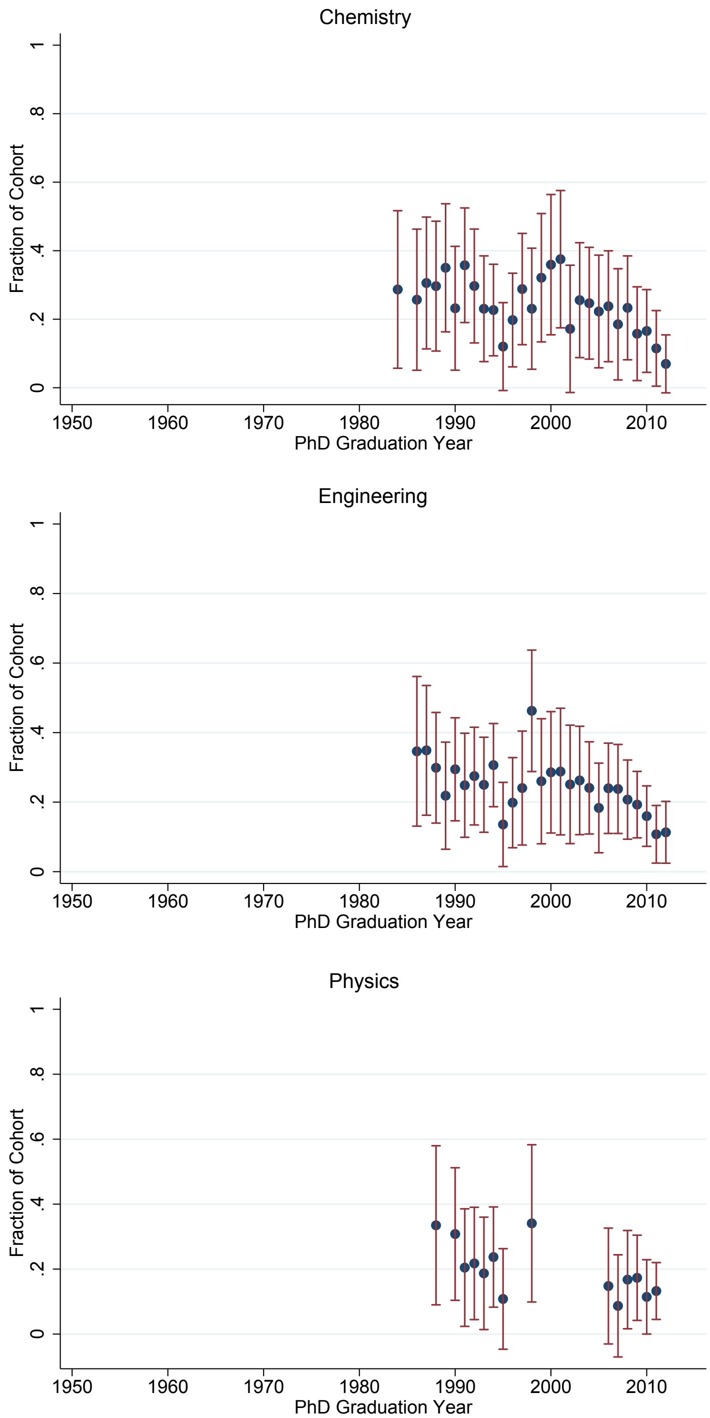
Notes: These graphs give the three-year moving 95% confidence intervals for the fraction of each chemistry (top), engineering (middle), and physics (bottom) Ph.D. cohort that is ever observed in an academic tenure-track position. For disclosure purposes, only cohorts with at least fifty individuals and cells with at least five individuals are shown.

Figure B.7: Fraction Observed in an Academic Tenure-Track Position with No Postdoctoral Experience by Ph.D. Cohort for Additional Fields



Notes: These graphs give the three-year moving 95% confidence intervals for the fraction of each chemistry (top), engineering (middle), and physics (bottom) Ph.D. cohort observed in an academic tenure-track position within two years of their Ph.D. graduation without any postdoctoral experience. For disclosure purposes, only cohorts with at least fifty individuals and cells with at least five individuals are shown.

Figure B.8: Fraction Transition from Postdoctoral Position to an Academic Tenure-Track Position by Ph.D. Cohort for Additional Fields



Notes: These graphs give the three-year moving 95% confidence intervals for the fraction of postdoctoral researchers from each chemistry (top), engineering (middle), and physics (bottom) Ph.D. cohort who transition to an academic tenure-track position within two years of their last postdoctoral position. For disclosure purposes, only cohorts with at least fifty individuals and cells with at least five individuals are shown.

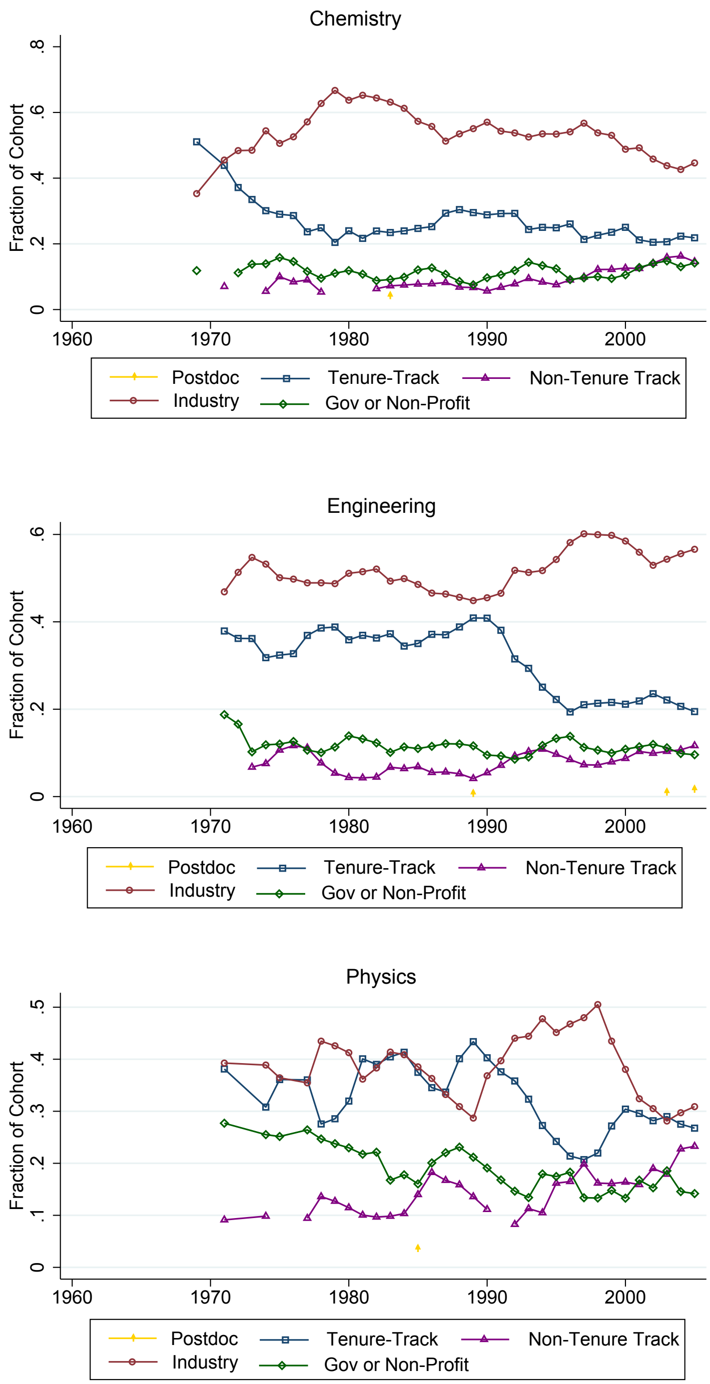
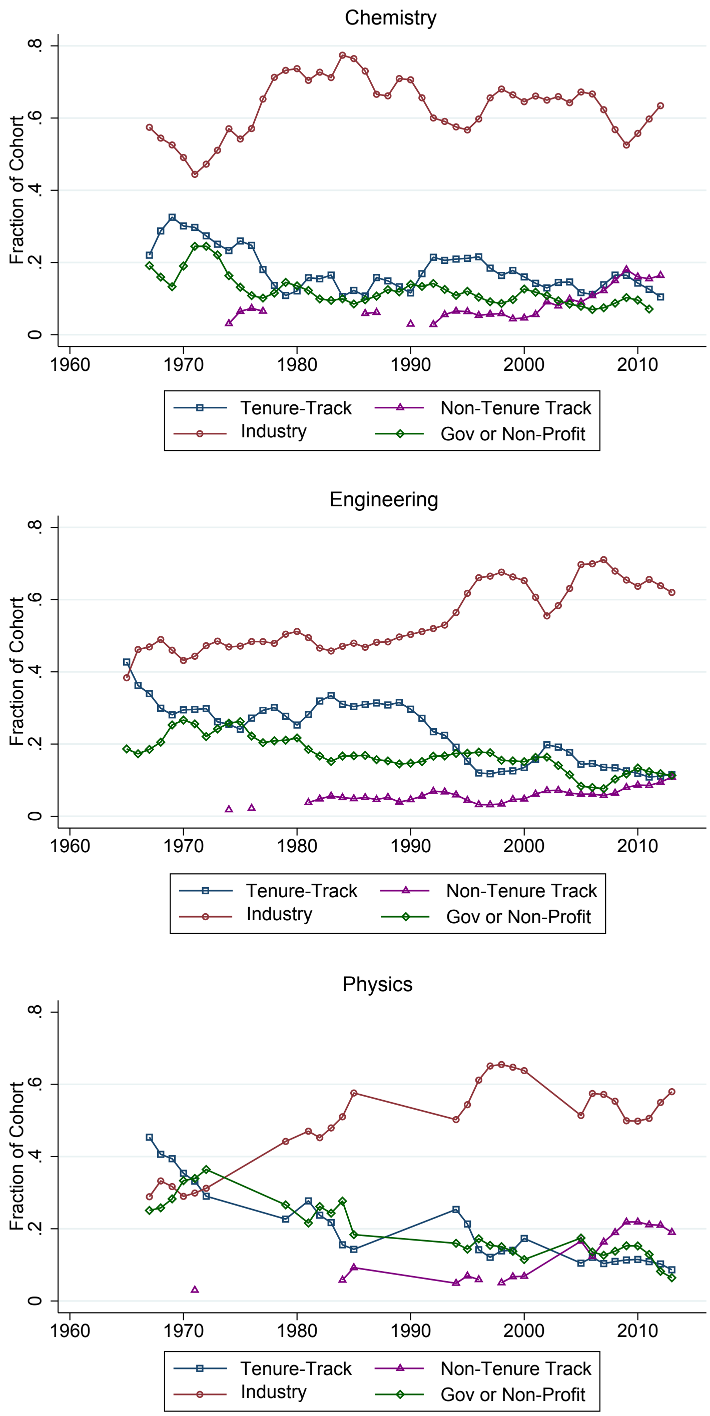


Figure B.9: Job Distributions Ten Years Post-Ph.D. Graduation for Additional Fields

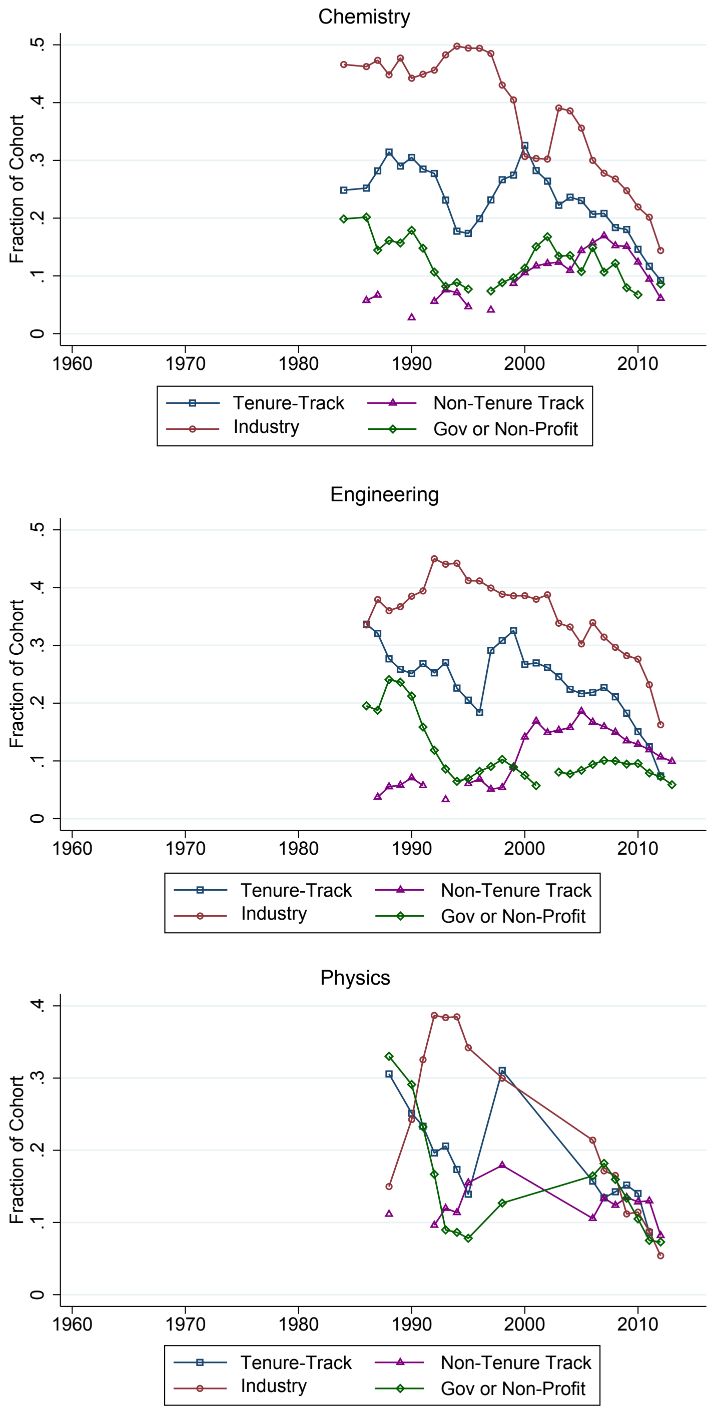
Notes: This graph gives the three-year moving fraction of each chemistry (top), engineering (middle), and physics (bottom) Ph.D. cohort working ten years post-Ph.D. graduation in each job type. Individuals who are not working or do not have data ten years post-Ph.D. are not included. For disclosure purposes, only cohorts with at least fifty individuals and cells with at least five individuals are shown.

Figure B.10: Distribution of Non-Postdoc Job Transitions After Ph.D. Graduation by Ph.D. Cohort for Additional Fields



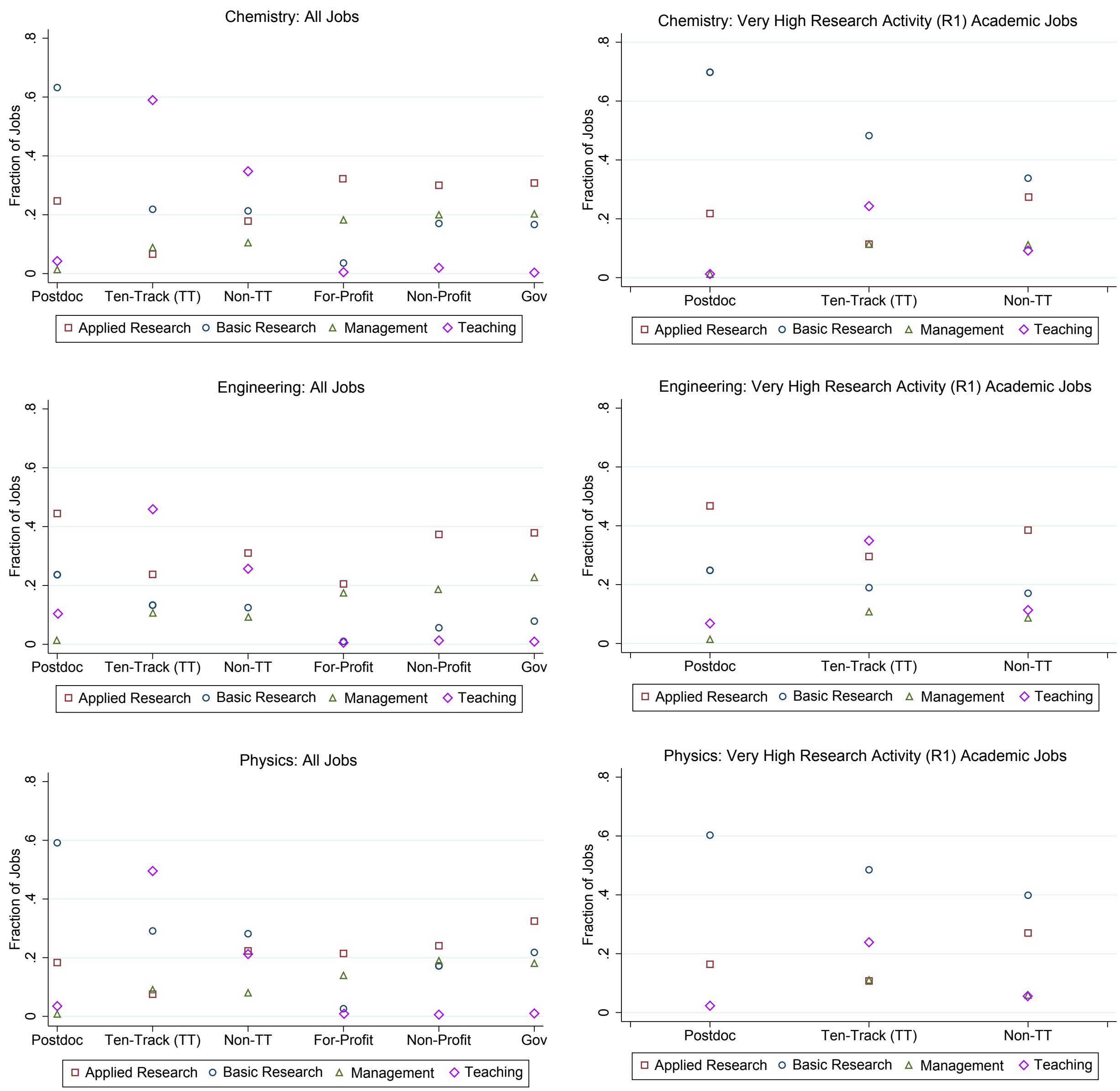
Notes: These graphs give the three-year moving distribution of each chemistry (top), engineering (middle), and physics (bottom) Ph.D. cohort who do not have postdoctoral experience that transition into each non-postdoc job type within two years of their graduation. For disclosure purposes, only cohorts with at least fifty individuals and cells with at least five individuals are shown; some job types are combined or suppressed due to low counts.

Figure B.11: Distribution of Job Transitions After Last Postdoctoral Appointment by Ph.D. Cohort for Additional Fields



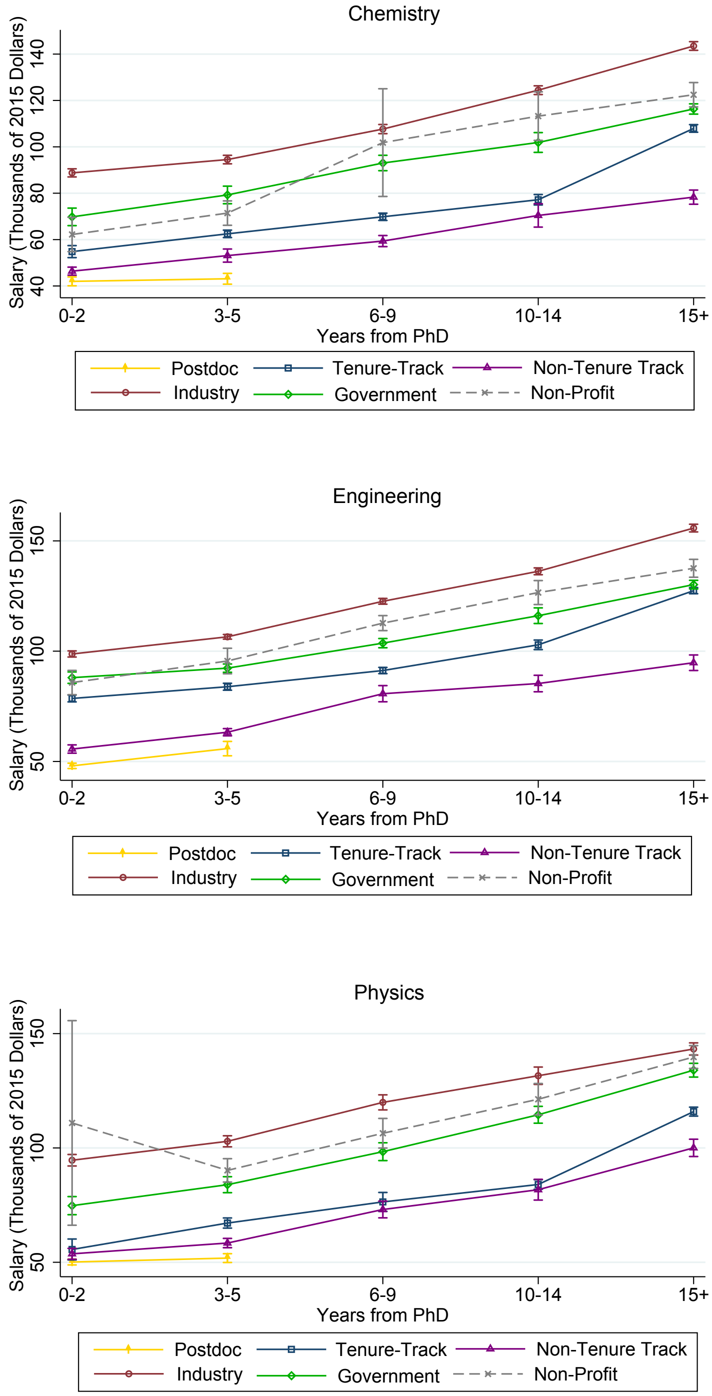
Notes: These graphs give the three-year moving distribution of each chemistry (top), engineering (middle), and physics (bottom) Ph.D. cohort who have postdoctoral experience that transition into each non-postdoctoral job types within two years of their last postdoctoral position. For disclosure purposes, only cohorts with at least fifty individuals and cells with at least five individuals are shown; some job types are combined or suppressed due to low counts.

Figure B.12: Most Common Work Activity by Job Type for Additional Fields



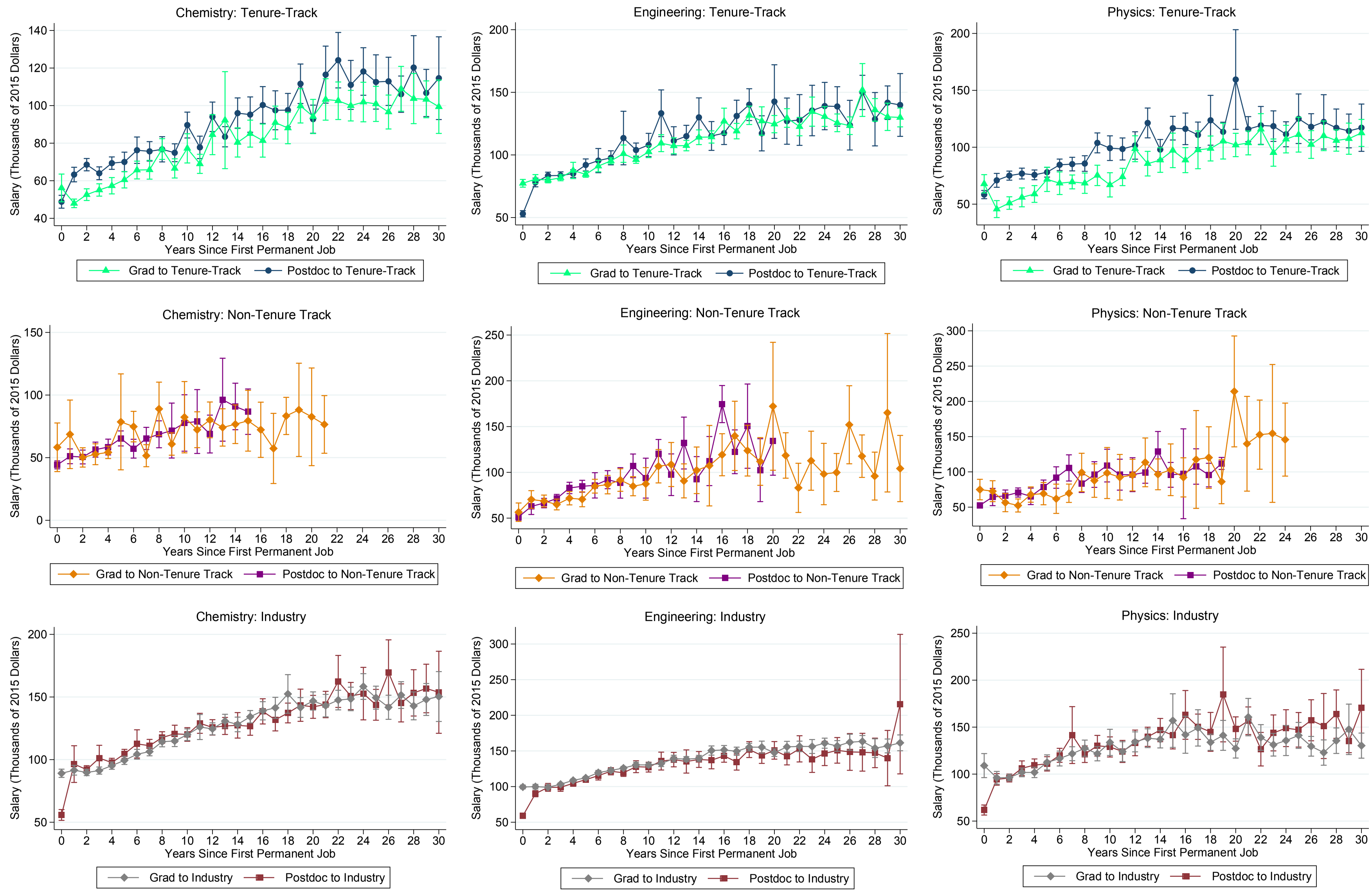
Notes: These graphs give the fraction of chemistry (top row), engineering (middle row), and physics (bottom row) Ph.Ds. holding each job type during the survey period (1993-2015) that state they spend the most work hours on applied research, basic research, management, or teaching. Right column limits to academic sector jobs (postdoctoral, tenure-track, non-tenure track) at R1 Carnegie-Classified R1 "very high research activity" universities.

Figure B.13: Average Salary by Job Type and Career Stage for Additional Fields



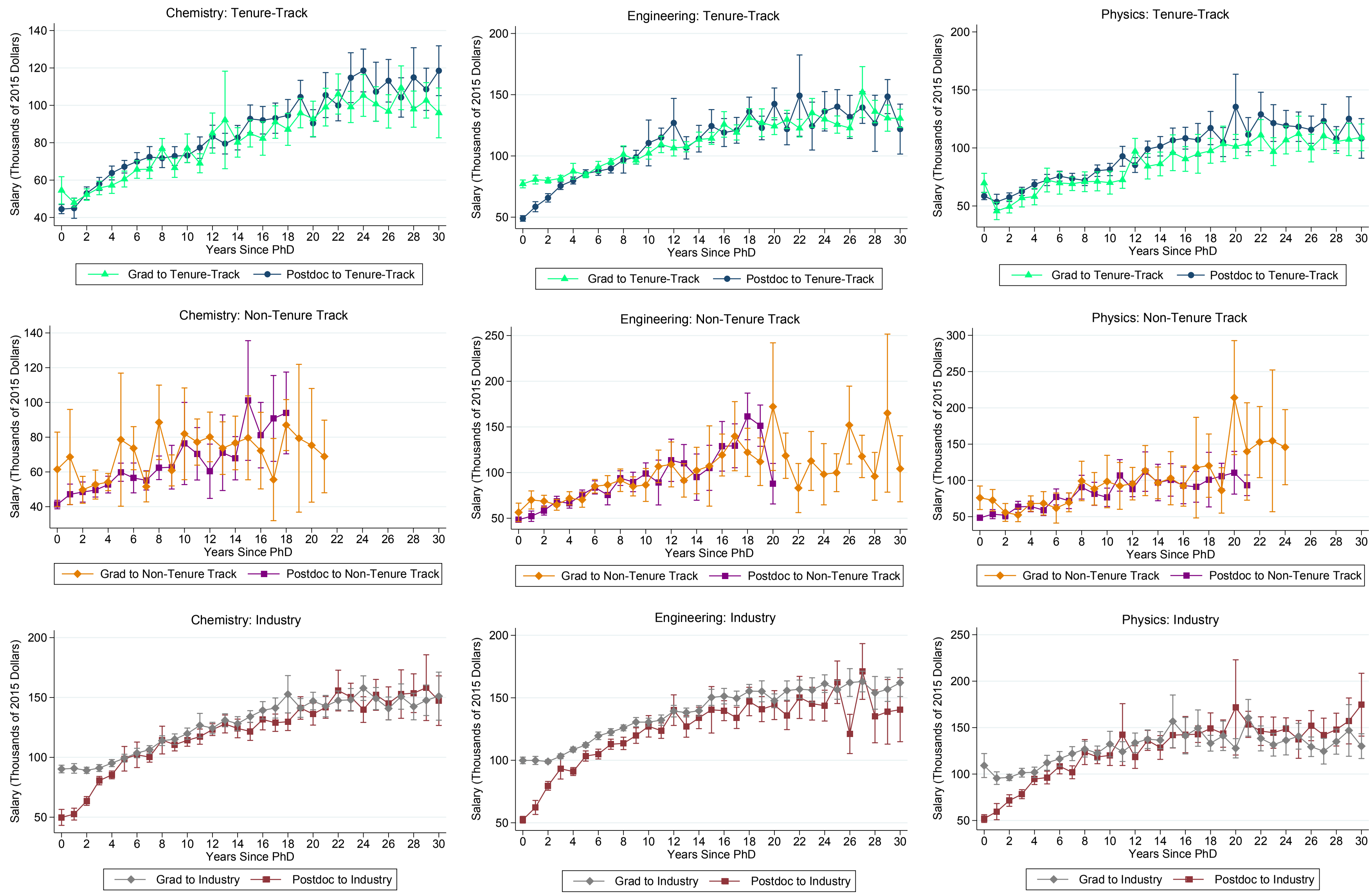
Notes: This graph gives 95% confidence intervals for the inflation-adjusted salary during the survey period (1993-2015) of chemistry (top), engineering (middle), and physics (bottom) Ph.Ds. in six job types - postdoctoral researcher, academic tenure-track, academic non-tenure track, for-profit industry, non-profit, and government - grouped by years since Ph.D. graduation.

Figure B.14: Average Salary in Each Year Since First Permanent Job by Postdoctoral Path



Notes: These graphs give the average salary in tenure-track (top row), non-tenure track (middle row), and industry (bottom row) jobs for the first thirty years after starting a non-postdoctoral job type among chemistry (left column), engineering (middle column), and physics (right column) Ph.Ds., grouped by whether the individual pursued any postdoctoral experience. The first permanent job year is the Ph.D. graduation year for individuals transitioning directly from graduate school and is the last postdoctoral appointment year for individuals transitioning from a postdoctoral position.

Figure B.15: Average Salary in Each Year Since Ph.D. Graduation by Postdoctoral Path



Notes: These graphs give the average salary in tenure-track (top row), non-tenure track (middle row), and industry (bottom row) jobs for the first thirty years after Ph.D. graduation amonng chemistry (left column), engineering (middle column), and physics (right column) Ph.Ds., grouped by whether the individual pursued any postdoctoral experience.