

Postdoctoral research training and the attainment of faculty careers in social science and STEM fields in the United States

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Abstract

Purpose – While postdoctoral research (postdoc) training is a common step toward academic careers in science, technology, engineering and mathematics (STEM) fields, the role of postdoc training in social sciences is less clear. An increasing number of social science PhDs are pursuing postdocs. This paper aims to identify factors associated with participation in postdoc training and examines the relationship between postdoc training and subsequent career outcomes, including attainment of tenure-track faculty positions and early career salaries.

Design/methodology/approach – Using data from the National Science Foundation Survey of Earned Doctorates and Survey of Doctorate Recipients, this study applies propensity score matching, regression and decomposition analyses to identify the role of postdoc training on the employment outcomes of PhDs in the social science and STEM fields.

Findings – Results from the regression analyses indicate that participation in postdoc training is associated with greater PhD research experience, higher departmental research ranking and departmental job placement norms. When the postdocs and non-postdocs groups are balanced on observable characteristics, postdoc training is associated with a higher likelihood of attaining tenure-track faculty positions 7 to 9 years after PhD completion. The salaries of social science tenure-track faculty with postdoc experience eventually surpass the salaries of non-postdoc PhDs, primarily via placement at institutions that offer relatively higher salaries. This pattern, however, does not apply to STEM PhDs.

Originality/value – This study leverages comprehensive, nationally representative data to investigate the role of postdoc training in the career outcomes of social sciences PhDs, in comparison to STEM PhDs. Research findings suggest that for social sciences PhDs interested in academic careers, postdoc training can contribute to the attainment of tenure-track faculty positions and toward earning relatively higher salaries over time. Research findings provide prospective and current PhDs with information helpful in career



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planning and decision-making. Academic institutions, administrators, faculty and stakeholders can apply these research findings toward developing programs and interventions to provide doctoral students with career guidance and greater career transparency.

Keywords Doctoral students, Postdoctoral training, Faculty positions, Social science, STEM

Paper type Research paper

Introduction

Although postdoctoral research (postdoc) scholar positions are often considered as an important step toward obtaining tenure-track faculty and academic research positions in many science, technology, engineering and mathematics (STEM) fields (Sauermann and Roach, 2016; Stephan, 2013; McConnell *et al.*, 2018), the role of postdoc training in the career trajectories of PhDs in social science fields is less clear (Cavanaugh, 2018; Nerad and Cerny, 1999; Stephan, 2013). Norms for postdoc training, a “temporary and defined period of mentored advanced training to enhance [...] professional skills and research independence” (National Science Foundation [NSF], 2007; NSF, 2009, p. II-37) have not yet been widely established in social science fields (Hanchane and Recotillet, 2003; National Research Council [NRC], 2010). Rather, it has been more common for social science PhDs to directly begin their careers in more permanent positions (Neumann and Tan, 2011). In recent years, the number of social science postdocs in the USA has been growing, with a 35% increase from 2000 to 2010 (Einaudi *et al.*, 2013). For context, recent data from the NSF indicate that as of 2018, the percentage of doctorate recipients in social sciences and psychology (combined) who planned for postdoctoral training was 39.2% (NSF, 2020). Still, little is known about the relationship between postdoc training and the early career outcomes of social science PhDs. With the increasing number of social science PhDs choosing postdoc positions at the start of their post-PhD careers, it is critical to understand the role of postdoc training in their long-term career trajectories, so as to provide prospective PhDs with >more information regarding employment outlooks and greater career transparency. Therefore, we examine the factors associated with the attainment of postdoc positions, as well as the relationship between postdoc training and subsequent career outcomes for social science PhDs, in comparison to PhDs in STEM fields in the USA.

Previous studies have highlighted the importance of studying the career outcomes of postdocs by field of study (Horta, 2009; Kahn and Ginther, 2017). Here, we focus on social science fields, which include anthropology, economics, geography, linguistics, political science, public policy and sociology, in comparison to STEM fields, which include computer and information sciences, engineering and mathematics. Although we are primarily interested in the social sciences, we use these particular STEM disciplines as a reference group because postdoc training in these STEM disciplines are also increasingly becoming more important in their graduates’ pursuit of academic careers. Yet, unlike the social sciences, there is a longer-standing tradition of postdoc training in these STEM fields.

Our study thus extends the literature on the role that postdoc training plays in the academic career trajectories of social science PhDs. We examine a nationally representative sample of social science and STEM PhDs from the NSF’s Survey of Earned Doctorates (SED) and Survey of Doctorate Recipients (SDR). We focus on PhDs who earned their doctorates from US institutions and who hold post-PhD positions in the USA Using propensity score matching, logistic regression, linear regressions and decomposition analyses, we address the following research questions:

RQ1. Which individual- and departmental-level factors are associated with participation in postdoc training?

RQ2. Are PhDs with postdocs more likely to attain tenure-track faculty positions than non-postdoc PhDs?

RQ3. How does postdoc training link to early-career salary among PhDs in tenure-track positions?

Our study extends the literature on occupational change and provides insights for educators, institutions, doctoral students and social scientists regarding the role of postdoc training in the career trajectories of social sciences, as well as STEM, PhDs. Research findings provide prospective social science PhDs, employers and other stakeholders with critical information regarding the outlook for postdoc training and its role in the long-term career paths of social science PhDs. Our findings also provide critical foundational information for academic institutions, PhD programs and stakeholders toward enhancing social science postdoc programs that resonate with workforce demands.

Background/literature review

Patterns of postdoctoral research training

The population of postdoc scholars continues to grow in both social science and STEM fields. While only 24.1% of social science and psychology PhDs held postdoc positions in 1998, this percentage increased to 39.2% in 2018 (NSF, 2020). Meanwhile, 19.7% of engineering PhDs and 22.3% of mathematics and computer sciences PhDs planned to pursue postdoc training in 1998, compared to 34.2% of engineering PhDs and 32% of mathematics and computer sciences PhDs in 2018 (NSF, 2020).

The rise in the number of social science postdocs, as in other fields, can be attributed to factors such as shifts in funding mechanisms for academic research (Britt, 2012; Foley, 2013); the increasingly adverse job market conditions for tenure-track faculty positions (American Association of University Professors, 2018; Cantwell and Taylor, 2015; Fernandes *et al.*, 2019; Kezar and Sam, 2010; Neumann and Tan, 2011; Stephan and Ma, 2005); and growing enrollment in graduate degree programs (Arbeit and Kang, 2017; Einaudi *et al.*, 2013). The proportion of PhDs who take postdoc positions also tends to vary due to economic conditions. For example, increases in the number of postdocs occurred following economic downturns, such as those in 1993, 2003 and 2010 (National Bureau of Economic Research, 2012).

Factors associated with the pursuit of postdoctoral research

Previous studies have found that across fields of study, participation in postdoc training is associated with factors such as nationality, age, sex and family status (Felisberti and Sear, 2014; Helbing *et al.*, 1998; Main *et al.*, 2018; Stephan and Ma, 2005). In general, PhDs who are men, unmarried and younger are more likely to take postdoc positions (Hanchane and Recotillet, 2003; Stephan and Ma, 2005; Yang and Webber, 2015). In contrast, women PhDs – especially those with family obligations, such as caring for young children – are less likely to take postdoc positions (Helbing *et al.*, 1998; Lin and Chiu, 2016; Main *et al.*, 2018; Yang and Webber, 2015). Of note is that temporary visa holders are more likely to take postdoc positions (Stephan and Ma, 2005). PhD candidates who take more time to complete their degrees are also more likely to plan for a postdoc position (Lin and Chiu, 2016).

STEM PhDs who have indicated aspirations for academic research careers are also more likely to pursue postdoc training (Nerad and Cerny, 1999; Sauermann and Roach, 2016; Stephan, 2015). Based on their 2013 survey, Sauermann and Roach (2016) found that respondents predominantly considered postdoc training to help increase their chances of getting a job that they desired, particularly a tenure-track faculty position. Similarly, Stephan (2015) found that interest in science and aspiration for a research career play

important roles in taking a postdoc position. Participation in postdoc training may also be driven by opportunities to enhance research skills, build the number of publications and expand social networks (Horta, 2009; Recotillet, 2007; Stephan and Ma, 2005). On the other hand, with an increasingly competitive job market (Cantwell and Taylor, 2015), taking a postdoc position could also reflect a lack of alternate job opportunities (Lin and Chiu, 2016).

Career outcomes of postdoctoral research training

Although evidence on the effect of postdocs on salary 3–15 years after PhD completion is limited (Recotillet, 2007; Yang and Webber, 2015), postdoc experience appears to correlate with research productivity (Horta, 2009; Yang and Webber, 2015) and the likelihood of a career in academic research (Hanchane and Recotillet, 2003; Kahn and Ginther, 2017; Lin and Chiu, 2016). Several studies have reported differential effects of postdoc training across demographic groups. In particular, postdoc training benefits women, racially minoritized PhDs and international PhDs to a lesser extent in terms of advancing to an independent research career compared to their respective counterparts (Eisen and Eaton, 2017; Gibbs *et al.*, 2016; Meyers *et al.*, 2018; Nerad, 2004; Nerad and Cerny, 1999).

Relatively few studies have examined the effect of postdoc experience in the social sciences. Of these, Horta (2009) found that, in Mexico, postdoc experience is associated with a higher number of book publications among social science faculty. Hanchane and Recotillet (2003) found that, in France, postdoc training increases the chances of obtaining a research career for those in the natural sciences; however, such training decreases the chances for those in human and social sciences. In this study, we focus on social science postdoc scholars using data from the USA.

Data and context

Our data come from the NSF SED and SDR surveys, as well as from the NRC doctoral program rankings (NRC, 2010). The NSF SED is an annual census of all recipients of a research doctorate from an accredited US institution. The data set includes respondents' educational histories, demographic characteristics and post-graduation plans. The SDR, which is conducted every 2 to 3 years, provides employment histories of a sample of PhDs from the SED. We obtained research activity rankings for each doctoral program from the NRC. We then merged the NRC, SED and SDR data to generate a comprehensive data set that includes individual- and departmental-level variables.

Although the NSF SDR is widely known as a survey of PhD recipients in science, engineering and health sciences, it also includes data from psychology and social sciences. To determine which programs to include in the “social sciences” category of our study, we followed the designations used in the NSF report on “Doctorate Recipients in the Social, Behavioral and Economics Sciences: 2017” (National Center for Science and Engineering Statistics, 2020). We also used the Classification of Instructional Programs (CIP) as a general reference to categorize each PhD program as a social science field or as a STEM field (Morgan and Hunt, 2002; Ingels *et al.*, 2011). Our resulting social science fields include anthropology, economics, geography, linguistics, political science, public policy and sociology, whereas our STEM fields encompass computer and information sciences, engineering and mathematics. We did not include biomedical and life sciences in our analyses, as postdoc training in these fields has a longer duration compared to other fields and is largely considered a required step in academic careers (Kahn and Ginther, 2017). Moreover, Mitic and Okahana (2020) reported that two-thirds of biological and life sciences PhDs in faculty positions had taken a postdoc position, half of which lasted more than five years. We also did not include psychology in our analyses because its designation has

shifted over time to a STEM field (American Psychological Association, 2010). Similarly, the economics discipline for social sciences does not include econometrics or quantitative economics, as they are both now designated as STEM (CIP codes; Redden, 2018).

We identified postdoc scholars as PhDs who indicated “postdoctoral fellowship” or “postdoctoral research associateship” as their post-PhD plan in the SED, regardless of the employment sector of the postdoc. A limitation associated with our study is that while survey respondents completed the SED shortly before PhD completion, and thus their response best reflects their post-PhD plans at that time point, there is a possibility that the respondent’s post-PhD plan may have changed from what they reported. For context, NSF provides statistics on the distribution of employment sectors among postdocs in federally funded research and development centers (FFRDCs). In 2013, 46% of postdocs were in university-administered FFRDCs, 26% in nonprofit-administered FFRDCs and 29% in industry-administered FFRDCs (Hinz *et al.*, 2019).

We limited our sample to individuals who reported working full time and responded to at least two waves of the SDR as follows: 1 to 3 years after their PhD completion and again 7 to 9 years after their PhD completion. Until 2008, the SDR was limited to US-trained PhDs who primarily resided in the USA. Therefore, our analyses focus on PhDs who earned their degrees from US institutions and then remained in the USA for post-PhD work. Both US citizens and non-US citizens who received their degrees from non-US institutions are not included in our study. We note that the National Postdoctoral Association (2017) estimates that about 55% of the postdoc scholars working in the USA hold temporary visas and while the present study does not examine their career trajectories, future work will investigate the experiences and outcomes of international scholars.

We examined the factors associated with participation in postdoc training using the SED (1985–2013), and then used the merged SED and SDR (1993–2013) data to examine career outcomes of postdoc scholars versus non-postdoctoral scholars (non-postdocs). Our resulting sample includes 1,949 social science and 9,980 STEM PhDs, out of which 242 and 2,926 planned for postdocs, respectively. Table 1 provides summary statistics of the NSF SDR (1993–2013) sample. Although the proportion of men and women social science PhDs is relatively similar in the social sciences, the proportion of women PhDs in STEM fields is much smaller at 19%. PhDs in both the social science and STEM fields tend to be White, US citizens or permanent residents and to have attended mid-ranked NRC institutions. In terms of primary financial support during the doctoral program, 25.4% of social science PhDs received teaching assistantships compared to 14.6% of STEM PhDs. Meanwhile, 42.4% of STEM PhDs and 11.7% of social science PhDs received research assistantships.

Methods

Factors associated with the attainment of postdoctoral research positions

To examine factors associated with the attainment of postdoc positions, we estimated a binary choice model with the dependent variable of whether a PhD planned to take a postdoc position. We estimated logistic regression models for social science and STEM fields separately, using the following equation:

$$\text{Ln}\left(\frac{p_i}{1-p_i}\right)X_i\beta + u_i, \quad (1)$$

where p_i is the probability that individual i planned to take a postdoc position, X_i is the set of the individual- and departmental-level characteristics described below (and summarized in Table A1) and u_i is an error term.

Variable	Social sciences		STEM	
	<i>n</i>	(%)	<i>n</i>	(%)
<i>Gender</i>				
Male	1,026	52.6	8,094	81.1
Female	923	47.4	1,886	18.9
<i>Race/ethnicity</i>				
White	1,183	60.7	5,671	56.8
Asian	303	15.5	2,783	27.9
URM	463	23.8	1,526	15.3
<i>Citizenship</i>				
US citizen or permanent resident	1,692	86.8	7,498	75.1
Temporary resident	257	13.2	2,482	24.9
<i>Major</i>				
Anthropology	269	13.8		
Economics	500	25.7		
Geography	87	4.5		
Linguistics	124	6.4		
Political science	348	17.9		
Public policy	90	4.6		
Resources/agricultural econ	73	3.7		
Sociology	458	23.5		
Engineering			5,126	51.4
Computer science			718	7.2
Math			752	7.5
Physical science			3,384	33.9
<i>Primary financial support</i>				
Savings/earnings	486	24.9	1,161	11.6
Fellowship/grant	400	20.5	1,186	11.9
Research assistantship	229	11.7	4,231	42.4
Teaching assistantship	495	25.4	1,460	14.6
Other support	339	17.4	1,942	19.5
<i>Graduation term</i>				
Spring/Summer	1,136	58.3	5,493	55
Fall	502	25.8	2,882	28.9
Other	311	16	1,605	16.1
<i>NRC program ranking</i>				
Top ranked	286	14.7	1,885	18.9
Mid ranked	1,464	75.1	7,178	71.9
Not ranked	199	10.2	917	9.2
<i>Father's education level</i>				
High school or unknown	871	44.7	4,450	44.6
Bachelor's degree	380	19.5	2,334	23.4
Graduate degree	698	35.8	3,196	32
<i>Mother's education level</i>				
High school or unknown	1,130	58	6,072	60.8
Bachelor's degree	398	20.4	2,159	21.6
Graduate degree	421	21.6	1,749	17.5

Table 1.
Description of the
1993–2013 NSF SDR
sample

(continued)

Variable	Social sciences		STEM	
	<i>n</i>	(%)	<i>n</i>	(%)
<i>Marital status at the time of PhD</i>				
Married	1,152	59.1	5,728	57.4
Not married	797	40.9	4,252	42.6
<i>Dependent under age 6 at time of PhD</i>				
0	1,842	94.5	9,644	96.6
1 or more	107	5.5	336	3.4
Post-PhD				
<i>Post-PhD employment</i>				
Postdoc	242	12.4	2,926	29.3
Non-postdoc	1,707	87.6	7,054	70.7
Total	1,949	100	9,980	100

Table 1.

Individual-level characteristics. In terms of demographic characteristics, the models include gender, race/ethnicity, US citizenship or permanent resident status, age at the time of PhD completion and parental education levels, as past literature shows these characteristics are relevant to postdoc employment (Felisberti and Sear, 2014; Helbing *et al.*, 1998; Main *et al.*, 2018; Stephan and Ma, 2005; Yang and Webber, 2015). The models also incorporate several family-related variables, including marital status and number of young children (under age 6) in the household at the time of PhD completion (Hanchane and Recotillet, 2003; Helbing *et al.*, 1998; Lin and Chiu, 2016; Stephan and Ma, 2005; Yang and Webber, 2015). To account for the potential role of parenthood in the career trajectories of men and women, we interacted gender with the marital and young dependents variables. Consistent with previous research, we also included time to degree as years between enrollment and graduation (Lin and Chiu, 2016). To examine the relationship between doctoral research experience and post-PhD employment, we followed Sauermann and Roach's (2016) approach and used the primary financial support during doctoral training to proxy for the level of doctoral research experience. Previous studies have also found the source of financial support to be associated with access to academic careers (Fernandez, 2019; Main and Wang, 2019).

Departmental-level PhD program characteristics. A doctoral program's characteristics may also influence a student's decision to pursue postdocs (Austin, 2002). Students' perception of departmental norms regarding career choices can influence their career choices (Roach and Sauermann, 2010). To proxy for the social influence and employment culture of a PhD's doctoral program, for each individual in our sample, we calculated the fraction of the five previous PhD cohorts' placements in the different employment sectors (academia, industry, government or postdoc position).

We included a measure of doctoral program research quality from the NRC research activity rankings. This variable provides further information regarding the departmental research environment and prestige (Burris, 2004). For each program's research activity ranking, the NRC provides the 5th and 95th percentiles of its rank received from all raters who rated the programs in a given field. We averaged the two percentiles to obtain a single measure for each program's research ranking, "NRC Ranking." Our models have the following three groups: top-ranked (top 10 percentiles); mid-ranked (11th–100th percentiles); and not ranked. In addition, we have constructed the NRC ranking variable as continuous

and categorical (based on deciles or quartiles of the ranking) and we find similar results, regardless of how we define this variable.

Postdoctoral research training and attainment of tenure-track faculty positions

To examine the relationship between postdoc training and the attainment of tenure-track faculty positions, we estimated the linear probability model as follows:

$$\hat{p}(Y_i = 1) = \beta_0 + \beta_1 \text{postdoc}_i + u_i \quad (2)$$

where Y_i is a binary variable that equals 1 if individual i obtained a tenure-track job 7 to 9 years after graduation, and 0 otherwise; postdoc_i is a binary variable that equals 1 if individual i planned a postdoc position upon PhD graduation and 0 otherwise and u_i is an error term.

Attainment of a postdoc position is not random, as it depends on a set of the individual- and departmental-level factors, as well as the job market environment. To the extent that the determinants of postdoc attainment are comparable between those who participated in postdoc training and those who did not (that is, the participants and nonparticipants differ only in postdoc training status), we can estimate the effect of postdoc training on subsequent career outcomes. To estimate β_1 , we first matched the participants and nonparticipants of postdoc training on the propensity score of receiving postdoc training, such that the covariates of postdoc training are balanced between postdoc participants and nonparticipants. We applied both unweighted one-to-one matching and weighted matching based on the inverse probability of treatment. We restricted our sample to postdoc scholars and non-postdocs whose initial job placement was not in a tenure-track faculty position. In [Figure A1](#), we use kernel density plots to show that the propensity score matching procedures improved the balance between the sample of postdoc scholars and non-postdocs for the social sciences (Panel A) and STEM (Panel B) groups. Although we balanced our groups based on the observable factors to mitigate potential bias in postdoc training and career outcomes, there may still be unobservable factors correlated with both postdoc training and subsequent career outcomes, such as career preferences and other employment opportunities. As such, our estimates are considered correlational rather than causal.

Postdoctoral research training and early career tenure-track faculty salary

To examine the extent to which postdoc training enhances the labor market returns of PhDs who pursued academic career paths, we compared the salary trajectories of postdocs and non-postdocs eventually used in tenure-track faculty positions in three sets of analyses. First, we compared the average salary in tenure-track positions between PhDs with and without postdoc training. In doing so, we regressed earned salary on the number of years in the tenure-track position, conditional on postdoc experience and controlling for other individual- and departmental-level factors described in [equation \(1\)](#). Using estimates from the regression, we then predicted salary with all of the control variables held constant at the mean, varying only postdoc experience and the number of years in the tenure-track position. Estimates based on the weighted and unweighted matching were consistent; thus we based our regressions only on the unweighted matched sample.

Because postdocs tend to earn relatively lower salaries than tenure-track faculty, we also examined the opportunity costs associated with taking a postdoc position after PhD completion and the number of years it takes to compensate for the salary loss ([Krueger, 1999](#); [Murnane and Olsen, 1989](#)). We regressed salary on the number of years, as PhD completion for those who worked as tenure-track faculty at 7 to 9 years after PhD

completion, conditional on postdoc experience and other control variables described in [equation \(1\)](#). We then calculated the salary loss in each year and the number of years it takes before the average salaries of former postdoc scholars and non-postdocs break even.

Salary decomposition for social science tenure-track faculty

To understand the channels through which postdoc training affects the salary of tenure-track faculty in social sciences, we decomposed the salary gap between former postdoc scholars and non-postdocs in tenure-track faculty positions over seven groups of observable covariates as follows: demographic information; characteristics of employer institution; PhD program ranking; field of study; years of experience; tenure status; and research productivity. For all individuals who ever reported to be tenure-track faculty in the SDR, we first identified their starting year, that is, the first survey wave in which they indicated to be tenure-track faculty and obtained their salary information after 7 to 9 years in the tenure-track position (as opposed to 7 to 9 years after PhD completion). We then estimated the unconditional and conditional salary gaps in the set of equations as follows:

$$Y_i = \gamma^{base} postdoc_i + u_i$$

$$Y_i = X_i\beta + \gamma^{full} postdoc_i + u_i \tag{3}$$

where Y_i is the annual salary in 2013 dollars of individual i after 7 to 9 years in a tenure-track faculty position and X_i includes seven groups of covariates that control for demographic information (gender and race/ethnicity); characteristics of employer institution (including the academic institution’s Carnegie classification, whether the employer academic institution is a public institution and the geographic region of institution); PhD program (NRC ranking of the PhD program); experience (number of years since PhD completion); tenure status; and research productivity measured by the number of articles published or accepted averaged over years reported and normalized by field.

We then decomposed the total salary gap, that is, the difference between γ^{base} and γ^{full} . The decomposition follows the method proposed in [Gelbach \(2016\)](#) and applied by [Li and Koedel \(2017\)](#). Assuming the full model in [equation \(3\)](#) is well-specified, then decomposition of $\gamma^{full} - \gamma^{base}$ is equivalent to decomposing the omitted variable bias, which can be achieved by running auxiliary regressions of each group of covariates on $postdoc_i$. To calculate group-specific components of omitted variable bias, [Gelbach \(2016\)](#) proposed creating a heterogeneity variable for each group g as follows: $H_{(i)}^g = \sum_{k \in group\ g} X_{k(i)} \hat{\beta}_{k(i)}$, where k is the k th covariate in group g . We then conducted an auxiliary regression for each group and recorded the coefficient estimate for the respective group-level variable.

Results

Factors associated with the attainment of postdoctoral research training

[Table 2](#) presents the estimated marginal effects of factors associated with postdoc training. Marginal effects are calculated as the partial effects evaluated at the mean level of each covariate. Overall, for social science and STEM fields, PhDs who pursue postdoc training appear to have greater indicators for academic research career trajectories. Social science PhDs with more research experience during doctoral training (as evidenced by primary financial support through fellowships/grants or research assistantships), as well as those who graduated from PhD programs with top NRC research ranking, are more likely to take postdoc positions compared to those supported by personal funds and those who graduated

Table 2.
Marginal effects of
factors associated
with postdoc
attainment

Variable	Social Sciences		STEM	
	(1)	(2)	(3)	(4)
<i>Individual factors</i>				
Female	-0.006 (0.005)	-0.006 (0.005)	-0.019*** (0.003)	-0.023*** (0.004)
Temporary resident	0.059*** (0.005)	0.059*** (0.005)	0.144*** (0.002)	0.171*** (0.003)
Asian	0.054*** (0.006)	0.053*** (0.006)	-0.005* (0.002)	-0.006** (0.003)
Black	0.061*** (0.008)	0.061*** (0.008)	-0.019*** (0.007)	-0.023*** (0.008)
Hispanic	0.027*** (0.007)	0.027*** (0.007)	0.024*** (0.005)	0.028*** (0.006)
Other race	0.023** (0.009)	0.023** (0.009)	0.03*** (0.006)	0.036*** (0.007)
Married	-0.027*** (0.004)	-0.027*** (0.004)	-0.039*** (0.002)	-0.047*** (0.003)
Dependent < 6	-0.018** (0.007)	-0.018*** (0.007)	-0.005 (0.004)	-0.006 (0.005)
Married*Female	0.009 (0.006)	0.009 (0.006)	0.009* (0.005)	0.011* (0.006)
Dependent < 6 at Grad. *Female	0.018 (0.012)	0.019 (0.012)	0.023** (0.009)	0.027** (0.011)
Time to degree	-0.007*** (0.001)	-0.007*** (0.001)	-0.009*** (0.001)	-0.011*** (0.001)
<i>Primary financial support</i>				
Fellowship/grant	0.065*** (0.006)	0.068*** (0.007)	0.17*** (0.005)	0.199*** (0.007)
Research assistantship	0.083*** (0.007)	0.084*** (0.008)	0.147*** (0.004)	0.177*** (0.006)
Teaching assistantship	-0.009* (0.005)	-0.007 (0.006)	0.073*** (0.005)	0.085*** (0.006)
<i>Institutional factors</i>				
Previous Cohorts' Job Placement				
Prev. Postdoc	0.278*** (0.016)	0.276*** (0.016)	0.289*** (0.005)	0.346*** (0.006)
Prev. Academia	-0.055*** (0.012)	-0.056*** (0.012)	-0.011* (0.006)	-0.013* (0.007)
Prev. Industry	-0.031 (0.029)	-0.032 (0.03)	-0.205*** (0.007)	-0.242*** (0.008)
Prev. Government	-0.055** (0.027)	-0.053* (0.027)	0.011 (0.011)	0.012 (0.013)
<i>NRC program ranking</i>				
Top ranked	0.022*** (0.005)	0.038*** (0.013)	0.01*** (0.003)	0.058*** (0.015)
Not ranked	-0.014** (0.005)	-0.014 (0.012)	-0.011*** (0.003)	-0.057*** (0.013)
<i>Primary financial support*NRC program ranking</i>				
Fellowship/grant*not ranked		-0.013 (0.016)		0.08*** (0.018)
Research assistantship*not ranked		0.025 (0.019)		0.088*** (0.016)
Teaching assistantship*not ranked		-0.005 (0.018)		0.048*** (0.016)
Fellowship/grant*top ranked		-0.014 (0.012)		-0.025 (0.015)
Research assistantship*top ranked		-0.02 (0.014)		-0.063*** (0.014)
Teaching assistantship*top ranked		-0.014 (0.014)		-0.011 (0.017)
Observations	54,143	54,143	236,512	236,512

Notes: *, ** and *** denote statistical significance at the 10, 5 and the 1% levels, respectively. Standard errors are in parentheses. Major, degree year and parents' education level are included in the models but not shown in the table. The category "Other support" in primary financial support is not reported in the table

from mid-ranked programs, respectively. Results for STEM PhDs are qualitatively consistent with those for social science PhDs.

The job placements of previous PhD cohorts from the same doctoral program are also strong predictors of a PhD's post-graduation employment. A one-standard deviation increase in the fraction of job placement as postdocs in previous cohorts is associated with a

28% point likelihood of postdoc training in the social sciences and 35% points in STEM. Placement in the academic sector and government positions in previous cohorts are both associated with 6% points lower likelihood in postdoc training in the social sciences.

The estimates on other control variables are largely consistent with findings from previous literature (Stephan and Ma, 2005; Yang and Webber, 2015). Asian, Black and Hispanic/Latinx PhDs in social sciences are more likely to attain postdoc positions compared to their White counterparts, all else held constant. That is, relative to their representation in the PhD population, Hispanic/Latinx PhDs are more likely than White PhDs to become postdoc scholars in the social sciences. This trend is also evident among Hispanic/Latinx PhDs in STEM fields. Further, women STEM PhDs with young children are relatively more likely than men PhDs who reported not having young dependents at the time of PhD completion to obtain postdoc positions.

Postdoctoral research training and attainment of tenure-track faculty positions

Table 3 presents the estimated average treatment effect of postdoctoral training on the likelihood of attaining tenure-track faculty positions 7 to 9 years after PhD completion. With the observable factors related to postdoc training balanced between postdocs and non-postdocs, we found evidence of an increased likelihood of obtaining tenure-track faculty positions associated with postdoc training. Among social science PhDs who did not start as tenure-track faculty upon PhD completion, postdoc training is associated with a higher likelihood of obtaining tenure-track positions (by 11% points based on unweighted matching and 16% points based on weighted matching). For STEM PhDs, we found the effect to be 14% points (unweighted) and 13% points (weighted).

Postdoctoral research training and early career salary among tenure-track faculty

Figure 1 shows the projected tenure-track faculty salary for postdocs and non-postdocs. Up to six years in tenure-track faculty positions, there is no statistically significant salary gap between former postdoc scholars and non-postdocs in either social science [Figure 1(a)] or STEM faculty [Figure 1(b)]. However, over time, the salary gap between social science postdocs and non-postdocs in tenure-track faculty positions widens and becomes statistically significant. The same pattern is not found among STEM PhDs in tenure-track faculty positions.

To calculate the current value of initial salary loss due to postdoc training at the time of PhD graduation (rather than a permanent position), we followed Krueger (1999) and assumed a 3% real discount rate. For social science tenure-track faculty, we found that the initial salary loss is recovered 5 years after PhD graduation, with the total salary loss prior to the break-even point calculated at approximately US\$31,100. For faculty in STEM fields, the salary loss due to postdoc training is recovered around 3 years after PhD completion,

Variable	Social Sciences		STEM	
	Unweighted	Weighted	Unweighted	Weighted
Postdoc Training	0.111** (0.064)	0.163*** (0.058)	0.143*** (0.014)	0.130*** (0.014)
Observations	188	187	2,313	2,322

Table 3. Postdoc training on the likelihood of obtaining tenure-track faculty position 7–9 years after PhD

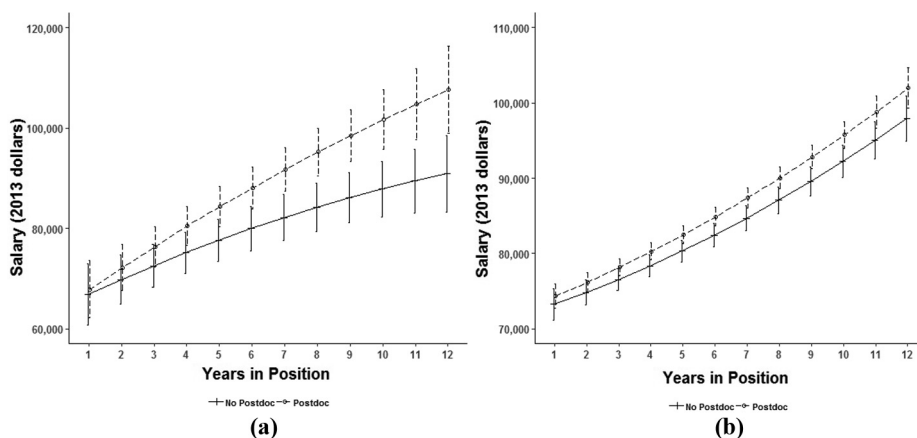
Notes: *, ** and *** denote statistical significance at the 10, 5 and the 1% levels, respectively. Standard errors are in parentheses. Postdoc and non-postdoc groups are matched on the propensity score of obtaining postdoc training. Weighted matching is based on the inverse probability of obtaining postdoc training. The numbers of social science and STEM postdocs are 108 and 1,424, respectively

with total salary loss calculated at approximately US\$4,200. The shorter average time needed for STEM PhDs to recover the salary loss is likely due to postdocs being more customary in some STEM fields, especially in mathematics and physics.

We next explored the factors that explain the widening salary difference over time between former postdoc scholars and non-postdocs among tenure-track faculty. Unconditional salary regressions of equation (3) show a statistically significant salary gap for social science faculty 7 to 9 years in their positions and no significant gap for STEM faculty. Therefore, we only performed a decomposition of the salary gap for the social sciences. To interpret the salary gap decomposition results in Table 4, a positive coefficient estimate indicates the group of covariates explains the salary gap, whereas a negative coefficient estimate indicates that the variation in the group of covariates helps narrow the salary gap. Our primary finding is that among the seven groups of covariates, employer institution explains the greatest proportion of the salary gap, indicating that postdoc experience may be associated with higher salaries because those with postdoc experiences are more likely to be placed at academic institutions that provide relatively higher salaries, such as Research I universities. Tenure status at 7 to 9 years in the faculty position also explains a positive, albeit a smaller portion of the salary gap. This is consistent with tenured faculty earning, on average, higher salaries than those who are not yet tenured. Research productivity as measured by the number of articles published contributes to the salary gap negatively, indicating that PhDs who do not have postdoc experience can overcome the salary gap with higher research productivity.

Discussion

By contrasting the social science fields with STEM fields, we provide a more comprehensive examination of the role of postdoc training in the career trajectories of social science PhDs who earned their degrees from US institutions. Our findings show that for both social science and STEM fields, PhD graduates with greater research experience based on the source of doctoral program funding, as well as higher NRC program research ranking, are more likely to obtain postdoc training. We also found that for both social sciences and STEM fields, PhD graduates who identified as Hispanic/Latinx are relatively more likely than White PhDs to attain postdoc positions. Postdoc experience in social science and STEM fields appears to increase the likelihood of obtaining a tenure-track faculty position, suggesting that, on average, postdoc



Notes: (a) Social sciences; (b) STEM

Figure 1.
Predicted salary in
2013 dollars of
postdocs and non-
postdocs 1–12 years
in tenure-track
faculty position with
95% confidence
bands. Notes: (a) Social
sciences; (b) STEM

training prepares an individual for a career in academic research. For social science tenure-track faculty, the projected salary grows faster for former postdoc scholars after six years in the position, despite a relatively higher initial salary loss due to postdoc training. In STEM fields, although the initial salary loss is lower, postdoc training does not enhance salary growth later in the career. The differential effects of postdoc training on tenure-track faculty salary between social science fields and STEM fields are likely due to the difference in the importance of postdoc training between the two groups of fields.

In fields where postdoc training is less customary, such as in the social sciences, the additional training as a postdoc appears to enhance labor market returns for PhDs pursuing academic careers. On the contrary, in STEM fields where postdoc training is much more prevalent toward obtaining tenure-track faculty positions, postdoc training does not significantly add to labor market returns. For social science tenure-track faculty, postdoc experience is associated with higher subsequent salary primarily through placement in higher-paying academic institutions. However, for non-postdocs, the salary gap due to lack of postdoc experience is mitigated with higher research productivity.

For social science and STEM PhDs who are interested in careers in academic research, especially those who already possess relatively high research experience, but desire additional training beyond the doctoral program, postdoc training is likely to provide a foundation for a career as an academic researcher. In the social sciences, postdoc experience may help facilitate job placement in more prestigious and higher-paying institutions. As such, for social science PhDs with aspirations for tenure-track faculty careers, postdoc training can be helpful in achieving career goals and enhancing monetary outcomes, especially among those aiming to increase their number of publications. For institutions that employ social science postdocs, our findings suggest that, on average, such employment can be beneficial for the participants provided that they are interested in academic careers.

Decomposition component	Estimates	Percentage explained (%)
Demographic	95.54 (258.85)	1.65
Employer institution	6,556.88*** (1,670.9)	112.91
PhD program rank	566.85 (763.67)	9.76
Field	-2,214.3 (1,691.04)	-38.13
Experience	-147.67 (208.18)	-2.54
Tenure status	1,674.54** (831.48)	28.84
Productivity	-724.53** (346.5)	-12.48
Total gap	5,807	

Table 4.
Decomposition of salary gap by postdoc experience among tenure-track faculty

Notes: *, ** and *** denote statistical significance at the 10, 5 and the 1% levels, respectively. Standard errors are in parentheses. Salary gap between tenure-track faculty in social sciences 7 to 9 years into their faculty career, between former postdocs and non-postdocs. Covariates in each group for decomposition are: Demographics (gender and race/ethnicity); Employer Institution (Carnegie classification, public/private, and geographic region); PhD program NRC ranking; Experience (years since PhD); Tenure status; Productivity (number of articles published or accepted averaged over years reported and normalized by field)

Limitations

Our empirical analyses have several limitations. We defined postdoc scholars using information from both the SED and the SDR. While the SED reports PhD post-graduation plans, it is unclear whether there might have been changes in the PhD's plans for post-graduation employment. While the SDR reports employment information, the first SDR wave is conducted around two years after PhD graduation, by which time a large proportion of postdoc appointments may have concluded. For the same reason, we are not able to determine the exact length of the postdoctoral training. In addition, by analyzing separate samples of social sciences and STEM PhDs, we are not able to perform direct comparisons of the parameter estimates across the two groups of fields.

Our results speak only to the returns to postdoc training among PhDs who earned their degrees from US institutions and who pursued postdoc training in the USA. As a large proportion of postdoc scholars did not receive their degrees from US institutions, future work should investigate the returns to postdoc training for this group. Given the existing data, it is also difficult to attach causal relationships between postdoc training and subsequent career outcomes. Several factors, such as individual motivation and interest, correlate with both postdoc employment and career outcomes and we are not able to fully observe or measure these factors. We used propensity score matching to help address this selection issue. Identifying causal effects of postdoc training would entail access to a much richer data environment such as information on individual history of academic achievement, job applications, interviews and job offers, as well as institutions providing postdoc positions. Our results should thus be interpreted as correlational. Nevertheless, the NSF SED and SDR are two of the most comprehensive data sets available for examining the career outcomes of PhDs and we used both sources of information to provide insights regarding postdoc placement and subsequent employment outcomes.

Conclusion

Postdoc positions have become increasingly common in social science fields, where norms of postdoc training have not yet been well-established and where empirical evidence is still sparse regarding its role in participants' long-term career development. With more newly minted social science PhDs taking postdoc positions, we examined the factors associated with postdoc attainment and their subsequent career outcomes in the context of PhDs who received their degrees and worked in the USA. Our findings provide doctoral programs and their prospective graduates with a career outlook for postdoc scholars, especially those with career interests in academia.

Our findings indicate that similar to STEM fields, postdoc scholars in social science fields are characterized by relatively greater research experience. They are also more likely to graduate from departments with a greater proportion of previous cohorts placed in postdoc positions. These findings are consistent with previous studies of postdoc scholars in STEM fields, which have found that, to a large extent, postdoc training is taken by PhD graduates with relatively greater interest in academic research careers (Sauermaun and Roach, 2016). Postdoc training is associated with a greater likelihood of attaining tenure-track faculty positions compared to PhDs with initial positions in other employment sectors (e.g. industry or government).

We also found that for tenure-track faculty in the social sciences, postdoc training is associated with a higher average salary – a trend not found in STEM fields. The primary channel leading to the salary gap is that former postdocs are able to obtain tenure-track faculty positions at institutions associated with higher salaries. Given our data, we make two conclusions as follows: participation in postdoc training in both social science and STEM fields is associated with compatibility with academic research careers and postdoc

training can help facilitate the establishment of academic careers as tenure-track faculty members. In social science fields, participation in postdoc training can also help facilitate securing tenure-track faculty positions at institutions with higher salaries.

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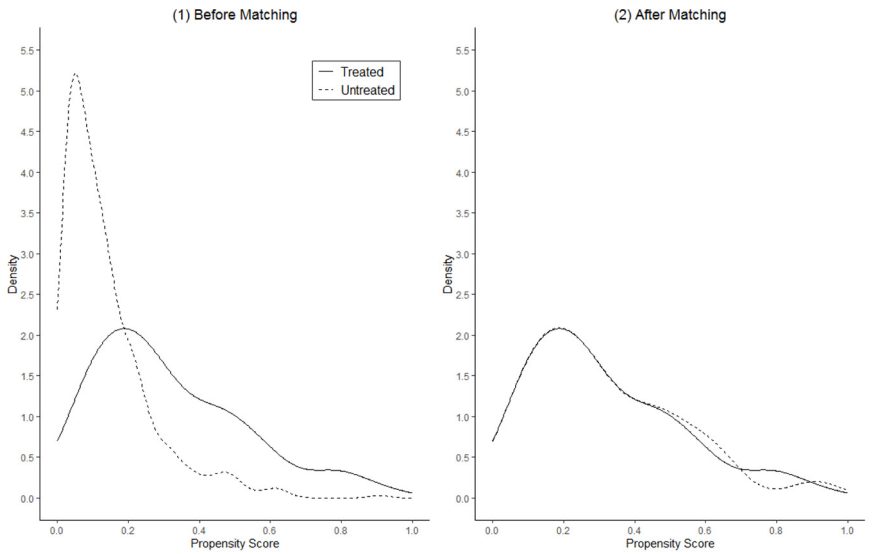
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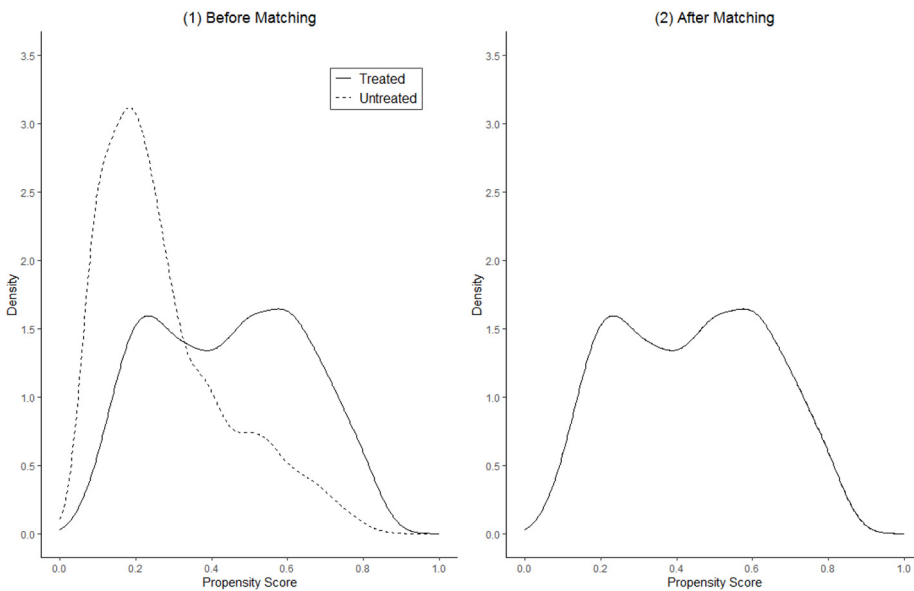
Joyce B. Main can be contacted at: jmain@purdue.edu

Variable	Type	Description
<i>Gender</i>	Categorical	Reference category: Male
<i>Race/ethnicity</i>	Categorical	Reference category: White
<i>Citizenship</i>	Categorical	Reference category: US citizen or permanent resident
<i>Major</i>	Categorical	Reference category: Social sciences – Anthropology; STEM – Engineering
<i>Age at degree</i>	Continuous	Age doctoral degree is awarded
<i>Degree year</i>	Continuous	Academic year doctoral degree is awarded
<i>Time to degree</i>	Continuous	Number of years between doctoral program entry and completion
<i>Prev. Postdoc</i>	Continuous	Average fraction of doctorate recipients in the same department in the five previous cohorts with initial placement as postdoc
<i>Prev. Academia</i>	Continuous	Average fraction of doctorate recipients in the same department in the five previous cohorts with initial placement in academia (including tenure track and non-tenure track positions)
<i>Prev. Industry</i>	Continuous	Average fraction of doctorate recipients in the same department in the five previous cohorts with initial placement in industry
<i>Prev. Government</i>	Continuous	Average fraction of doctorate recipients in the same department in the five previous cohorts with initial placement in the governments
<i>Primary financial support</i>	Categorical	Reference category: Other support
<i>Graduation term</i>	Categorical	Term that doctoral degree is granted – Fall (December–January); Spring/Summer (May–August); Other (all other months). Reference category: Fall
<i>NRC program ranking</i>	Categorical	Ranking of doctoral program's research activity within its subfield group by the NRC. Reference category: Not ranked
<i>Father/mother's education level</i>	Categorical	Reference category: High school or unknown
<i>Marital status</i>	Binary	=1: Married at the time of doctorate awarded
<i>Dependent < 6 at Grad.</i>	Categorical	Reference category: Have no child below age six in the household at the time of doctorate receipt

Table A1.
Variable description



(a)



(b)

Figure A1.
Kernel density plot of
the propensity score
before and after
matching

Notes: (a) Social science; (b) STEM