What do we know about careers of STEM PhDs?

Daniela Klammer
Short answer

- Little is known about where research-funded PhD’s go when they graduate and enter the private sector, and even less is known about the characteristics of the businesses that employ them.
- European universities only recently started tracking their alumni, mostly on an institutional level
- Look up academic society for career statistics
- In the US mostly law and business schools have provided such data, but science departments usually don’t provide such data
Science PhD Career Preferences: Levels, Changes, and Advisor Encouragement
H. Sauermann, M. Roach, Plos ONE, https://doi.org/10.1371/journal.pone.0036307

- Large-scale survey among PhD students at 39 tier-one US research universities in spring 2010
- 4109 participants (59% life sciences, 18% chemistry, 23% physics)
Career attractiveness

Little difference between career attractiveness between early and late stage PhD students
Encouragement from advisors, lab, or department
US STEM PhD holders academic/non-academic positions (2010)
Council of Graduate Schools: PhD Career Pathways 2019

• Little is known about job transitions PhD degree holders experience
• Understanding PhD Pathways for Program Improvement tried to explore this
• Looks into current and immediate prior jobs of PhD holders 3 y (cohort A), 8 y (cohort B) and 15 y (cohort C) ago
Career changes

• No surprise: job changes more often at the beginning of the career
Movement between sectors

- More people move from academia to BGN
- But: There are also people who move back
Big differences btw OECD countries

Figure 12. Percentage distribution of 1990-2006 doctoral graduates by sector of employment 2006

Note: 2005 for Belgium. See also Footnote 2.

Figure 24
Median expected basic annual salary of doctorate recipients with definite commitments in the United States, by position type and broad field of study: 2019

- Life sciences
- Physical sciences and earth sciences
- Mathematics and computer sciences
- Psychology and social sciences
- Engineering
- Education
- Humanities and arts
- Other non-S&E fields

S&E = science and engineering.

Note(s):
Definite commitment refers to a doctorate recipient who is either returning to predoctoral employment or has signed a contract (or otherwise made a definite commitment) for employment, including postdoctoral study, in the coming year and plans to stay in the United States. Industry includes all nonacademic sectors, including self-employment, private for-profit and private nonprofit, and government.

Source(s):
APS - Employment
Field of Physics PhDs 1 year after degree

The majority of potentially permanent positions accepted by physics PhDs were in fields other than physics

Classes of 2013 & 2014 combined
AMS – BIG Career Data

- A quarter of 2006-07 PhD graduates work in BIG environment
AMS – math PhDs conferred vs open positions
US market for scientists and engineers

Some historical data

Figure 7.3. Job position by field, five- and six-year cohort, 1973–2006. Source: National Science Foundation (2011b). The use of NSF data does not imply NSF endorsement of the research methods or conclusions contained in this book.
European Science Foundation

- 9 institutions participated
- Participants received PhD between 2010 and 2016
- 2046 complete responses
- 23% of those who received survey invitation
2017 Career Tracking Survey

- High rates of employment
- Majority working on permanent contract
- 80% working as researchers
- Jobs partly related to PhD for majority of respondents working in business/industry/non-profit sector

- Slightly over half of those in academia employed on permanent contract
- Universities and academic sector main destination (62%)
- Relative smooth job transition
- 40% holding a job at completion of PhD; for the rest it took on average 4 months
- Researchers felt more prepared for first job, job perspectives were clearer
Figure 13: The average rated benefits of doctorate degree for career development among researchers and non-researchers

- My doctorate properly prepared me for my first job
- My doctorate enabled me to progress towards my desired career
- My doctorate allowed me to offer added value to the organisation/company where I work
- It was clear to me what career opportunities I could aspire to after my doctorate
- If I could restart my career, I would do my doctorate again
- The transition to my first job after doctorate was difficult
- Having a doctorate made no difference to my career path

Mean agreement by engagement in research
(1: Strongly disagree ... 4: Strongly agree)

- Engaged in research
  (n=1533-1546)
- Not engaged in research
  (n=374-381)

Note: Only employed respondents are included in the analysis.
Figure 21: Minimum education requirement for current job by sector of employment
Figure 32: Job satisfaction: researchers vs. non-researchers

<table>
<thead>
<tr>
<th>Category</th>
<th>Engaged in Research (n=1579)</th>
<th>Not Engaged in Research (n=387)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Career growth opportunities</td>
<td>3.4</td>
<td>2.9</td>
</tr>
<tr>
<td>Intellectual challenge</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Contribution to society</td>
<td>3.2</td>
<td>3.1</td>
</tr>
<tr>
<td>Organisation/job prestige</td>
<td>3.2</td>
<td>3.1</td>
</tr>
<tr>
<td>Organisational culture</td>
<td>3.1</td>
<td>2.8</td>
</tr>
<tr>
<td>Job security/stability</td>
<td>3.4</td>
<td>2.8</td>
</tr>
<tr>
<td>Salary</td>
<td>3.1</td>
<td>2.8</td>
</tr>
<tr>
<td>Mentoring and training</td>
<td>2.9</td>
<td>2.7</td>
</tr>
<tr>
<td>Work/life balance</td>
<td>3</td>
<td>3.1</td>
</tr>
<tr>
<td>Proximity to family</td>
<td>3.1</td>
<td>2.9</td>
</tr>
</tbody>
</table>
Figure 35: Plans to change career in next three years by sector of employment
Vitae career survey (2016): What do researchers do next?

- 78% of participants aspired an academic career
- 24% aspire research career outside of HE
- 11% non-research career outside of HE

Most common reasons for leaving (selection):
- Better job security
- Better work-life-balance
- Difficulty to get funding
- Better work environment
- Better salary
- Wanting to do something other than research
High level of satisfaction with current job and current career aspirations:

- > 4/5 respondents satisfied in current work/job:
  half of these reported being ‘very satisfied’, with no significant gender difference.
- < 1/20 respondents were ‘not at all’ satisfied, citing various reasons, such as preferring to go back to HE research, work not sufficiently challenging, dissatisfied with salary, employment conditions, job security, management or nature of work.

The long-term career aspirations of respondents had changed significantly since being employed in HE research:

- Only 18% continued to have aspirations for an academic career.
- Most common career aspiration was for a non-research career outside HE, selected by one-third of respondents.
- Aspirations to self-employment/running own business/consultancy, and other role in HE both more than quadrupled to around a fifth of all respondents noting each career as an aspiration.
An evidence-based evaluation of transferrable skills and job satisfaction for science PhDs


Overall job satisfaction

PhDs employed in RI and NRI employment categories reported comparable levels of job satisfaction, challenging the prevailing notion that RI careers provide maximal career fulfillment for PhDs. Level of satisfaction is consistent with other recent national data sets (e.g., the 2013 Survey of Doctorate Recipients) which shows that scientists across the country and across occupations are largely satisfied with their work.
Careers of IST postdocs

Career objective of IST postdocs

- Anything/ Everything: 65%
- Career in Industry (e.g. quality control, software development, sales, ...): 20%
- Permanent research position in academia other than PI: 7%
- Permanent research position in industry other than PI: 4%
- PI position in academia: 3%
- PI position in industry: 1%

Next Step after IST Austria

- Academia: 67%
- Faculty: 28%
- Business and Industry: 21%
- Postdoc: 20%
- Group leader: 14-6%
- Other position in academia: 13%
- Info Not Public: 10%
- Public Service: 5-2%

2017 survey

2019 alumni data, N=425
Ph.D. Long-term Career Outcomes

2014-15 Ph.D. degree recipients five years out - data collected in 2020

Career Outcomes - Graduate School Overall

- Nonacademic: 41%
- Tenure-track faculty: 35%
- Post-doctoral: 4%
- All other post-secondary academic: 11%
- Unknown: 9%

371 Ph.D. recipients

Career Outcomes by Division

<table>
<thead>
<tr>
<th>Division</th>
<th>% of Nonacademic</th>
<th>% of Tenure-track faculty</th>
<th>% of Post-doctoral</th>
<th>% of All other post-secondary academic</th>
<th>% of Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>Humanities</td>
<td>5%</td>
<td>23%</td>
<td>48%</td>
<td>15%</td>
<td>10%</td>
</tr>
<tr>
<td>Social Sciences</td>
<td>1%</td>
<td>10%</td>
<td>57%</td>
<td>24%</td>
<td>8%</td>
</tr>
<tr>
<td>Natural Sciences</td>
<td>6%</td>
<td>11%</td>
<td>23%</td>
<td>50%</td>
<td>11%</td>
</tr>
<tr>
<td>Engineering</td>
<td>2%</td>
<td>26%</td>
<td>59%</td>
<td>9%</td>
<td>10%</td>
</tr>
</tbody>
</table>
Current Positions of Students who Graduated 2009-2013

- Faculty 26%
- Industry/Biotech 22%
- Research Staff 12%
- Postdoc 9%
- Education 6%
- Medicine 2%
- Consulting 4%
- Finance 6%
- Other 13%
Why have career prospects changed so much?
Growth of faculty positions vs PhDs awarded (US)
Increase in postdoc positions

The number of researchers in US postdoctoral positions has more than tripled since 1979. The vast majority of postdocs are in the life sciences. Across fields, median salaries for postdocs are outstripped by those for non-postdoc positions, when measured up to 5 years after receiving a PhD.

Nature 520, 144–147 (09 April 2015)
Biomedical fields show biggest increase

Source: Biomedical Research Workforce Working Group, NIH, Summer 2012
Also: More funding for project-based science

• Research important factor for economic growth
Investing in research

- Last two decades have seen a sharp increase in budgets of funding agencies
- Research important contribution to economic growth
- R&D is needed to solve large societal and environmental problems
- Focus on excellence: competitive funding via funding agencies to increase research output
Similar development in the US

Massive increase of NIH
Increase on national level

- Budgets of many national research agencies have increased
- Often increase is not considered to be enough
Third factor: Rise of non-tenure track positions

• Rise in PhD graduates allows universities to employ temporary lecturers
• US universities cover a lot of teaching by adjunct faculty
• German speaking universities cover a considerable part of teaching via “Privatdozenten” and “external lecturers”
• Universities under financial stress can cut costs
• Cheaper, more flexible
Higher budgets for funding agencies: Bottleneck situation

- Discussed in literature and in the media
- Possible reason: Politics mainly cares about unemployment rates
- Unemployment rates among PhD holders are low → no reason to act
- PhD holders moving to industry/business sectors are important for innovation chain
- Little known about business/industry demands for PhD holders (do PhDs displace masters?)
Unemployment rates
Various countries, OCED working paper 2010
Career satisfaction of postdoctoral researchers in relation to their expectations for the future

• Survey among 225 postdocs at two Dutch universities across all fields
• 85% want to stay in academic field, only <3 % was offered a tenure-track position
  • Comparable to postdocs employed in the UK and Japan, where 78 and 75 %, respectively, aspire to stay in academia (CROS 2013; NISTEP 2008)
  • IST survey: 85% want to stay in academia
• Uncertainty of their future prospects in academia lowered their job satisfaction
• Only few of the postdocs spent time in preparing for a career outside academia, and less than a third attempted to develop any transferable skills, although the importance of networking was recognized
• Almost half of postdoc did not attend any training module or course during their postdoc period
Hanging tough: post-PhD researchers dealing with career uncertainty

• Two types of uncertainty:
  • Intellectual uncertainty (am I a good enough scientist?)
  • Career uncertainty (will I be able to find a permanent position?)

• High level of stress and anxiety

• Career trajectories complex process of three interwoven work strands: intellectual, networking, and institutional
  • Intellectual: developing research expertise, establish credibility as researcher
  • Networking: local, national, international relationships, known in scientific community, establish collaborations
  • Institutional: formal affiliation, institutional responsibilities, access to career development initiatives, grant offices

• Difficulty to imagine oneself as anything other than academic researchers
Perceived career prospects and their influence on the sector of employment of recent PhD graduates


- Intellectual challenge and autonomy are key values that keep people in science
- Situation somewhat similar to the arts

| Table 3. Job attributes that played a role in job choice by sector of employment |
|---------------------------------|-----------------|----------------|-----------------|-----------------|-----------------|
| Job attributes                  | Sector of employment |               |                |                |                |
|                                 | Academia | Non-ac. res. | Outside res. | Total | p-value         |
| Relating to intellectual development and job content |                |               |                |       |                |
| Intellectual challenge          | 87       | 80            | 68             | 83    | < 0.001        |
| Degree of independence          | 76       | 65            | 57             | 70    | < 0.001        |
| Possibility to develop new skills | 69      | 75            | 62             | 70    | 0.038          |
| Creativeness                    | 66       | 61            | 39             | 62    | < 0.001        |
| Level of responsibility         | 57       | 64            | 57             | 59    | 0.087          |
| Contribution to society         | 49       | 58            | 55             | 52    | 0.022          |
| Social status                   | 20       | 21            | 23             | 21    | 0.605          |
| Infringement on personal life   | 20       | 17            | 18             | 19    | 0.435          |
| Workload                        | 17       | 17            | 21             | 17    | 0.596          |
| Relating to terms of employment |                |               |                |       |                |
| Opportunities for career advancement | 50        | 45            | 43             | 47    | 0.218          |
| Job security                    | 28       | 37            | 43             | 33    | 0.002          |
| Salary                          | 24       | 43            | 38             | 31    | < 0.001        |
| Travelling distance             | 26       | 29            | 37             | 28    | 0.084          |
| Job opportunities within organization | 19        | 32            | 24             | 23    | < 0.001        |
| Benefits                        | 21       | 28            | 17             | 22    | 0.024          |
| Availability of permanent jobs within the organization | 21        | 25            | 21             | 22    | 0.301          |
| Personal and family-related circumstances | 25        | 17            | 17             | 22    | 0.010          |
| Organization's HRM and career policy | 8         | 18            | 11             | 11    | < 0.001        |

N.B. Percentages may not add up to 100 due to rounding. P-values from Pearson’s chi-squared test of independence between sector of employment and job attribute playing a role in job choice.
Remarks

• Social sciences paper often have a focus on how researchers are doing, evaluating and experience their situation → more critical of academic system

• Reports with a focus on employment/salary statistics merely ask about employment → overall tone is positive
Research Culture: A survey-based analysis of the academic job market

- Survey of applicants for faculty positions
  - Between May 2018 and May 2019
  - 317 responses

- above a certain threshold, the benchmarks traditionally used to measure research success – including funding, number of publications or journals published in – were unable to completely differentiate applicants with and without job offers

- respondent pool was notably enriched in applicants who received at least one off-site interview (70%) → people who are successful are more likely to participate

- Men reported significantly more first-author publications, total publications, overall citations, and a higher h-index compared to women
Candidates who received offers typically submitted more applications.

Population split in 2 groups: <15 applications, > 15 apps

Respondents who submitted more than 15 applications had a significantly higher average number of off-site interviews.

71% of applicants did not apply for other jobs and these applicants had a small, but significant increase in offer percentage.

Lower correlation between application number and offers (compared to application number and interviews) suggests other criteria (e.g. the strength of the interview) are important in turning an interview into an offer.
• Majority (74%) of respondents were not an author on a CNS paper, and yet most participants received at least one offer (58%).

• Applicants with CNS paper did have higher number of onsite interviews and faculty job offer percentage.

• Total number of publications, number of first author publications, number of corresponding author publications, and h-index did not significantly correlate with offer percentage.

• Approximately 55% of respondents were applying for the first time, and these candidates fared significantly better in terms of offer percentages than those who were applying again.

• Preprints were perceived to be important to show productivity if work is not yet published.
• Significant differences between men and women!
What the committee members say matters to them
Darby Saxbe @darbysaxbe - 20 Nov 2019
I'm on a search committee this year, and we just rejected some amazing candidates for our faculty position. Important PSA: it's not personal. A rejection is (truly) not a referendum on you or your skills/qualifications. More often than not, the decision comes down to fit. 1/

Darby Saxbe @darbysaxbe - 20 Nov 2019
Maybe your work is great, but someone else in the department is already doing something similar. Or maybe no one here is doing work like yours and the department would rather consolidate its strengths than branch out in a new direction. Maybe someone is retiring and we want to 2/

Darby Saxbe @darbysaxbe - 20 Nov 2019
replace them. Maybe we need a certain course covered. These are factors that you can never fully anticipate, and they shift throughout the process. That is, of course, incredibly frustrating for candidates— but hopefully also comforting to keep in mind. During our search, for 3/

Darby Saxbe @darbysaxbe - 20 Nov 2019
every person we interviewed, there were at least five who would have been terrific additions to our department. Ultimately there's a larger systemic problem— too few tenure-line jobs out there for the incredible candidates on the market.

Darby Saxbe @darbysaxbe - 20 Nov 2019
What can candidates do? Accept that there are aspects of the process you can’t control, and exert control over the parts you can. Make your research statement engaging and clear so that it stands out from the statements we are slogging through. Use active verbs & avoid jargon. 5/

Darby Saxbe @darbysaxbe - 20 Nov 2019
Get multiple people to read yr materials to catch errors. Show you’ve done yr homework on the dept. Name specific programs, initiatives, & collaborators that would draw you here. But most of all, know that whatever is going on behind the scenes has nothing to do with your worth!
A. “What was helpful for your application?”

Funding
Networking
Preprints
Presubmission-Feedback
Pedigree
CNS-papers
Research-Fit
Teaching-Certificate
Luck
Conferences
Connections
Grant-Writing
Papers
Lab-Pedigree

B. “What was an obstacle for your application?”

No-Funding
No-Feedbak
Few-Papers
Language-Harrier
Having-Family
Maternity-Leave
No-CNS-Papers
Poor-Mentorship
Nepotism
Citizenship-status
Interdisciplinary-research

C. “What is your general perception of the entire application process?”

Unpredictable
Non-ordinary-requests
Information-Sparse
Biased
Difficult
Frustrating
Stressful
Futile
Depressing
Painful
Awful
System-not-working
Despair
Demeaning
Burdens-on-research
Time-Consuming
Black-box
Not-Healthy
Isolating
No-Mentorship
Not-centralized
Teaching

- The degree of teaching experience did not change based on target institution of applicant,
- Percentage of offers received did not significantly differ between groups based on teaching experience
- Bias?
Publication metrics and success on the academic job market
van Dijk, O. Manor, L.B. Carey, Current Biology Vol 24 No 11, R516

• Machine learning approach to predict who becomes a PI
• Data from over 25,000 scientists in PubMed
• Publications matter
• Higher h-index, actual number of publications is less predictive, journal impact factor seems to be more important, best: cites/IF because number of citations of a paper is correlated with journal IF
• Good news: Many scientists who become PIs never published in a high impact factor journal; these however publish more 1st author papers, per year
• More 1st or 2nd author publications helps
• More middle author publications no help
Publication metrics and success on the academic job market
van Dijk, O. Manor, L.B. Carey, Current Biology Vol 24 No 11, R516

- Short pre-PI career scientists have different publication behavior than longer pre-PI career authors
  - More than 7 y to PI: more citations per paper (important papers in low IF journals, becoming PI takes longer)
- University rank is predictive of becoming a PI independent of other publication features
- PIs increase their ranking in first five years, decline is not helpful
- Men are overrepresented as PIs, even after correcting for all other publication and non-publication derived features
• Clear differences in bibliometric criteria

• Possible differences to survey: a lot of graduate students and postdocs may never enter the academic job market
Systematic inequality and hierarchy in faculty hiring networks

*Science Advances* 12 Feb 2015: Vol. 1, no. 1, e1400005

DOI: 10.1126/sciadv.1400005
Summary & take away messages

• Faculty jobs are the alternative career.
• Within a dire academic job market, IST alumni are doing well.
• Hoping for a time when the academic job market will be better is unrealistic.
• Creating more permanent positions is needed, but will not be a solution for everyone.
• Situation is now recognized, but universities have not fundamentally changed curricula.
• Academic job market does not appear to be random.
• Publishing in a CNS journal is not a must.
• Thorough evaluation of career plans 5 years after PhD advisable in the life sciences.
• Submit enough applications!
• Heuristic knowledge compatible with statistics.
• Vast majority of people enjoy their lives outside the ivory tower.