

Ready to fly the nest? How autonomy provisions and mobility requirements shape researchers' early career choices

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Abstract:

The increasing reliance on postdoc positions has been a source of concern in many countries. At the same time, postdoctoral positions have increasingly become a necessary ticket of entry for tenured positions in academia, especially in STEM disciplines. We leverage rich and detailed population-level data to analyze the determinants of early-career choices of PhD graduates in Denmark within all fields. We analyze the effects of a systemic change of funding for postdoc positions away from individual postdoc grants towards (predominantly) embedded postdocs and (few) international mobility grants. We argue this is associated with a general loss of autonomy for researchers in junior positions and our findings suggest that the change may have contributed to recent trends in PhD graduates' preference for industry over academia. On the contrary, we find no evidence of any significant "brain drain" abroad as a result of this change in postdoc funding regime.

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On January 30th 2020, the World Health Organization Director General declared the novel coronavirus outbreak a public health emergency of international concern, WHO's highest level of alarm. The COVID19 pandemic has been a global health crisis without precedents. The scientific response to this crisis has also been without precedents, with an effective vaccine developed in record times, showing clearly how society's future and development is dependent on knowledge produced by science. If the large and sometimes unexpected challenges society is facing require the production of ground-breaking scientific insights, the question of where these bold and revolutionary ideas come from is therefore of paramount importance.

Who is more likely to produce breakthroughs that challenge the existing paradigms and status quo?

Across different settings, we generally see new entrants, even outsiders, take on that role, while incumbents suffer from inertia. This is also the case in science, where individual scientific trajectories tend to be stable over scientists' lifetimes, and breakthrough discoveries often originate from young "outsiders", early on in their scientific careers. Given these observations, the question becomes if the current funding system of universities is correctly designed to increase the probability of novel science being produced.

One key area where funding could make a difference is the support to young researchers, the "entrants" who theoretically have the highest chance and desire to produce novel science. The current system based on competitive funding tends to privilege postdoctoral positions that are part

of larger research projects, in labs managed by senior scholars. Senior researchers seek funding for projects, and when they obtain it they act as Principal Investigators (PIs) in those projects, being responsible for hiring and managing postdoctoral researchers (among other things), who conduct their work inside the more or less flexible boundaries of the defined, funded projects. PIs are often what we describe as “incumbents” and their work tends to exhibit a high degree of path dependency, as scientific trajectories are sticky and following previous lines of work is often the best strategy to get one’s project funded.

As block funding of universities decreases, researchers rely more on competitive sources of funding that usually do not provide salaries for permanent positions, but are rather “soft” money, paying for salaries for temporary positions, including postdoc positions and non-tenure track assistant professorships. This type of postdoctoral positions has therefore proliferated (Powell, 2015; Heggeness et. al. 2017; Kahn & Ginther, 2017; Hayter & Parker, 2019). A number of criticisms have surrounded this form of employment, such as reduced salaries (Russo, 2008; Kahn & Ginther, 2017; Athanasiadou, 2018; Sainburg, 2023; Yalcin et. al., 2023), and lack of job security (Nerad & Cerny, 1999). One important aspect that has not been investigated so far is the specific conditions of the postdoctoral positions and how they affect the composition of the junior scientific workforce. While postdoctoral positions are indeed characterized by a high level of uncertainty regarding future employment prospects in academia, some of them provide more than just additional training and temporary employment. In particular, in many countries local and

international funders (in the EU that is the case of the Marie Curie fellowships) provide specific instruments for postdoctoral researchers, where the postdoc themselves are the initiators of the grant. While still limited in time, these postdoctoral grants come with a much higher degree of independence (the researchers are still hosted in a lab, but they need to come up with a proposal to submit to the funding agency), providing a signal to future employers about the ability of an individual to attract research funds. However, these grants often come with international mobility requirements, such as the Marie Curies grants offered by the European Research Council (ERC), or the Fulbright Program. Such programs are rationalized on the premise that mobility is inherently beneficial for science, facilitating exposure to diverse perspectives, fostering collaborations, providing access to resources and networks, and enhancing the prestige of researchers. However, this emphasis on mobility presents a tradeoff for early career academics, who tend to be at the family formation and expansion ages. Therefore, not all researchers are equally able or willing to relocate, making grants' mobility requirement a potential barrier to retention of non-mobile groups in academic science. At a systemic level, the loss of talent may lead to the loss of valuable ideas and expertise from certain demographic groups, also known in the literature as the lost Einsteins or Marie Curies. At the same time, these grants have the added benefit of allowing early career academics to pursue their research ideas, and set their own research agenda. This feature could be critical when aiming to retain individuals with a higher 'taste for science', those who are motivated by the promise of intellectual exploration and discovery. Therefore, when facing an early career

choice, individuals are asked to balance, based on their preferences, between their desire to promote their own line of research, and the need to move in the case of international mobility requirements. Moreover, constraints on academic freedom may alter the calculus for early career academics weighing the decision between pursuing an academic or industry position, potentially shifting the tipping point towards industries that offer greater autonomy and flexibility in research pursuits. These different grant conditions have the potential to attract and retain different types of individuals in academia, ultimately affecting the type of science that is going to be produced in the long term.

In this paper we use an unexpected change in the Danish funding system regarding funding to postdocs to investigate the question of how the interplay of provision of autonomy and mobility requirements affect the employment choices of young researchers. For several years, the Danish Research Council (DFF) awarded individual postdoctoral grants where the postdoctoral researcher was directly the PI. Those grants presented a very similar, if not identical, employment situation to any other postdoc position in the country (that were usually embedded in larger projects led by a tenured PI) in terms of length and salary but provided higher autonomy and a signal of the ability to attract research funding. In 2016, these grants were unexpectedly removed from the portfolio of available funding instruments, following a reduction in the budget for the Research Council. Starting from that year, the scope for obtaining individual postdoc fellowships in Denmark was

greatly reduced, as there were few additional equivalent grants recent PhD graduates could apply to independently, neither public nor private.

We study how this change is associated with the employment dynamics of the population of PhD graduates in Denmark over the period from 2013 to 2017. We leverage rich and detailed population-level data that relate PhD graduates within all fields to their educational and employment trajectories before and after completing their PhD. We study how changes in available funding for postdoc positions combine with demographic characteristics and individual performance metrics of PhD graduates to affect their early career outcomes. The main focus of the paper will be early-career academics during the period immediately following their PhD graduation and the role played by external funding in establishing opportunities at this critical junction of their future in academia.

Our main findings suggest that the shift of postdoc funding is associated with compositional effects among junior academics in Denmark: there is a positive time trend in the share of women among the SSH graduates who stay at a Danish university and the share of foreigners with a STEM-H background increases significantly more for university employees than for graduates in industry. For the performance indicator of having at least one publication before graduation, there is a negative time trend for STEM-H graduates in Danish universities, but no trend among graduates who go to industry. This is consistent with the shift in postdoc funding towards

embedded positions being associated with a relative strengthening of the academic credentials of (STEM-H) graduates who go to industry as compared to Danish universities. On the contrary, we find no evidence of any significant "brain drain" abroad because of the change in postdoc funding regime.

In the following, we first outline the Danish context of our analysis, including the structure of PhD education and the changing funding opportunities for postdoc positions in the country. We also provide the main descriptives of the population of PhD graduates in Denmark during the period considered and their employment dynamics. In the second part of the analysis, we compare the entry dynamics of early-career academics while comparing two contrasting funding environments pre- and post-2016, and the associated compositional changes.

Data and Context

We investigate these questions using a novel database combining registry data on the general population with data on PhD enrolments and graduations as well as academic employment, publications, and funding. This dataset allows us to precisely observe the full population of PhD graduates and their subsequent employment history, including embarking on an academic career after graduating from the PhD.

The population of PhD graduates

We base our analysis on the population of all PhD graduates from Danish universities. Their university records are collected in the government PhD registry by Statistics Denmark. During our period of investigation from 2013 through 2017, a total of 10,611 individuals who could be identified by their personal ID number, graduated from a Danish university.⁴ Overall, for the years considered here, the number of individuals graduating with a PhD is seen to be stable across years. In terms of their distribution across main fields, Table 1 shows that approximately 80 per cent of graduates are in a science, technology, engineering and mathematics or health-related field of study (STEM-H for brevity) whereas the remaining approximately 20 per cent graduate in a social science or humanities field (SSH for brevity).

< Table 1 about here >

From the PhD registry, we will be able to link individuals to the overall government registry information via their unique personal identification number.⁵ This link will allow us to precisely characterize the population of PhD graduates in key dimensions that are potentially important for their further career choices, although usually not accessible via university records, such as educational backgrounds, family relationships, or immigration status. We further enrich this data with individual information on publication records and academic job titles obtained from the wage bills of all university employees.

Key basic demographics of the population of PhD graduates are seen in Table 2. The gender distributions differ between main fields with STEM-H fields having a higher proportion of men

⁴ For the few cases of multiple PhD degrees obtained during this period, we kept the most recent one for our analysis.

⁵ Upon enrolment some foreign students were assigned a temporary ID which was subsequently not corrected when they received their permanent ID. These individuals could not be linked with other data sources.

than women whereas SSH fields have more women graduates (Table 2, Panels A and B, columns (1) and (2)). When distributed according to their country of birth, the PhD graduates also differ between main fields. STEM-H fields have more graduates born outside of Denmark (about 40 per cent) than do SSH fields. For both cases, the share of non-natives is increasing over the period considered.

< Table 2 about here >

A special feature of the Danish university system is that universities employ most PhD students on a scholarship whether their funding derives from block funding to the university from a government source or from an external grant to the university, typically from a private source. In either case, students are employed at the university of enrolment. This is the case for approximately two-thirds of all PhD students (Table 3). The remaining students will typically have an employment relationship either with another public institution, such as a hospital, ministry, or an independent research institute, or with a private firm. Only a small minority of students report no employment relationship upon enrolling into their PhD studies.

< Table 3 about here >

Upon graduating with a PhD, individuals (Table 4) are on average 34 years old (median age 32 years) and the age distribution appears stable over the period considered. Upon the year before graduating from their PhD, about 40 percent of graduates share their household with at least one child. Domestic students for whom we are in most cases able to register a high school GPA, have average GPAs that correspond to the 81st percentile of the overall distribution of GPAs in their high school cohorts (equivalent to 9.3 on the Danish “12” scale). Finally, it is about half of PhD students who manage to publish at least one journal article before the year of graduation.

< Table 4 about here >

Financing of PhD studies in Denmark

All Danish universities are public and most students in PhD programs enroll in a three-year program with no tuition. Students will in most cases obtain a government scholarship or a privately funded scholarship which is uniformly of approx. DKK 30,000 (USD 4,400) per month (pre-tax), approximately corresponding to the median (pre-tax) income. The scholarship is the basis of employment by the university on terms governed by a collective agreement with trade unions. The scholarship is limited to three years although some students will remain enrolled in the PhD program for longer. During any period of extension, students may retain university employment working as so-called “scientific assistants” on terms like the PhD scholarship, or they may remain unpaid by the university and complete their studies while having employment outside of the university. A minority of about 5 per cent PhD students are financed on the so-called “industrial PhD program” in which they are employed by a firm and partly financed by the government agency “Innovation Fund Denmark.”

Junior academic positions in the Danish university system

After having obtained their PhD, a person can be employed at a Danish university in a junior position as a postdoc or as an assistant professor. Postdoc positions typically span two or three years with few or no teaching or administrative obligations. Assistant professorships are associated with both research and teaching obligations. Most junior positions have traditionally not led to a tenure decision as tenured positions were filled by open calls. Danish universities have recently started introducing tenure-track assistant professorships, typically lasting six years. Since tenure-

track positions are relatively few in the period covered by our analysis and most assistant professorships do not lead to a tenure decision, we will refer to postdocs and assistant professorships jointly in our analysis as junior positions.

Funding of junior academic positions

There are three main sources of financing for junior positions at Danish universities. Assistant professorships are typically financed from university block funding. Postdoc positions are usually based on funding from external sponsors, including the Independent Research Fund Denmark (DFF), or from private foundations. These externally financed positions can be based on a stand-alone fellowship for which the junior academic is the primary investigator (“individual postdocs”), or they can be embedded in a research grant headed by a senior colleague (“embedded postdocs”).

During the period considered from 2013 to 2017, the DFF was the major public sponsor of researcher-initiated projects in Denmark, similar in its role to the NSF or the NIH in the US, or the British Research Councils. The DFF offered a portfolio of funding instruments across all scientific disciplines and covers both junior and senior academics. One program that has particular interest for our analysis is the “Individual Postdoc” program, offering postdoctoral fellowships across all scientific disciplines, typically of two years’ duration. During the period from 2011 and 2015, the program annually supplied between 130 and 170 fellowships (Figure 1). Fellowships for a given budget year were distributed over two annual rounds, both of which were announced in the annual call for applications issued in August of the previous year.

< Figure 1 about here >

The budget for DFF is set yearly by the Government. The significance of this became apparent when in 2016, the overall budget for the DFF was cut by approx. 25 per cent on the Government

budget. Adjusting the Fund's overall portfolio of instruments in response to this, the Board of DFF decided to abolish the "Individual Postdoc" program.⁶ The 2015/2016 DFF call for applications which was published in August 2015, had thus stipulated two deadlines, a Fall deadline by the end of October 2015 and a Spring deadline by the end of April 2016. Following the Government budget decision, the revised call for Spring 2016 that was issued in January 2016 excluded the Individual Postdoc instrument. The revised call also announced that the Government budget frames for 2017 and 2018 were to be similarly reduced and that changes were therefore to be expected. The permanent abolition of the "Individual Postdoc" program was confirmed when the DFF call for 2016/17 was announced in August 2016.⁷

The magnitude of the cutback due to the abolition of the "Individual Postdoc" program was significant. In terms of the number of postdoc fellowships awarded, it amounted to about 7 per cent when compared to the average number of PhD graduates from Danish universities during 2013, 2014, and 2015.

Starting in 2017, a new DFF program called "International Postdoc" was introduced. It was based on individual fellowships but unlike the previous program, it implied strict conditions of the awardee being internationally mobile for close to the entirety of the postdoc period. The scope of the program was much smaller; when announced for 2017, the expected scope was between 38 and 42 fellowships, although the actual number awarded that year was only 30; the number of grants has been 40 or less in subsequent years (Figure 1).

⁶ Danish Council for Independent Research: Call for proposals. Spring 2016 (revised January 2016). https://dff.dk/en/apply/application/calls/call-spring-2016_english-final-a-1.pdf

⁷ Danish Council for Independent Research: Call for proposals. Autumn 2016 and Spring 2017. <https://dff.dk/en/apply/application/calls/dff-call-autumn-2016-and-spring-2017.pdf>

An alternative source of financing for junior positions was the award to more senior primary investigators of larger so-called “project grants” in which there were embedded postdoc positions. Before 2016, the shares of individual and embedded postdoc positions in total DFF postdoc grants were fairly equal (Figure 1). With the abolition of the “Individual Postdoc” program in 2016, the distribution of DFF funded postdoc positions turned decisively towards embedded positions.

PhD graduates’ employment transition

As a descriptive measure to characterize the fairly stable funding environment that prevailed prior to the 2016 abolition of the DFF “Individual Postdoc” program, Figure 2 shows the fraction of the graduates in the 2013 PhD cohort who were employed in a main academic position with a Danish university. A “main” position would typically imply full-time employment by the university, such as PhD positions, postdocs, assistant/associate/full professorships. The “transition function” that illustrates the employment transition of PhD graduates will cover a time window extending from four quarters before the graduation quarter until eight quarters after. Assuming that the abolition of the program was unexpected, the 2013 cohort of PhD graduates will have remained unaffected throughout this window.

Panel A shows the full 2013 cohort with quarter “0” marking the official graduation. For most students, their employment relationship and the associated scholarship will end during the quarters leading up to graduation. From a level of more than 50 per cent in university employment four quarters prior to graduation, the level of university employment declines and then stabilizes at a level of approx. 29 per cent for the 2013 cohort during the four quarters after graduation. Finally, we observe a slow attrition from university employment during the second year after graduation.

We find, however, that the overall picture masks important heterogeneities. First, splitting the PhD graduates' population into STEM-H vs SSH reveals some intriguing differences. Whereas STEM-H and SSH fields are comparable before graduation, their paths differ quite sharply afterwards: STEM-H fields show a continuous decline whereas SSH graduates present an interesting pattern of “re-entry” into academia: while they may find alternative employment (or become unemployed) upon graduation, they seem to be able to re-enter academic jobs later on, possibly after having been awarded a postdoctoral grant. In terms of the key demographics, gender and immigration status, groups co-evolve much more closely, with generally a higher university employment propensity for women than for men, and for natives over foreign-born, respectively.

< Figure 2 about here >

Importantly, the 2013 cohort was arguably not affected by the abolition of the DFF “Individual postdoc” fellowship program during the eight quarters considered here. For later cohorts, on the other hand, as an increasing part of their initial post-graduation experience happened during the less beneficial post-2016 funding regime.

Visually, this tendency becomes clear from comparing across cohorts in Figure 3. Specifically, we compare the quarterly cohorts of graduates in the 4th quarters of the years 2013, 2014, 2015, and 2016. While the 2013Q4 cohort remains unaffected within this time window, the 2014Q4 cohort faced the new funding environment during their second post-graduation year and the 2015Q4 cohort felt it effectively throughout their full post-graduation period. Finally, the 2016Q4 cohorts had information about the abolition of the postdoc program ahead of graduating. For this and later cohorts it is therefore important also to consider potential effects of the abolition during the pre-graduation window as fewer people might be looking for interim “scientific assistant”

positions to effectively extend their PhD scholarship if they perceive the post-graduation funding outlook to be bleak.

< Figure 3 about here >

Early career outcomes of PhD graduates

Most Danish PhD graduates do not enter an academic career upon graduation. In Figure 4, we track their employment status by November of the year following their graduation.⁸ The share of graduates who go to industry broadly defined, including eg. hospitals and public administration, increased over the period reaching 50 percent around 2015. The “industry” group includes hospitals (19 percent of the 2018 cohort), pharma (3 percent), R&D in science and engineering (2 percent), and R&D in biotechnology (1 percent), see Appendix Table A4 for a breakdown of this group. The share of a cohort that goes to Danish universities, on the other hand, plummeted in 2015 and remained at a level of 23 percent in 2018. Finally, a heterogenous group of “Others” accounted for the remaining 27 percent of graduates in the 2018 cohort.

< Figure 4 about here >

The group of “Others” consist of individuals who happen to be between employers by the end of November but are generally employed (5 percent), individuals who are unemployed during that particular week (1.5 percent), or individuals who are registered as self-employed (less than 1 percent of the cohort). The majority in this group are individuals who are no longer resident in Denmark during the first year after their year of graduation (14 percent of the 2018 cohort).

⁸ The annual labor force statistics is based on their main employment during the last week of November.

Compositional changes pre- and post-2016

The abolition of the “Individual postdoc” program and the dominance of embedded postdoc positions in the post-2016 might have affected the initial career choices of PhD graduates. To look further into this, we calculated in Table 5 the changes in the compositions of the three main groups of graduates according to employment status in year 1 following their graduation year. The table provides comparison of means tests for a number of demographics and for graduates’ publication performance during PhD studies. For each variable, the table also provides pairwise tests of differential trends between the “University” and “Industry” groups, and between the “University” and “Other” groups, respectively.

< Table 5 around here >

We observe a positive time trend in the share of women among the SSH graduates who stay at a Danish university. The increasing share of foreigners in PhD cohorts among STEM-H graduates is reflected in all three groups, although significantly more so for university employees than for graduates in industry. STEM-H graduates with kids account for a significantly declining share among PhD graduates in industry. There is marginally significant evidence of a negative trend in high school GPAs for SSH graduates in industry. Finally, for the indicator of having at least one publication before graduation which we take as a measure of performance during PhD, there is a negatively significant time trend for STEM-H graduates in Danish universities and "Others", but no trend in DK industry employees. This suggests that the period of shifting postdoc funding towards embedded positions is associated with a relative strengthening of the academic

credentials of (STEM-H) graduates who go to industry as compared to DK universities or "other" destinations. There is no evidence of a significant "brain drain" abroad as "others" have a similar negative time trend as graduates who go to DK university. This is the case even though "others" are a mix of people, including the recipients of outward mobility grants.

Postdoc employment in Danish universities

As a final part of the empirical exercise, we analyzed detailed information on university job titles to single out the type of junior positions occupied by recent PhD graduates. This information is available from 2016, so we are able to precisely characterize the job positions held at the end of year 1 following graduation for the 2015 cohort onwards.

< Table 6 around here >

A few individuals occupy a position as "scientific assistant" (which does not require a PhD) whereas others have already moved up to a tenured position as associate professor (or more likely, they were already in such a position before being granted a PhD).

However, the vast majority of university employees within this group of junior academics are employed as postdocs (72 percent in 2018) or as assistant professors (14 percent). Moreover, these numbers reflect a strong tendency that postdoc positions have substituted for assistant professorships in the Danish university system.

Table 6 also shows that a non-negligible group of about 8 per cent of university employed PhD graduates hold a university main appointment, but in a non-academic position. A further breakdown of this group shows that most (about two-thirds) are now in administrative university positions whereas smaller groups occupy teaching-only or technical positions. We will leave for further research (and extensions of the data) to examine the extent to which such non-academic positions provide early career “steppingstones” toward future academic employment, or if they are indeed permanent destinations for PhD graduates.

When adding the fact that existing postdocs increasingly become embedded due to the changing funding structure, these trends suggest a strong decline in the level of autonomy associated with a typical junior academic position in the Danish university system. As a general loss of autonomy for junior researchers, this may have contributed to recent trends in PhD graduates’ preference for industry over academia.

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Table 1: The distribution of PhD graduates over years of graduation and between main fields. Population of PhD graduates in Denmark 2013-2017.

PhD Graduation Year		SSH (1)	STEM-H (2)	Total (3)
2013	Frequency	365	1,592	1,957
	Percent	18.65	81.35	100.00
2014	Frequency	375	1,791	2,166
	Percent	17.31	82.69	100.00
2015	Frequency	391	1,708	2,099
	Percent	18.63	81.37	100.00
2016	Frequency	463	1,804	2,267
	Percent	20.42	79.58	100.00
2017	Frequency	403	1,719	2,122
	Percent	18.99	81.01	100.00
Total	Frequency	1,997	8,614	10,611
	Percent	18.82	81.18	100.00

Table 2: The distribution of gender and immigration status by main field. Population of PhD graduates in Denmark 2013-2017.

Panel A: STEM and Health (STEM-H) fields

PhD Graduation Cohort		Male	Female	Total	Danish Born	Not Danish Born	Total
		(1)	(2)	(3)	(4)	(5)	(6)
2013	Frequency	854	723	1,577	1,001	576	1,577
	Percent	54.15	45.85	100.00	63.47	36.53	100.00
2014	Frequency	964	799	1,763	1,114	649	1,763
	Percent	54.68	45.32	100.00	63.19	36.81	100.00
2015	Frequency	886	795	1,681	1,038	643	1,681
	Percent	52.71	47.29	100.00	61.75	38.25	100.00
2016	Frequency	973	811	1,784	1,077	707	1,784
	Percent	54.54	45.46	100.00	60.37	39.63	100.00
2017	Frequency	887	803	1,690	994	696	1,690
	Percent	52.49	47.51	100.00	58.82	41.18	100.00

Panel B: Social Science and Humanities (SSH) fields

PhD Graduation Cohort		Male	Female	Total	Danish Born	Not Danish Born	Total
		(1)	(2)	(3)	(4)	(5)	(6)
2013	Frequency	190	173	363	291	72	363
	Percent	52.34	47.66	100.00	80.17	19.83	100.00
2014	Frequency	168	197	365	268	97	365
	Percent	46.03	53.97	100.00	73.42	26.58	100.00
2015	Frequency	170	218	388	301	87	388
	Percent	43.81	56.19	100.00	77.58	22.42	100.00
2016	Frequency	198	260	458	326	132	458
	Percent	43.23	56.77	100.00	71.18	28.82	100.00
2017	Frequency	179	219	398	290	108	398
	Percent	44.97	55.03	100.00	72.86	27.14	100.00

Table 3: PhD students' employment status at time of enrolment, 2013-2017

PhD Graduation Cohort		<i>In Denmark</i>						Abroad	Unknown	Total
		At enrollment institution	At other public org.	At other private org.	At other	No employment				
2013	Frequency	1,203	189	76	4	43	13	429	1,957	
	Percent	61.47	9.66	3.88	0.20	2.20	0.66	21.92	100	
2014	Frequency	1,499	274	89	6	41	19	238	2,166	
	Percent	69.21	12.65	4.11	0.28	1.89	0.88	10.99	100	
2015	Frequency	1,577	258	69	11	64	17	103	2,099	
	Percent	75.13	12.29	3.29	0.52	3.05	0.81	4.91	100	
2016	Frequency	1,649	309	97	10	125	19	58	2,267	
	Percent	72.74	13.63	4.28	0.44	5.51	0.84	2.56	100	
2017	Frequency	1,510	332	72	14	116	23	55	2,122	
	Percent	71.16	15.65	3.39	0.66	5.47	1.08	2.59	100	

Table 4: Individual characteristics. Population of PhD graduates in Denmark 2013-2017.

PhD Graduation Cohort		Age at graduation (Years)	Any children in year before graduation (0/1)	High School GPA	Any publication in year before graduation (0/1)
2013	N	1,940	1,856	1,264	1,957
	Mean	33.98	0.40	9.28	0.53
	Median	32	0	9.55	1
2014	N	2,128	2,053	1,354	2,166
	Mean	33.98	0.41	9.35	0.54
	Median	33	0	9.7	1
2015	N	2,069	1,992	1,320	2,099
	Mean	33.99	0.41	9.35	0.55
	Median	32	0	9.7	1
2016	N	2,242	2,154	1,382	2,267
	Mean	34.01	0.39	9.28	0.53
	Median	32	0	9.7	1
2017	N	2088	2029	1297	2122
	Mean	34.07	0.40	9.28	0.48
	Median	32	0	9.7	0

Table 5: Change in PhD graduate groups' composition in terms of demographic and performance-related variables. Main groups are defined according to employment status during November of the year after graduation. Changes are between the pre-period (2011-14) and the post-period (2016-18).

Panel A: STEM-H					
	(1) DK University	P-value (1)=(2)	(2) DK Industry	P-value (1)=(3)	(3) Other
Gender (fraction women)	0.024	[0.87]	0.020	[0.46]	0.004
	[0.25]		[0.14]		[0.84]
Not Danish Born (fraction)	0.093	[0.05]	0.048	[0.64]	0.080
	[0.00]		[0.00]		[0.00]
Any Kids before graduation (fraction)	-0.026	[0.68]	-0.035	[0.19]	0.006
	[0.18]		[0.01]		[0.67]
Age at graduation (years)	-0.151	[0.27]	0.125	[0.57]	-0.299
	[0.45]		[0.40]		[0.07]
High school GPA (scale points)	-0.084	[0.92]	-0.072	[0.34]	-0.246
	[0.42]		[0.19]		[0.07]
Any Pubs before graduation	-0.082	[0.00]	0.015	[0.72]	-0.071
	[0.00]		[0.32]		[0.00]

P-values in brackets.

Panel B: SSH					
	(1) DK University	P-value (1)=(2)	(2) DK Industry	P-value (1)=(3)	(3) Other
Gender (fraction women)	0.085	[0.49]	0.054	[0.08]	-0.005
	[0.01]		[0.10]		[0.90]
Not Danish Born (fraction)	0.072	[0.18]	0.027	[0.49]	0.038
	[0.01]		[0.21]		[0.36]
Any Kids before graduation (fraction)	-0.020	[0.29]	0.027	[0.93]	-0.016
	[0.52]		[0.41]		[0.69]
Age at graduation (years)	0.078	[0.96]	0.115	[0.47]	-0.506
	[0.85]		[0.82]		[0.46]
High school GPA (scale points)	0.014	[0.12]	-0.285	[0.35]	0.290
	[0.92]		[0.04]		[0.27]
Any Pubs before graduation	0.007	[0.75]	-0.005	[0.97]	0.006
	[0.80]		[0.85]		[0.86]

P-values in brackets.

Table 6: Recent PhD graduates employed in a main position by a Danish university. Job position by the end of year 1 after graduation. Population of PhD graduates in Denmark 2015-2018.

		PhD Graduation Year			
		2015	2016	2017	2018
Non-Academic	Frequency	40	43	40	36
	Percent	9.20	8.30	8.32	7.64
PhD/Scientific Assistant	Frequency	27	24	30	19
	Percent	6.21	4.63	6.24	4.03
Postdoc	Frequency	260	318	299	339
	Percent	59.77	61.39	62.16	71.97
Assistant Professor	Frequency	98	114	99	65
	Percent	22.53	22.01	20.58	13.80
Associate/Full Professor	Frequency	5	7	6	3
	Percent	1.15	1.35	1.25	0.64
Unknown	Frequency	5	12	7	9
	Percent	1.15	2.32	1.46	1.91
Total	Frequency	435	518	481	471
	Percent	100.00	100.00	100.00	100.00

Figure 1: Postdoc grants awarded by the Independent Research Fund Denmark (DFR), by fiscal year and type, 2011-2021 (source: DFR Annual Report, various editions).

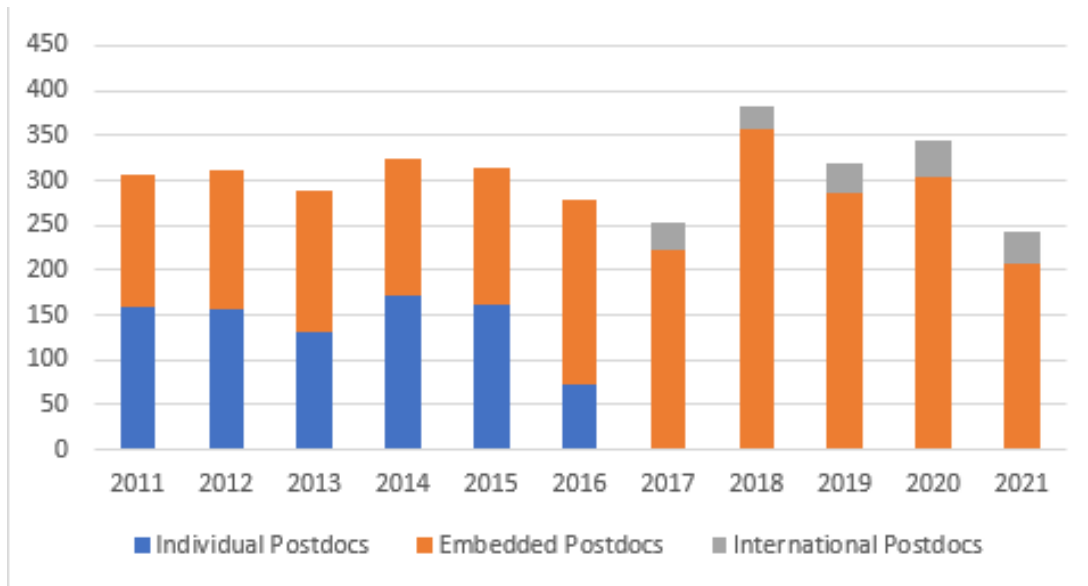


Figure 2: Number of Danish PhD graduates employed in a main position by a Danish university as a fraction of the total number of PhD graduates in Denmark in 2013. Panel A: Total. Panel B: Main fields (STEM-H and SSH). Panel C: Gender. Panel D: Immigration status.

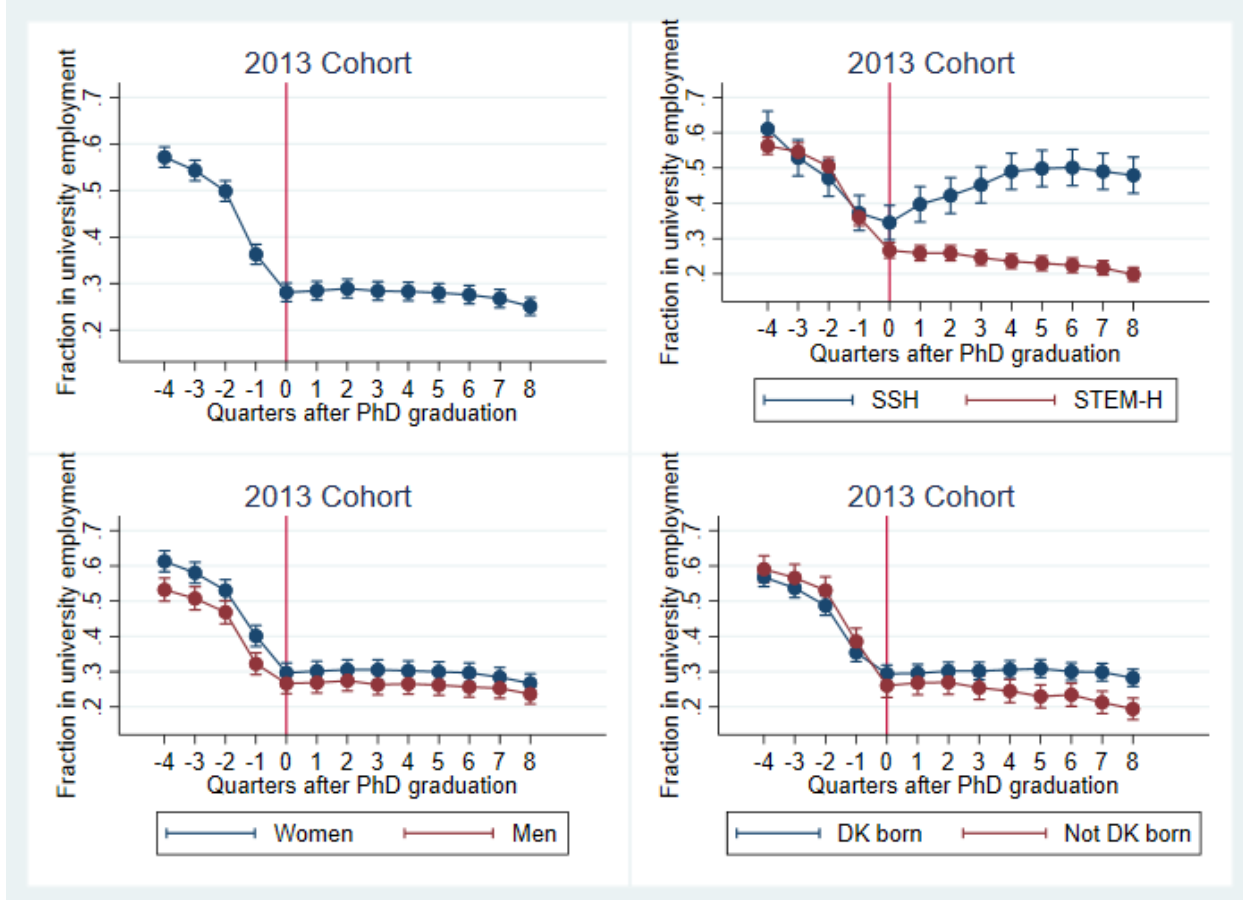


Figure 3: Number of Danish PhD graduates employed in a main position by a Danish university as a fraction of the quarterly total number of PhD graduates. Panel A: PhD graduates in 2013, 4th quarter. Panel B: PhD graduates in 2014, 4th quarter. Panel C: PhD graduates in 2015, 4th quarter. Panel D: PhD graduates in 2016, 4th quarter.

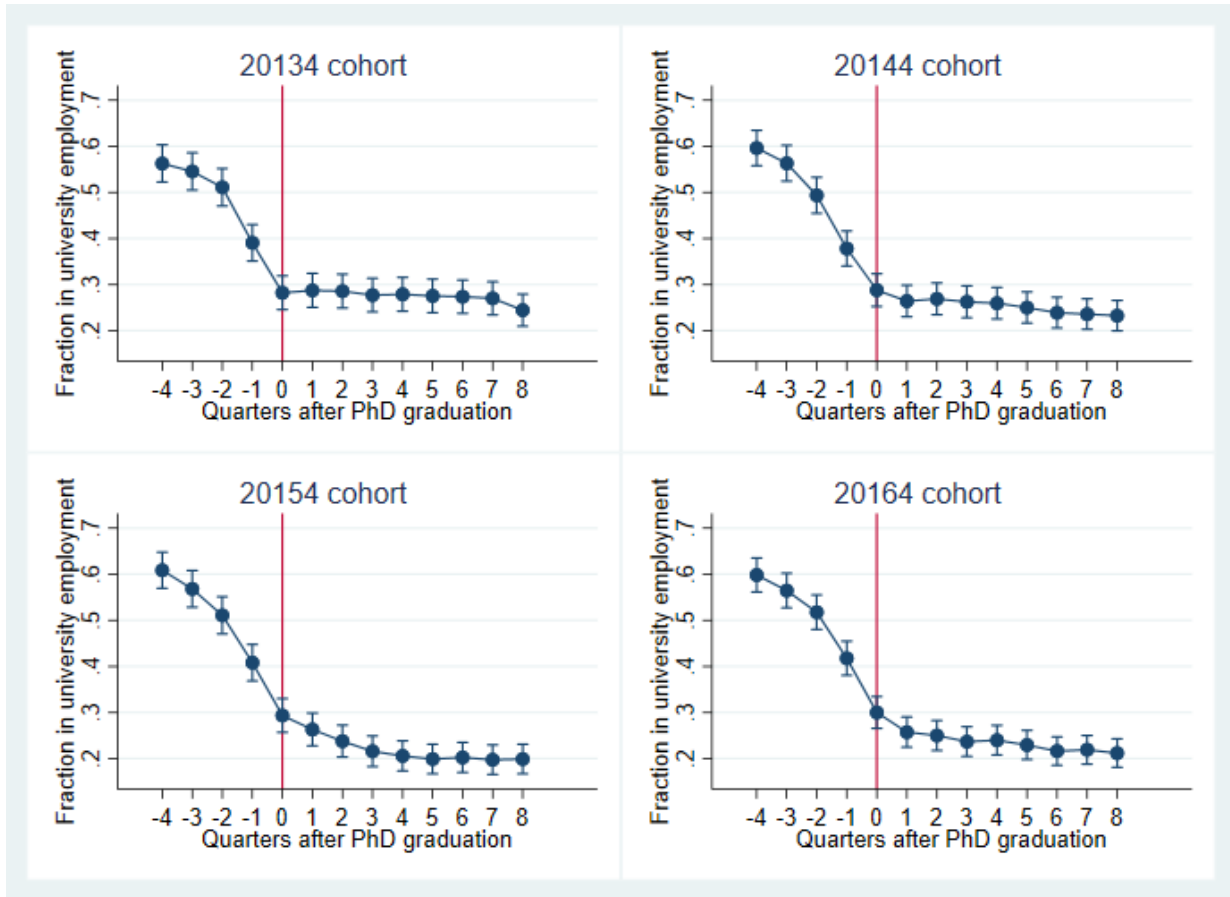
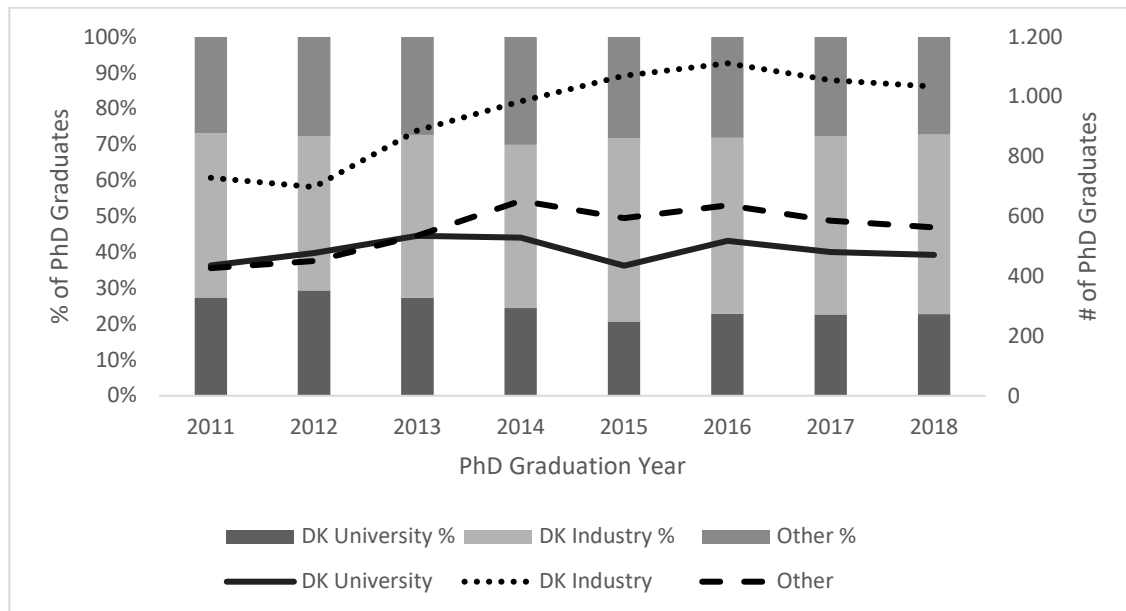


Figure 4: Early career outcomes of Danish PhD graduates. Employment status during November of the year after their graduation. Percentage distribution across main sectors (left-hand axis), absolute number of graduates (right-hand axis).



Appendix Table A1: Early career outcomes of Danish PhD graduates. Employment status during November of the year after graduation. Percentage distribution across main sectors and absolute number of graduates.

Graduates in all fields		PhD Graduation Year							
		2011	2012	2013	2014	2015	2016	2017	2018
DK University	Frequency	436	478	535	529	435	518	481	471
	Percent	27.39	29.38	27.34	24.42	20.72	22.85	22.67	22.78
DK Industry	Frequency	729	698	887	985	1,070	1,112	1,055	1,034
	Percent	45.79	42.90	45.32	45.48	50.98	49.05	49.72	50.00
Other	Frequency	427	451	535	652	594	637	586	563
	Percent	26.82	27.72	27.34	30.10	28.30	28.10	27.62	27.22
Total	Frequency	1,592	1,627	1,957	2,166	2,099	2,267	2,122	2,068
	Percent	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Appendix Table A2: Early career outcomes of Danish PhD graduates. Employment status during November of the year after graduation. Percentage distribution across main sectors and absolute number of graduates.

Graduates in a STEM or Health field		PhD Graduation Year							
		2011	2012	2013	2014	2015	2016	2017	2018
DK University	Frequency	284	329	347	381	279	357	327	353
	Percent	22.54	24.74	21.80	21.27	16.33	19.79	19.02	20.73
DK Industry	Frequency	621	608	764	867	926	934	905	879
	Percent	49.29	45.71	47.99	48.41	54.22	51.77	52.65	51.61
Other	Frequency	355	393	481	543	503	513	487	471
	Percent	28.17	29.55	30.21	30.32	29.45	28.44	28.33	27.66
Total	Frequency	1,260	1,330	1,592	1,791	1,708	1,804	1,719	1,703
	Percent	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Appendix Table A3: Early career outcomes of Danish PhD graduates. Employment during November of the year after graduation. Percentage distribution across main sectors and absolute number of graduates.

Graduates in a Social Sciences or Humanities field		PhD Graduation Year							
		2011	2012	2013	2014	2015	2016	2017	2018
DK University	Frequency	152	149	188	148	156	161	154	118
	Percent	45.78	50.17	51.51	39.47	39.90	34.77	38.21	32.33
DK Industry	Frequency	108	90	123	118	144	178	150	155
	Percent	32.53	30.30	33.70	31.47	36.83	38.44	37.22	42.47
Other	Frequency	72	58	54	109	91	124	99	92
	Percent	21.69	19.53	14.79	29.07	23.27	26.78	24.57	25.21
Total	Frequency	332	297	365	375	391	463	403	365
	Percent	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Appendix Table A4: Early career outcomes of Danish PhD graduates. Employment status during November of the year after graduation. Percentage distribution and absolute number of graduates across top non-university sectors of employment.

Graduates in all fields		PhD Graduation Year							
		2011	2012	2013	2014	2015	2016	2017	2018
Hospitals	Frequency	250	234	295	327	346	347	370	397
	Percent	34.29	33.52	33.26	33.20	32.34	31.21	35.07	38.39
Pharmaceutical Manufacturing	Frequency	54	55	93	101	110	90	81	69
	Percent	7.41	7.88	10.48	10.25	10.28	8.09	7.68	6.67
R&D Science and Engineering	Frequency	106	85	101	109	106	86	70	51
	Percent	14.54	12.18	11.39	11.07	9.91	7.73	6.64	4.93
Post-secondary Non-tertiary Education	Frequency	24	23	44	35	49	58	47	61
	Percent	3.29	3.30	4.96	3.55	4.58	5.22	4.45	5.90
Computer Programming	Frequency	20	11	13	17	23	41	32	24
	Percent	2.74	1.58	1.47	1.73	2.15	3.69	3.03	2.32
General Public Administration	Frequency	5	11	17	18	25	37	23	19
	Percent	0.69	1.58	1.92	1.83	2.34	3.33	2.18	1.84
R&D Biotechnology	Frequency	14	14	16	21	16	23	25	25
	Percent	1.92	2.01	1.80	2.13	1.50	2.07	2.37	2.42
Other Sectors	Frequency	256	265	308	357	395	430	407	388
	Percent	35.12	37.97	34.72	36.24	36.92	38.67	38.58	37.52
Total	Frequency	729	698	887	985	1,070	1,112	1,055	1,034
	Percent	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Appendix Table A5: Early career outcomes of Danish PhD graduates. Individuals with no November employment status in year after graduation. Percentage distribution and absolute number of graduates across main socioeconomic categories.

		PhD Graduation Year							
		2011	2012	2013	2014	2015	2016	2017	2018
Self-employed	Frequency	5	9	13	11	9	17	13	15
	Percent	1.17	2.00	2.43	1.69	1.52	2.67	2.22	2.66
Employed	Frequency	88	88	120	153	146	116	115	97
	Percent	20.61	19.51	22.43	23.47	24.58	18.21	19.62	17.23
Unemployed	Frequency	32	25	24	60	36	47	41	30
	Percent	7.49	5.54	4.49	9.20	6.06	7.38	7.00	5.33
On leave scheme	Frequency	15	20	32	36	23	39	25	21
	Percent	3.51	4.43	5.98	5.52	3.87	6.12	4.27	3.73
Other DK residents (beginning of year)	Frequency	76	73	98	103	119	116	96	105
	Percent	17.80	16.19	18.32	15.80	20.03	18.21	16.38	18.65
Non-residents in DK (beginning of year)	Frequency	211	236	248	289	261	302	296	295
	Percent	49.41	52.33	46.36	44.33	43.94	47.41	50.51	52.40
Total	Frequency	427	451	535	652	594	637	586	563
	Percent	100	100	100	100	100	100	100	100