Are you on the right path? Postdoctoral experiences and academic careers

HC Kongsted[1], Yotam Sofer[2], Valentina Tartari[3]

Paper Outline

Introduction

The scientific system relies increasingly on postdoctoral researchers for its functioning (Powell, 2015; Heggeness et. al. 2017; Kahn & Ginther, 2017; Hayter & Parker, 2019). 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. The rise in these temporary positions has been a source of concern in many countries, as individuals usually receive lower retribution than their counterparts in permanent positions and face high uncertainty about their future employment.

At the same time, postdoctoral positions have become a necessary ticket of entry for tenured positions in academia, especially in STEM disciplines, and studies have shown that they are indeed a prerequisite for an academic career (Kahn & Ginther, 2017). Not all postdoctoral positions are the same though. While all of them 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

[1] Copenhagen Business School, hck.si@cbs.dk
[2] Copenhagen Business School, ys.si@cbs.dk
[3] Stockholm School of Economics and Copenhagen Business School, valentina.tartari@hhs.se

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.

The documented increase in the proliferation of postdoctoral positions (Powell, 2015; Heggeness et. al. 2017; Kahn & Ginther, 2017; Hayter & Parker, 2019) was accompanied by increased criticism of this form of employment. Much of the discussion revolves around reduced salaries (Russo, 2008; Kahn & Ginther, 2017; Athanasiadou, 2018; Sainburg, 2023; Yalcin et. al., 2023), lack of job security (Nerad & Cerny, 1999), between field variation (Jiang et. al., 2023; Stephan & Ma, 2005), individual level determinants (Stephan & Ma, 2005; Sauermann & Roach 2016; Kahn & Ginther, 2017; Shauman & Huynh, 2023), and systemic consequences and considerations (Stephan, 2012; Ålund et. al., 2020; Ganguli et. al., 2020).

Changes in the availability of diverse types of postdoctoral positions can affect the overall dynamics of the scientific system and the individual career trajectories of researchers. In this paper we use an unexpected change in the Danish funding system regarding funding to postdocs to investigate this issue. 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 seek to investigate the short and long terms effects of this change. First, we look for the effect of the change on the composition of the academic workforce to see if there is an overall reduction of postdoctoral positions, or if those researchers who could have been granted this grant still stayed in academia but in other researchers' projects (what we call "embedded postdocs"). We then investigate if starting an academic career as an "embedded postdoc" has a different effect on the long-term likelihood of staying in academia compared to an "independent postdoc." Our reasoning is as follows: while both types of positions are temporary and provide the same economic conditions, only the "independent" one comes with a significant degree of independence eg. in terms of choosing the topic or method for the project, and adds an additional quality signal, making the recipients more likely to be successful in securing a permanent position afterwards.

Data and Context

We investigate these questions using a novel database combining population registry data, data from PhD enrolment and graduation, data from academic employment, publication and funding data, on the population of PhD graduates from Danish universities in the years 2013 through 2017. This dataset allows us to observe precisely the full population of PhD graduates, and their subsequent employment history.

The population of PhD graduates

Our analysis is based on the population of PhD graduates from Danish universities during the years 2013 through 2017. They are recorded by the government PhD registry and can be individually linked to the overall government registry information via their unique personal identification number.

A total of 10,728 final PhD graduations took place during this period and 10,611 unique individuals (98.9 per cent) have a valid ID. The PhD registry as well as the link to other government registries allow us to precisely characterize the population of graduates in many dimensions.

Graduating individuals are distributed evenly across years and main fields. Table 1 Panel A shows that approximately 80 per cent of graduates are in a STEM or Medical field of study (STEM for brevity) whereas the remaining 20 per cent graduate in a Social Science or Humanities field (SSH for brevity).

Gender distributions differ between main fields with STEM fields having a higher proportion of men than women whereas SSH fields have more women (Table 1, Panels B and C, columns (1) and (2)).

The distributions according to the country of birth of PhD graduates differ between main fields. STEM fields have more graduates who are born outside of Denmark (about 40 per cent) than SSH fields. In both cases, the share of non-natives is increasing over the period considered (Table 1, Panels B and C, columns (3) and (4)). Most students are employed by their university upon enrolment (Table 2) with remaining students having an employment relationship either with another public institution, such as hospitals, ministries, or independent research institutes, or with a private firm. Only a small minority of students report no employment relationship upon enrolling into PhD studies. Upon graduating, graduates (Table 3) are on average 34 years old (median age 32 years). Domestic students for whom we register a high school GPA, have an average GPA of 9.3 that corresponds to the 81st percentile of the overall distribution of GPAs in their high school cohorts. About 40 percent of graduates live in households with at least one child upon their graduation. Finally, about half of students manage to publish at least one journal article before graduation.

Table 1: The population of Danish PhD graduates 2013-2017

Panel A: *distribution between SSH and STEM fields*

PhD Graduation Cohort		SSH (1)	STEM (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

Panel B: *STEM fields – Gender and immigration distributions*

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

Panel C: *SSH fields – Gender and immigration distributions*

PhD Graduation Cohort		Male (1)	Female (2)	Danish Born (3)	Not Danish Born (4)	Total (5)
2013	Frequency	190	173	291	72	363
	Percent	52.34	47.66	80.17	19.83	
2014	Frequency	168	197	268	97	365
	Percent	46.03	53.97	73.42	26.58	
2015	Frequency	170	218	301	87	388
	Percent	43.81	56.19	77.58	22.42	

2016	Frequency	198	260	326	132	458
	Percent	43.23	56.77	71.18	28.82	
2017	Frequency	179	219	290	108	398
	Percent	44.97	55.03	72.86	27.14	

The financing of PhD studies in Denmark

Most students in PhD programs at Danish universities enroll in a three-year program. It is without tuition payments and students obtain a government scholarship of approx. DKK 30,000 (USD 4,400) per month (pre-tax). The scholarship is the basis of employment by the university. It is limited to 3 years although some students will remain enrolled in the PhD program for longer. During any period of extension, students may obtain university employment as so-called "scientific assistants" on terms like the PhD scholarship, or they may remain unpaid by the university.

Table 2 shows the distribution of PhD students according to their employment status upon enrolment in the program. A minority of about 5 per cent PhD students become enrolled in the so-called "industrial PhD program" in which they are employed by a firm and partly financed by the government agency "Innovation Fund Denmark."

Table 2: Danish PhD students' employment status at time of enrolment, 2013-2017

PhD Graduation Cohort		Main Employment at Enrolment							
		In Denmark							
		At enrollment institution	At other public org.	At other private org.	At other	No employment	Abroad	Unknown	Total
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 3: The population of Danish PhD graduates 2013-2017 – characteristics at time of graduation

PhD Graduation Cohort		Age at graduation (Years)	Any children (0/1)	High School GPA	Any publication (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

Junior academic positions in the Danish university system

After having obtained a PhD, a person can be employed at a Danish university in junior positions as a postdoc or as an assistant professor. Postdoc positions typically span two or three years and have 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, we will include postdocs and assistant professorships jointly in our analysis as junior 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 DFF and private foundations. The externally financed positions can be based on a stand-alone fellowship for which the junior academic is the primary investigator or embedded in a research grant headed by a senior colleague.

The 2016 abolition of the DFF "Individual Postdoc" program

The Danish Research Council (DFF) is the major public sponsor of researcher-initiated projects in Denmark. It offers a portfolio of funding instruments across all scientific disciplines and covers both junior and senior academics.

The budget for DFF is set yearly by the Government. 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.[4]

This "Individual Postdoc" program offered postdoctoral fellowships, typically of two years duration, across all scientific disciplines. 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. The 2015/2016 DFF call 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.

[4] 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

Following the Government budget decision, a revised call for Spring 2016 that excluded the Individual Postdoc instrument was issued in January 2016. The revised call also announced that the Government budget frames for 2017 and 2018 were similarly reduced and that changes were therefore to be expected. The permanent abolition of the Individual Postdoc program was confirmed with the appearance of the 2016/17 DFF call in August 2016.[5]

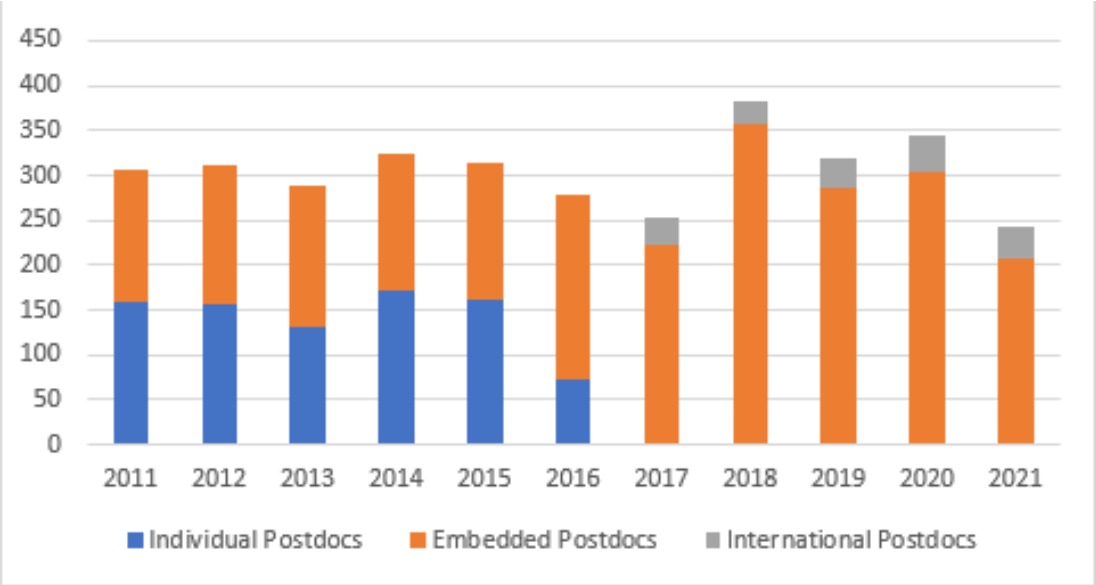
The magnitude of the cutback of the number of individual postdoc fellowships due to the abolition of the "Individual Postdoc" program was significant. In terms of the number of fellowships awarded, it amounted to 6.7, 7.9, and 7.3 per cent when compared to the number of PhD graduates from Danish universities during 2013, 2014, and 2015, respectively.

Starting in 2017, a new 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 and the number of grants has been 40 or less in subsequent years (Figure 1).

Throughout the period, DFF has awarded a number of postdoc positions that were embedded in larger so-called project grants (Figure 1). Before 2016, there was a fairly equal share of individual and embedded positions. With the abolition of the "Individual Postdoc" program, the distribution has turned decisively towards embedded positions.

[5] 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

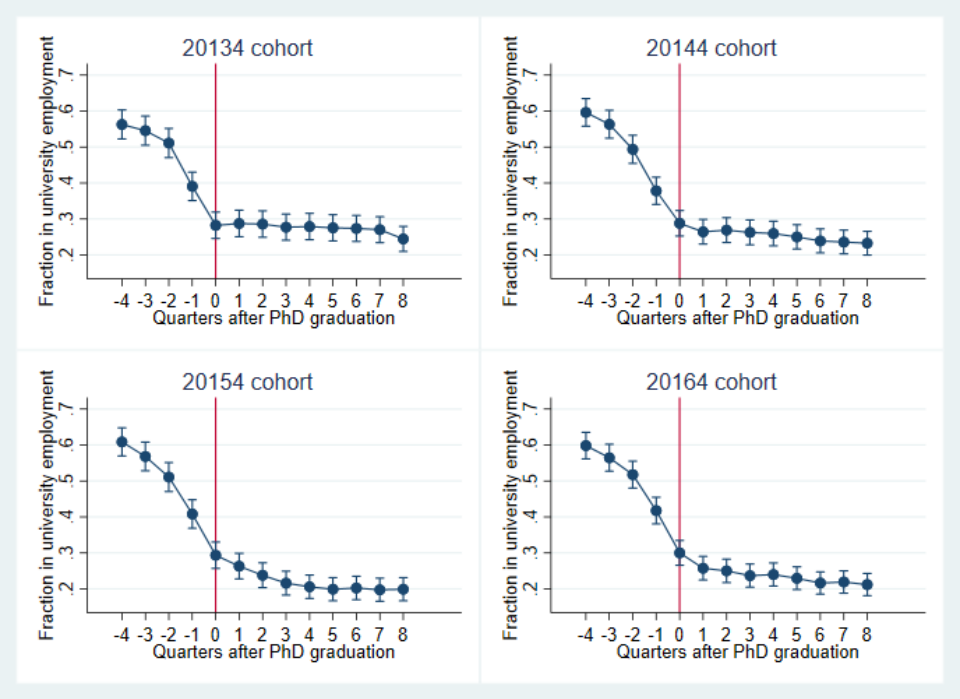
Figure 1: Postdoc grants awarded by DFF, by type, 2011-2021 (DFF Annual Report, various editions).



Early results:

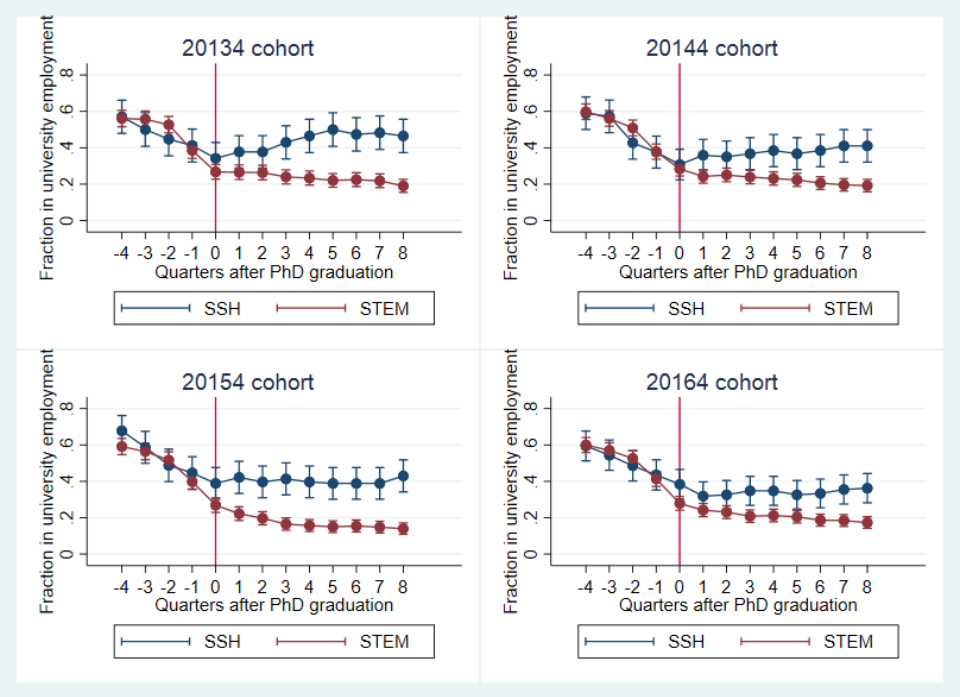
As a descriptive measure of the transition of PhD graduates, the following figures show the estimates from saturated dummy regressions across the different cohorts in our study for all fields (Figure 2) and split by STEM vs SSH (Figure 3). The red line represents the quarter of graduation: as expected, the share of individuals in academic employment lowers steadily as they approach graduation as some students will exhaust their scholarship well before final graduation. While for the 2013 and 2014 cohorts the academic employment persisted between 30% and 25% for the two years following graduation, for the 2015 and 2016 cohorts, the academic employment fell to 20% quite rapidly.

Figure 2: PhD graduates' entry into junior university positions, all fields. Quarterly graduations cohorts for the 4th quarter of the years 2013 to 2014.



Splitting the PhD graduates' population into STEM vs SSH reveals some intriguing differences. First, in every cohort, the percentage of SSH PhD graduates employed in academia is higher than that of STEM PhD graduates. Second, especially in the first cohort which was not affected by the abolition of the DFF fellowship program during the eight quarters considered here, SSH graduates present an interesting pattern of "re-entry" into academia: while they may find alternative employment upon graduation, they seem to be able to re-enter academic jobs later on, possibly after been awarded postdoctoral grants.

Figure 3: PhD graduates' entry into junior university positions, by main fields (STEM and SSH)



Finally, we estimated the impact of the abolition of the DFF "Individual Postdoc" program on the likelihood of being employed at a university as a postdoc or assistant professor in a simple regression. First, we provide (Table 4 (I)) a simple regression of an indicator variable for university employment on quarterly cohort dummies, a set of dummies for quarters relative to the quarter of graduation (from one year before graduation until two years after), and a dummy variable for the given quarter being post-2016, 1st quarter. We then introduce two sets of individual level demographic indicators to observe whether these controls affect the magnitude of the policy variable estimate (Table 4 (II and III)). The results are fairly robust. Abolishing the "Individual Postdoc" instrument led to a 2.9% decrease in the likelihood of staying in academia. When controlling for the extended set of individual level demographics, the magnitude of the effect increases to a 3.5% reduction. There is a decline in the number of observations reported with the inclusion of additional controls. This is mainly a result of the lack of information on the high school GPAs of non-native graduates.

Table 4: Regression results – Impacts of the 2016 abolition of the DFF "Individual Postdoc" program

VARIABLES	(1) No Demographics	(2) Basic Demographics	(3) Extended Demographics
Treated	-0.0291***	-0.0290***	-0.0348***
	(0.00552)	(0.00558)	(0.00699)
STEM		-0.141***	-0.186***
		(0.00903)	(0.0116)
Female		-0.0390***	-0.0249***
		(0.00652)	(0.00847)
Not Danish born		-0.0289***	-0.0515***
		(0.00681)	(0.0191)
Age at PhD graduation		-0.0135***	-0.0150***
		(0.000607)	(0.000939)
Any children			-0.0492***
			(0.00927)
High School GPA			-0.0123***
			(0.00227)
Any publication			0.0294***
			(0.00884)
PhD cohort FE	YES	YES	YES
Quarters since graduation FE	YES	YES	YES
Constant	0.603***	1.205***	1.409***
	(0.0177)	(0.0288)	(0.0476)
Observations	132,560	130,769	81,063
R-squared	0.075	0.111	0.120

Clustered standard errors on the individual level are shown in parenthesis. *$p<0.1$, **$p<0.05$, ***$p<0.01$.

Next steps and 'a timetable for completion'

The project is currently at its advanced data curation phase, and as seen above, early analysis has already been conducted. However, using the granularity and scope of Danish administrative data, we plan to conduct a much deeper investigation into the dynamics and factors at play during the

critical transition window studied. Indeed, while we still intend to expand the converge of our database (to include more funders, e.g., Novo Nordic Foundation; update our bibliometric indictors using the latest version of Dimensions; linking responses of a survey conducted in 2017), the already available data allow us to investigate how individual level characteristics (gender, marital and parental status, socio-economic indicators such as income, wealth, parental and spouse education) correlate with individual level outcomes. Assuming no unforeseen interruptions to the process, we believe that the timeline presented in Table 5 below is reflective of the authorship team's availability and intentions. Importantly, a full draft is believed to be ready by mid-April, with an early draft ready by mid-March, well ahead of the scheduled NBER meeting date.

Table 5: Tentative timetable of project

PERIOD	TASK	
FEBRUARY 15TH, 2024	*Data*	Finalizing database backbone using register data and already linked supplements (funders data, bibliometric indicators)
MARCH 15TH, 2024	*Data*	Linking additional data sources (additional funders data, updated bibliometric indicators, survey)
MARCH 1ST, 2024	*Analysis*	Conducting individual level analysis on (early) available data
MARCH 15TH, 2024	*Writing*	Writing an early draft of the full paper
APRIL 10TH, 2024	*Analysis*	Conducting individual level analysis on (full) available data
APRIL 15TH, 2024	*Writing*	Writing an updated draft of the full paper – with full database

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