PARENTHOOD AND THE ACADEMIC LADDER IN SCIENCE

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Abstract

Women continue to be underrepresented among senior scientists and professors, especially among permanent faculty in academia. Using Danish population administrative data and publication data, we study the impact of children on the career trajectories of researchers in academia. While men and women follow similar career trends before having a child, after becoming parents, their career paths in academia diverge. We find that mothers are 15 percentage points less likely than fathers to remain employed as faculty at universities. The motherhood penalty is particularly stark when we examine the likelihood of tenured employment after childbirth - while men's employment in tenured positions is unaffected by the arrival of a child, women, on average, experience a 20 percentage points drop in their rate of tenured employment, and even greater at 30 percentage points when considering only full time positions. This drop persists even 8 years after birth. We observe that the first childbirth is also followed by a drop in research output as measured by annual publications relative to productivity before birth. This can explain 1/3, but not all, of the penalty on tenured employment. We investigate how differences in the field of research, stage of career at first birth, and couple gender norms affect these penalties.

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1 Introduction

The share of women among professors in science, technology, engineering and math (STEM) remains low across the EU countries and the United States. Denmark is no exception with a share of 1/4 women among full professors (Uddannelses- og Forskningsministeriet (2023)). This defies notions of equity in society, particularly of equity in academia, but even beyond equity concerns, it has consequences for future generations through the selection of students and research topics that receive attention and funding. Existing research has found that the identity, including the sex, of role models and mentors can have positive impacts on the intensive and extensive margin of selection into STEM university degrees (Porter & Serra (2020a); Rose et al. (2022)). Therefore, the persistent lack of women professors that can act as role models for younger women, undermines the likelihood of women choosing to study STEM at the undergraduate level. Secondly, Antman et al. (2024) highlights that researchers' identities significantly shape the topics they investigate and the innovations they bring to society. Consequently, the underrepresentation of women as professors and principal investigators likely contributes to a disparity in research addressing issues particularly relevant to women. This includes areas such as diseases with a disproportionate impact on women and socio-economic barriers that uniquely affect women's well-being (Reber et al. (2021); Einiö et al. (2019)).

Despite the significant convergence in educational attainment and labor market performance between men and women, a gender gap in earnings and the glass ceiling still characterize women's labour market outcomes. Prior literature has pointed to parenthood and private care responsibilities as one of the main explanation for these differences. The child penalty, the extent to which having a child can affect labor market outcomes through the reduction in earnings and labour supply, has been extensively studied (Waldfogel (1998); Angelov et al. (2016); Kleven et al. (2019); Kleven et al. (2024)). Motherhood can push women to prefer flexible working schedules that allow for balancing care-taking and professional duties that in turn, due to non-linear compensation of hours and lack of flexibility in top occupations, exacerbate the gender gap in earnings (Goldin (2014)).

One of the occupations where there is an evident lack of women at the top is the academic sciences. There have only been 25 women Nobel prize winners ever in chem-

istry, physics, medicine and physiology together. Prevalent tenure-track systems to secure a professorship require very high productivity early in the career, so returns to early career effort and success are concave which could lead to larger child penalties in academia than elsewhere in the labor market. However, the flexible nature of the job where work can take place at any time of the day from home or the office, would likely lead to smaller penalties. As the arrival of children often takes place early in the research career, it is important to understand how parenthood contributes to 'the leaky pipeline' of women and identify factors that may either mitigate or exacerbate gender gaps.

In this paper, we ask how parenthood affects research careers in the academic sciences. We next examine how it affects the likelihood of promotion in the academic system, i.e., entering tenured employment. Finally, we study three sources of mitigating or exacerbating factors of the consequences of parenthood in academia: Differences across scientific fields that vary in their occupational flexibility, differences across the timing of parenthood relative to career stage and personal circumstances of the researcher (choice of partner).

To do so, we use administrative data from Denmark covering the universe of individuals enrolling in scientific Ph.D. programs from 1996 to 2016. We include the following fields of study: STEM (science, technology, engineering and mathematics), medicine, social sciences (economics, political science, sociology), humanities and arts. We link labor market outcomes with information on fertility, partners and family characteristics, in combination with high-quality publication data from Elsevier's database *Scopus*, which is a comprehensive database of bibliometric indicators indexing over 25,000 peer-reviewed journals, conference proceedings, and other scholarly literature across various disciplines, including the arts and humanities, technological sciences, the natural sciences, and the social sciences. Using administrative data on earnings and sector of employment combined with newly collected data on collective bargaining agreements on academic position earnings floors, we approximate the position of researchers to understand how fertility impacts tenured employment, i.e. promotions at university and in the broader research sector, comprising public universities, research institutes and laboratories. By starting with the full population of entrants to a Ph.D. program, we overcome issues around survivorship bias and study the early pipeline into academia. We estimate the child penalty for women and men scientists'

likelihood of staying in academia, on promotions into junior and tenured employment, and on publications. To do so, we use an event study research design examining the dynamics of the outcomes three years before and eight years after parenthood on a sample of researchers that become parents. This research design relies on the assumption that while a researcher's choice to have a child is not exogenous, the arrival of a child leads to a sharp change in the outcomes studied that is orthogonal to unobserved determinants that evolve smoothly over time. As we are interested in studying how the arrival of a first child affects career outcomes in academia, we exclude anyone who has had a child before the start of their PhD.

We find that parenthood has a significant impact on a scientist's academic career. Women are, on average, 15 percentage points less likely to be employed as faculty at universities or in the broader research sector in the 8 years after birth, while men are broadly speaking equally likely to stay employed at university or in the broader research sector after becoming fathers. The average child penalty on employment at university and in broader research over years 1 to 8 is estimated at 15 percentage points ($p = 0.000$). Next, we find that women's likelihood of tenured employment, the equivalent position of an associate or full professorship, immediately declines after motherhood and remains on average 20-35 percentage points lower than that of fathers over the next eight years. Men's likelihood of tenured employment is not affected by fatherhood. This leads to a sizable gender gap in tenure rates due to having children that persists even eight years beyond the birth. Using measures of research productivity, such as whether the individual published any research in a given year and their number of annual research publications, we find that men's productivity (relative to own prebirth productivity) is unaffected on both margins while women are overall less likely to publish in their first 4 years of motherhood and publish, on average, 23 percentage points less publications over the 8 years following childbirth relative to fathers. We corroborate this finding with results from a unique survey on Danish academics (2017) that shows that women reduce their hours much more upon becoming parents than men do.

With the aim of understanding the mechanisms, we divide the sample across several margins of heterogeneity. First, we divide individual Ph.D.s based on the nature of their scientific field of education. That is, we divide the natural science fields into

dry fields and *wet fields*. We define as "dry fields" those scientific fields that allow for making research progress from behind a desk and therefore offer more flexibility in the location and time when the research is being done, such as physics, math, statistics and computer science. We define as "wet fields" those scientific fields, where research is done in "wet laboratories" relying heavily on access to specific research infrastructure, machinery and technical equipment, and therefore require irregular and long-hours of presence at work, such as bio-chemistry, chemistry and biology.

We show that the child penalties on having an academic career and being promoted to a senior position are larger and more pronounced for the wet fields. This suggests that it is the lack of flexibility of wet fields in combination with the legacy of gender norms where women continue to take on the majority of child care-taking responsibilities in the private's sphere that impedes women's academic careers. Second, we split the sample across their timing of birth, namely whether the researcher became a parent during the six years after the start year of the PhD (*early birth*) or whether the researcher became a parent more than six years after the start year of their PhD (*late birth*). If the researcher's goal is to secure a senior academic position in the long run, the equivalent of an associate or full professor, becoming a mother earlier in the career, e.g., during her PhD-studies, leads to lower child penalties (24 percentage points) than becoming a mother later in the career when women experience larger child penalties (39 percentage points). Men's likelihood of tenured employment is not affected regardless of the career stage at which they pursue parenthood. Finally, we observe gender norms of researchers, proxied by the extent of leave-taking relative to the sample distribution. We define those mothers who take more leave than the 75th percentile of the sample distribution of academic mothers as "traditional mothers", and those fathers who take less leave than the 25th percentile of the sample distribution of academic fathers as "traditional fathers". We define progressive mothers and fathers as the inverse of traditional ones. Progressive mothers experience smaller child penalties on senior employment relative to progressive fathers, while traditional mothers experience large child penalties on senior employment relative to traditional fathers. Progressive male academics on average have similar rates of senior employment before and after parenthood, yet for traditional academic fathers, becoming a father positively affects their likelihood of senior employment as perhaps their partners upon birth specialize even more in household management. This leads to a larger estimated average child penalty

(29 percentage points) when comparing traditional mother and father academics, and a smaller estimated average child penalty when comparing progressive mother and father academics (18 percentage points).

One might ask whether fertility patterns of PhDs who remain in academia differ when compared to those individuals that leave academia, but we document that the vast majority of both men and women PhDs have children and we show that those who stay in academia do not delay or reduce fertility compared to those who leave academia. Fifteen years after the completion of their PhD, on average 87% of women and men working at universities have at least one child, as compared to 76-82% of women and men who work in other sectors. Similarly, both male and female PhDs regardless of whether they work in academia or other sectors have on average 1.8 to 1.9 children fifteen years after starting their PhD.

Our results speak to the forces driving the persistent underrepresentation of women in the top of science. Existing research has documented persistent gaps in tenure rates (Kahn (1993); Lundberg & Stearns (2019); Ginther & Kahn (2021); Auriol et al. (2022)). Studies have identified numerous obstacles that women face in academia, such as biased peer recognition, discrimination and harassment (Hussey et al. (2022); Sarsons et al. (2021); Hengel (2022); Wu (2018); Eberhardt et al. (2023)) as well as less support and fewer role models (Dupas et al. (2021); Porter & Serra (2020b); Rose et al. (2022)). This paper contributes to this literature by showing evidence that parenthood leads to a dramatic shift in women's academic career trajectories across all sciences. Although this question has been explored in the literature (see Cheng (2020) for a survey-based study on U.S. biologists), to the best of our knowledge, only Kim & Moser (2021) have examined it using event study estimation, focusing on a sample of U.S. scientists active in research during the post-World War II period. We complement their study in distinct ways: We study an unrestricted sample of PhDs irrespective of their survival in science; we study the recent generations; and, we make use of very detailed register data on childbearing, partners, and leave-taking to shed light on potential mechanisms. We define our sample by including everyone who starts a PhD at a Danish university between 1996 and 2016. This approach allows us to track individuals from their first step into academia and overcomes an important source of survivorship bias - namely getting an academic position in the first place after motherhood. As science

is becoming more competitive, it is taking a longer time to become an assistant professor (with the popularity of pre-docs, longer PhDs, and post-docs), understanding how parenthood could affect attrition out of academia, as well as delay promotions over career is ever more important.

This paper also contributes to the literature on the scientific productivity of researchers over their scientific career. Early career productivity has high returns (Levin & Stephan (1991); DiPrete & Eirich (2006)) and often overlaps with the life-changing and demanding event of becoming a parent. During Covid-19, mothers lost more research time than fathers, particular in the life sciences, (Deryugina et al. (2021); Myers et al. (2020)). Tatari et al. (2023) identify a child penalty on scientific productivity among university graduate researchers in Denmark, while Morgan et al. (2021) document a temporary short lived drop in productivity around childbirth for university employed academics in the US and Canada, respectively. Tatari et al. (2023) document that child penalties are extensive for researchers in fields where lab and field presence is required and among women who do not have access to informal childcare or support from a partner.

Finally, we contribute to a rich literature on gender gaps in knowledge-intensive and "greedy" occupations (see, e.g., Goldin (2014), Bütikofer et al. (2018), Adda et al. (2017)), and to the general labor literature on motherhood penalties on wage earnings and labor supply after birth (see Angelov et al. (2016); Kleven et al. (2019), Kleven et al. (2024), Lundborg et al. (2017)). Previous studies on knowledge-intensive private sector occupations such as finance, trial law and business consultancy have identified long hours and inflexible work conditions as culprits of gender gaps in labor market performance that exceed those found for the general labor market. Our contribution to this literature reinforces that inflexible work conditions can exacerbate the child penalty even within the same occupation - academia. We show that child penalties in having an academic career and being promoted to a senior position are larger and more pronounced in the wet fields where research relies on presence in the work place, long and irregular hours, and dependence on specialized research infrastructure.

2 Institutional Context and Data

This section provides a description of the institutional context of the Danish academic system and the data used in our analysis.

2.1 Academia in Denmark

The academic career in Denmark is similar to that in other European and Anglo-Saxon countries, and no major changes have occurred within the period we consider. The position equivalent to assistant professors (*adjunkt*) precedes the associate professorship (*lektor*) which is equivalent to obtaining tenure in many other settings. Obtaining a full professorship follows as the last step of the career path. As of 2024, the majority of full professors are Danes and/or obtained their PhD from a Danish university. While the teaching load varies across departments, pure teaching positions are extremely rare. The vast majority of the teaching at Danish universities is carried out by research faculty. The most common type of lecturers, besides research faculty, are individuals who work full-time in another job - e.g. the public sector - and teach a course close to their area of professional expertise.

Ph.D. programs are three years long and admission criteria include a relevant and qualifying two-year Master's or university graduate program. Most PhD students are employed at the university (or a university hospital) with earnings equivalent to a junior civil servant. Earnings are therefore set via collective bargaining.

Both faculty and Ph.D. students have the right to paid parental leave. Throughout the period we consider, generous maternity and parental leave have been in place. The duration of wage replacement is also set via collective bargaining. Mothers working at universities are offered full wage replacement for half a year, and fathers are offered fully compensated parental leave for three months. After this period is exhausted, individuals can receive benefits corresponding to unemployment insurance while enjoying job-protected leave for an additional three to six months. For individuals on temporary contracts, this arrangement works as a contract extension equivalent to the months spent on parental leave, unless the contract would have expired during the period on leave with wage replacement.

The Danish public childcare system for preschool children has universal coverage and offers childcare services on weekdays approximately between 7 am and 5 pm for children from the age of 6 months to the age of 5-6 years. From the age of 6 years, children attend school from 8 am, followed by after-school programs until 5 pm. For children above the age of 6, there is full-time care offered during the weeks of summer holidays.

2.2 Data

Our analysis is based on the merge of administrative registers for the full Danish population with bibliometric indicators from the Elsevier *Scopus* database containing granular data on individual researchers' annual scientific publications. Moreover, we rely on hand-collected data on collective bargaining earnings floors from the Danish trade union of academics.

From the registers we make use of demographic and family registers (BEF, FTFORAELD), labor market registers (AKM, IDAN, LON, IND, ISOLA) for main sector of employment, earnings, employment status, immigration register (VDNS) and education (UDDA, PHD). This allows us to select the population of PhDs and link to information on their education, fertility, partners, grandparents (parents of PhDs), high school grades, sector of employment, earnings and work hours.

We use educational registers to define field of research focusing primarily on STEM fields, and defining as wet fields those fields that require physical presence (e.g. lab work, data collection in the field) such as biology, chemistry and biochemistry, and as dry fields those fields that are more flexible in terms of being able to make research progress behind a desk (at home). The dry fields include physics, math, data science and civil engineering, .

We observe the usage of parental leave by new parents, and observe this for both the researcher and their partner. We classify couples as either traditional or progressive based on the leave taking of the focal PhD relative to the sample distribution of same gender peer PhDs.

2.3 Outcomes

We use several measures of the academic career trajectory. We observe sector of employment for all individuals in our sample as long as they are present in Denmark.

The first outcome, we consider is whether or not a person is employed at a university. Specifically, we focus on having university employment as one's main job. We define a job as the main employment of the individual, if a majority of their working hours occur in the given job.[1] In the registers, we also observe individuals' yearly working hours across the year. We can therefore zoom in on main employment relationships at university with unrestricted hours, hours equivalent to part time, and hours equivalent to full time positions. [2] Given our focus on employment as faculty, we focus on university employment excluding employment during the period of PhD-studies. That is we do not count university employment occurring before or during the PhD-studies. For PhD graduates, academic employment can then only occur from the year after graduation.

2.3.1 Defining the position of the researcher

Another outcome of interest is a measure of the position of the researcher. A useful feature of the Danish institutional setting is centralized collective bargaining that sets the earnings for all academics in Denmark. This translates into floors in yearly earnings for each academic position from 1997 to 2018 (PhD Fellow, Assistant Professor, tenured Associate Professor and Full Professor). We translate the annual wage floor to an hourly wage floor by diving the wage floor with the average hours of a full time annual contract (1924 hours per year or 37 hours per week).

To infer the position of researchers, we combine yearly earnings from the main employer and the annual thresholds obtained from collective bargaining. The data on collective bargaining has been collected from the archives of the trade union for

[1] Our results are robust to consider anyone with a contract at university. This would for example be individuals who work primarily at a hospital or a research institute but also has an affiliation with a hospital.

[2] In the Appendix, we supplement results on university employment with results for any and main employment in the the broader research sector, including at public universities, university hospitals, other hospitals, think thanks, public laboratories, and public research institutes.

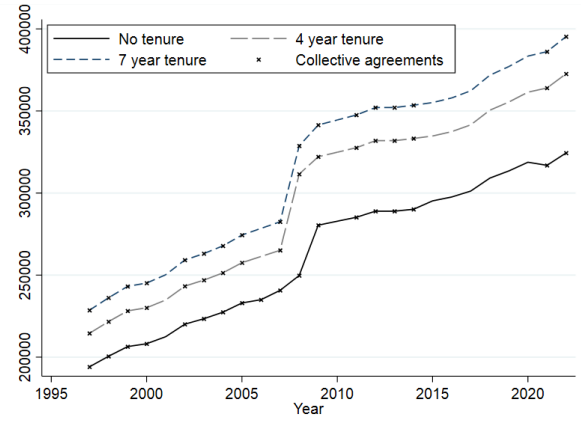
academics (Dansk Magister Forening). In collective bargaining, earnings consist of a base salary (grundløn) and an allowance (tillæg). The archives covered the years 1997-2014, and 2021 and 2022. The union further provided an index covering 2011 to 2021, which is used for adjustment for the years where the precise levels are unavailable.

Definition of senior researcher: To be classified as a senior researcher, an individual must have an employment relation at a university where their hourly wage is as least at the level of the wage floor for associate professors. We exclude employment during PhD-studies. In our main specification, we require contracts to be at least 80% of a full time contract to allow for some fluctuations in the year of birth and after birth.

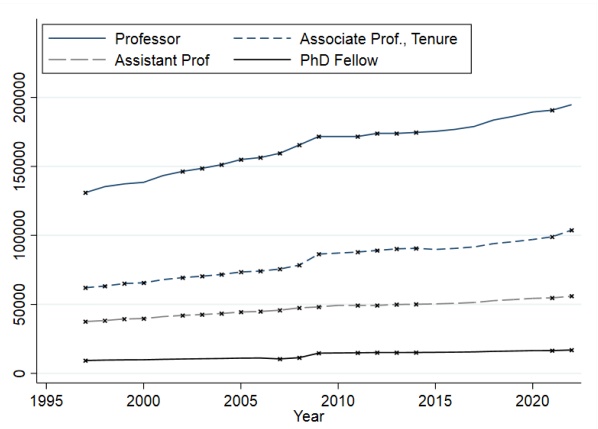
Definition of junior researcher: Mirroring the definition above, to be classified as a junior researcher, an individual must have an employment relation at a university where their hourly wage is below the wage floor for associate professors. We exclude employment during PhD-studies. In our main specification, we require contracts to be at least 80% of a full time contract to allow for some fluctuations in the year of birth and after birth.

Figure 1: Earnings from Centralized Bargaining

(a) Baseline Earnings



(b) Allowance



Notes: For each year since 1997, we have collected information on the base wage of researchers with different tenure durations (i.e. years of work experience) (panel a). On top of this base wage, researchers receive an allowance, corresponding to their position (panel b). In 1997, a change to the collective agreement system was put in place and gradually phased in. Until 1997, wages increased mechanically with years of employment and the rank of the researcher. This was abolished and replaced with a system with fewer steps and more discretion to allocate bonuses, whether yearly or permanent. From 1997 to 2008, new hires could choose between the two schemes. As of 2008, the new scheme was fully in place.

The base salary varies by years of relevant sector experience. According to the union, Ph.D. students are usually placed on the lowest level of experience, assistant professors on a salary level corresponding to four years of experience, and associate professors and professors on a salary level corresponding to seven or more years of experience. The allowance varies by position. The evolution of the base salary for the relevant levels as well as the allowances for each type of position are reported in Figure 1. An assistant professor can then be defined as having a salary with four years of experience + the assistant professor allowance, but below the level of seven years of experience + the associate professor allowance for a given year, i.e. between the light grey and dashed blue line. Both an associate professor and a professor would earn at least the base salary corresponding to 7 years of experience, but their allowances would differ. Heads of Department, Heads of the Ph.D. school etc. are likely to receive a bonus and thus earn a professor wage. Moreover, members of management also earn wages at the professor level. In addition, bonuses may be given for e.g. teaching excellence, success in securing external funding, and publications.

As of 1997, a change to the collective agreement system was agreed upon and gradually phased in. Until 1997, wages increased mechanically with years of employment and the position of the researcher. This was replaced with a system with fewer steps and more discretion to allocate bonuses, whether yearly (one-off) or permanent. From 1997 to 2008, new hires could choose between the 2 schemes. As of 2008, the new scheme was fully in place, leading to a discrete jump in the base salary for all individuals, regardless of experience. Information on the wage scheme before this reform was unavailable.

We validate a measure of academic rank obtained by combining earnings and information from collective bargaining against titles from pay slips. Pay slip data comes from the ISOLA dataset from the Agency for Digital Government, a public agency responsible for paying public sector employees, including university employees, delivered by the Ministry for Higher Education and Science. The two data sources overlap within some years (2017-2021). When using the measure obtained from collective bargaining, we slightly over-estimate tenure rates. The gender difference in the measurement error is tiny (i.e., leading to a 0.3 percentage points difference in the estimated share of women among tenured faculty in a given year). Since the measurement error appears to be uncorrelated with timing of parenthood it does not introduce a bias in

the estimates of the child penalty in tenure rates. [3]

2.3.2 Publication data

We measure research productivity using measures of publications. To each researcher, we add high-quality publication data from Elsevier's database *Scopus*, which is a comprehensive abstract and citation database indexing over 25,000 peer-reviewed journals, conference proceedings, and other scholarly literature across various disciplines, including the arts, humanities, sciences, and social sciences. Our preferred measure is a count of publications, but we also report results where we adjust for impact and quality. To do so, we weigh publications by the impact factor of the journal and by the citation count in the 3 years following the publications, respectively.

2.3.3 Survey evidence on academics in Denmark

We complement the data with a unique cross-sectional survey evidence on parenthood, gender norms, working hours and allocation of childcare that we collected among the population of academics at Danish universities in 2017. We surveyed the universe of academics in Denmark consisting of 10,000 individuals from seven different universities, namely the Universities of Copenhagen, Århus, and Ålborg, Copenhagen Business School, Roskilde University Center, Danish Technical University, and the University of IT. The response rate was above 30%, and the sample of respondents is representative with regard to field, seniority, institution, and gender. We asked researchers about their parental status, number of children and how many hours they spend working in a typical week. Moreover, we asked about their gender norms and sharing of childcare responsibilities within the household. Particularly, we asked researchers to account for their own share and the share of their partner on a number of childcare related responsibilities, such as getting up at night, bringing and picking up children from daycare, providing sick care, and bringing the child to a doctor's appointment. These questions

[3] Assuming pay slip data has the correct title of the researcher, we misclassify 8.7 % of individuals. This is largely due to misclassifying 6.7 % junior researchers as senior researchers (due to relatively high earnings, likely reflecting the payment of bonuses) without a gender gap. The remaining 2% are senior researchers (according to their pay slip) but with earnings below the earnings floor. This is more likely to occur for women. However, the discrepancy appears to be uncorrelated with timing of both parenthood and promotion.

were elicited by asking questions such as: *"In your household, when your youngest child was not yet of school age, who performed the following task? Taking the child to the doctor."* To which respondents could answer: *"Always me, mostly me, equally me and my partner, mostly my partner, always my partner."* We also elicited individual gender norms concerning sharing of housework and market work. Survey respondents were asked to indicate their level of agreement on a scale from one to four with the statement: *"Families usually function best if partners share childcare, household work and paid work tasks equally."*

3 Research Design and Sample

To investigate the impact of parenthood on the likelihood of staying in academia, on promotions, and on publications, we use an event study research design. Methodologically, the event study approach exploits the fact that changes in labor market outcomes due to parenthood occur sharply, while other determinants influencing productivity and labor market outcomes evolve more smoothly. Thus, a causal interpretation of the obtained estimates relies on the assumption that the effect of children on the outcomes of interest evolves orthogonally to unobserved determinants of those outcomes, conditional on age, year, and career stage. The event study approach has the additional advantage of tracing out the dynamic effects of parenthood.

For each researcher in our data, we denote the year they had their first child by j=0. We run the following regression:

$$Y_{i,j,t} = \alpha + \sum_{j=-3}^{5} \lambda_j YearSinceBirth_{i,j} + \sum_{j=-3}^{5} \sigma_j YearSinceBirth_{i,j} \cdot Female_i$$

$$+\beta_i X_{i,t} + \gamma_t + \epsilon_{i,j,t} \tag{1}$$

where $y_{i,t,j}$ is the outcome of individual i in year t and at event time j. We include a full set of event time dummies, λ_j, for j=-3, ..., 5, and year fixed effects, γ_t, to capture general changes such as increased competitiveness. $X_{i,t}$ includes sex, and a full set of dummies for years since enrollment, allowing us to flexibly control for underlying changes to academic productivity. Our coefficients of interest are the λ's which capture

the effect of parenthood, and the σ's which capture a potential gender gap.[4]

We estimate this specification on a **Sample** of individuals defined from the Danish education register (UDDA) who enrolled in a PhD-program in sciences at a Danish University between 1996 and 2016. We do not condition on PhD-graduation, as such also PhD-dropouts are sampled. We follow the individuals from their PhD-start and going forward to 2019, when the employment registers end. However, we can only observe employment status, when individuals are present in Denmark.

The second criterion we impose is that individuals must experience parenthood after starting a PhD, and that they must be observed in the registers at some point from three years before to ten years after their first birth. Therefore, first births included are occurring from 1997 until 2017. This defines an estimation sample of 11,930 individuals.Among the PhDs who are not included in the analysis, 1/3 have become parents prior to starting their PhD, while 1/3 either never become parents, have not yet become parents (by the end of our window of observation) or have had children after leaving Denmark.

Descriptives on the sample of academics

Table 3 describes the partner and fertility choice of academic men and women in our sample. We show that on average they have around 1.8 children, with around 50% having two children. Women on average have their first child in the year after they complete their PhD while men a year later. The average age of first parenthood for both men and women is 32 years old. The majority of male academic have a younger partner, while female academics partner with men older than themselves. The partners of female academics are on average more educated than the partners of male academics. In the period from 2002, female academics took on average 41 weeks of parental leave, while male academics took on average 10 weeks. Table 5 provides s on their employment and position in the year before parenthood and five years after parenthood. Tables 6 and 7 show summary statistics on the publishing trajectory of these academics. In the year before parenthood, on average 27% of men have published, while 24% of women have published. Before becoming parents, men on average have 1.07 publications, while women have 0.84 publications. Ten years after becoming parents, men have 11.58 publications while women have 6.17 publications. In the

[4]We set σ_{-1}=λ_{-1} = 0

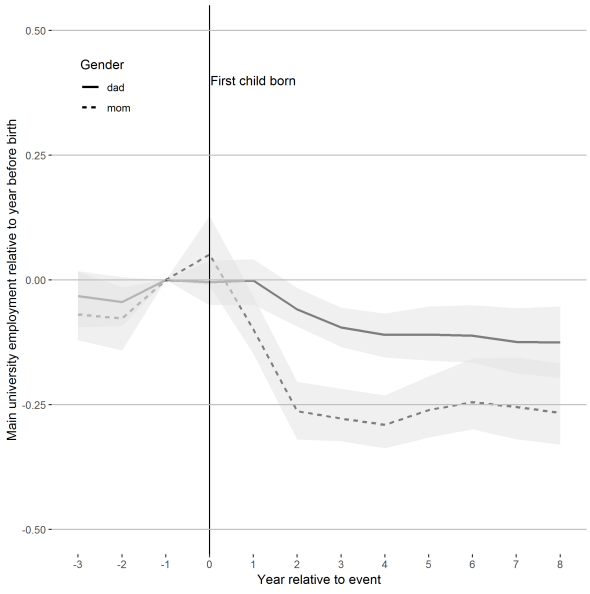
next section, we show how much of that increasing gender gap in publications can be causally attributed to the child penalty.

4 Staying in Academia and Promotions

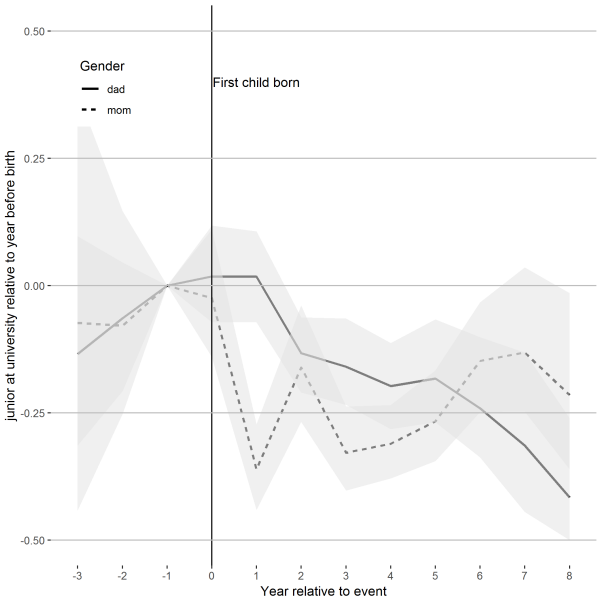
Does becoming a parent affect academic trajectories? In Figure 2 we show that parenthood has a significant impact on a women scientist's academic career.

Figure 2: University employment (excl. PhD-employment)

(a) Main employment



(b) Junior employment



Notes: Figure A shows the impact of childbirth (P_t) on a dummy for employment at universities, respectively for junior employment at university, for our sample of individuals who start a PhD from 1996 to 2016 in Denmark and have a first child after enrolling into their PhD-program. In Figure A, the estimated average annual child penalty over years 1 to 8 is 15 percentage points ($p = .004$). In Figure B, the estimated average annual child penalty over years 1 to 8 is 15 ppts ($p = .080$). In both figures, we have excluded PhD-employment that is employment occurring while being enrolled in a PhD-program. The figures include 90%-confidence intervals based on bootstrapped standard errors (100 replications). The estimations include fixed effects for age, year, and PhD-start age relative to event.

As seen from Figure 2, women are on average 25 percentage points less likely to be employed at a university eight years after birth, while men are only 10 percentage points less likely to stay in university employment after birth. Therefore, the average child penalty on employment at university over the first eight years is estimated at 15

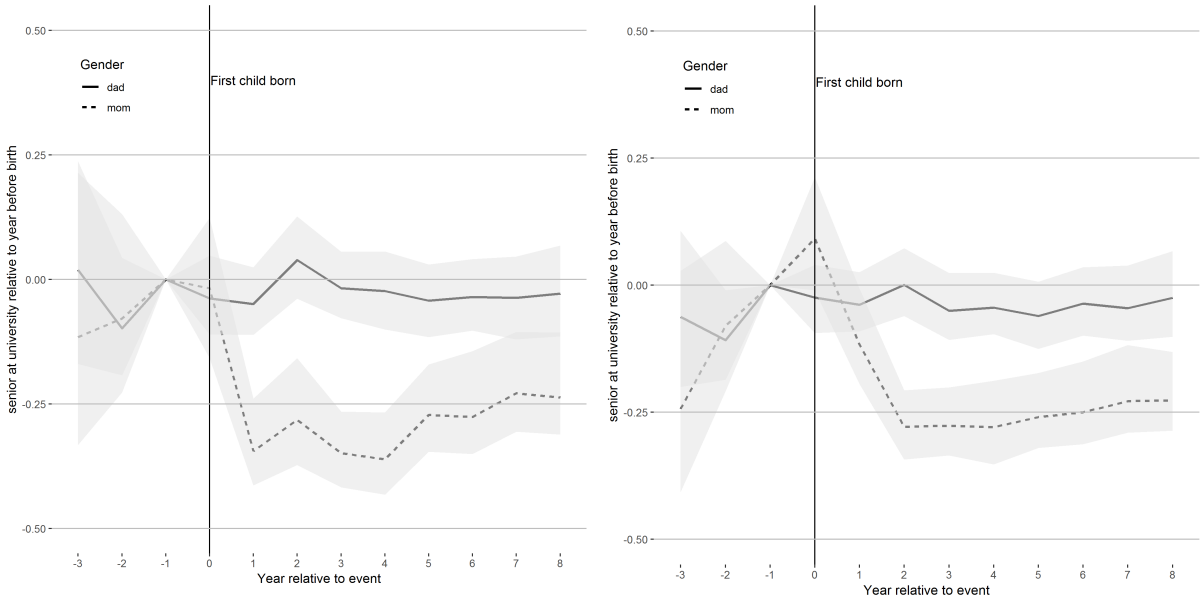
percentage points ($p = 0.004$). The penalty on junior employment in academia is very similar though the estimate is more noisy.

Next, in Figure 3 we show event study estimates on the likelihood of becoming tenured, the equivalent of an associate or full professor position, which is a senior position relative to PhDs and assistant professors in the academic trajectory.

Figure 3: Tenured employment at university

(a) Full time

(b) Unrestricted hours



Notes: Figures A and B show the impact of childbirth (P_t) on a dummy for employment as a senior researcher at universities for our sample of individuals who start a PhD from 1996 to 2016 in Denmark and have a first child after enrolling into their PhD-program. Employment as a senior is defined as having an annual salary above the cut-off equivalent to the hourly salary of a full-time employed senior. In Figure A, the estimated average annual child penalty over years 1 to 8 is 31 percentage points ($p = .000$). In Figure B the estimated average annual child penalty over years 1 to 8 is 19 percentage points ($p = .008$). In both figures, we have excluded PhD-employment that is employment occurring while being enrolled in a PhD-program. The figures include 90%-confidence intervals based on bootstrapped standard errors (100 replications). The estimations include fixed effects for age, year, and PhD-start age relative to event.

Less than 10% of first time parents are already senior upon becoming parents, and the six years following PhD completion is a key time for demonstrating their research potential for tenure. These six years are the period during which most of these academics become parents. We find that women's likelihood of tenured employment immediately declines after motherhood and remains on average 20-30 percentage points

lower than that of fathers over the next eight years. Men's likelihood of tenured employment is not affected by fatherhood. This leads to a sizable gender gap in tenure rates due to having children that persists even eight years beyond the birth. This is driven partly by women leaving academia but even when we condition on remaining employed in research, women are less likely to obtain a tenured position following parenthood.

In the Appendix in Figure 13 we show event study estimates on total earnings and earnings from their main job. Similarly, to the extensive labour literature, men's earnings remain unchanged while women suffer a drop in earnings following parenthood that persists over time. On average the estimated annual child penalty over the first eight years of motherhood is ten percentage points.

5 Productivity and Hours in Academia

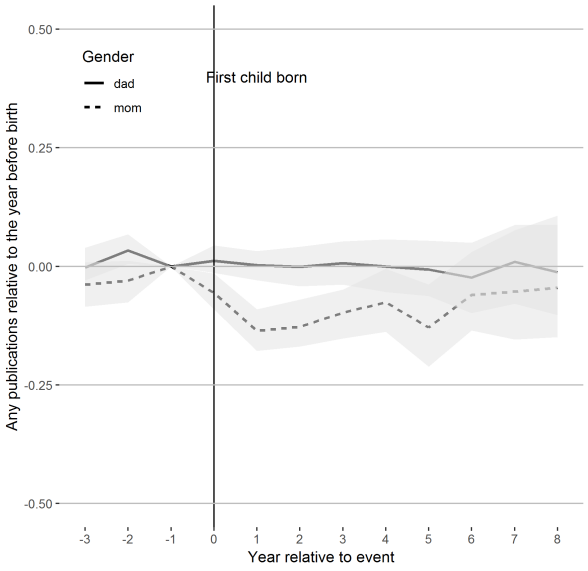
Having found evidence of a child penalty on staying in academia and getting a promotion to a senior position, we investigate whether this could be explained by a drop in research productivity. Academic positions in Denmark are predominantly research heavy (with the teaching load on average taking up to 25% to an academic's workload) and research productivity can be understood as a measure of job performance. Getting tenure, i.e. a senior position of an associate professor or higher, is also explicitly decided on the basis of one's publication record.

In Figure 4 we show the event study estimates on measures of research productivity, namely whether the individual published any research in a given year and their number of annual research publications. We find that men's productivity (relative to own pre-birth productivity) is unaffected on both margins while women are overall less likely to publish in their first 4 years of motherhood and publish, on average, 23 percentage points less publications over the 8 years following childbirth relative to fathers.

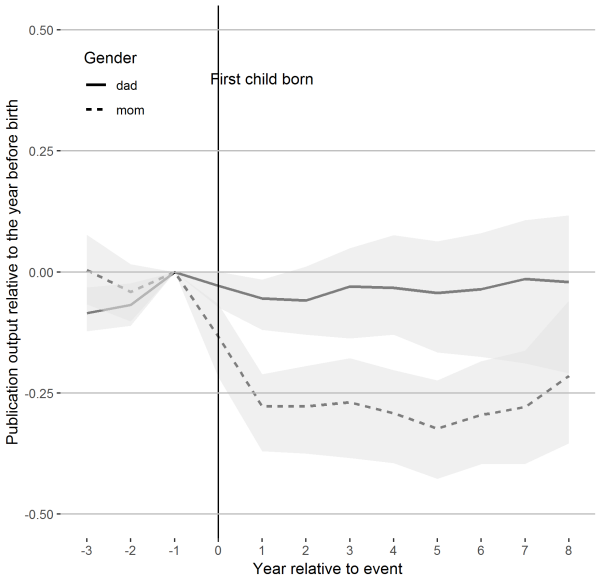
We corroborate this finding with results from a unique survey on Danish academics to understand the origin of the child penalty in research productivity. Academics within STEM and medicine appear to be relatively gender equal according to their

Figure 4: Scientific publications

(a) Any publication



(b) Publications



Notes: Figure A shows the impact of childbirth (P_t) on a dummy for having had any publication in year t, respectively on number of publications in year t for our sample of individuals who start a PhD from 1996 to 2016 in Denmark and have a first child after enrolling into their PhD-program. In Figure A, the estimated average annual child penalty over years 1 to 8 is 9.4 percentage points ($p = .102$) In Figure B the estimated average annual child penalty over years 1 to 8 is 23 percentage points ($p = .059$). The figures include 90%-confidence intervals based on bootstrapped standard errors (100 replications). The estimations include fixed effects for age, year, and PhD-start age relative to event.

elicited gender norms on how house work should be shared across partners. Yet, despite theoretically believing house work should be shared equally, in practice, survey results from both men and women academics show that mothers take the greater load, with women even likelier to think that. Across all categories asked (except for taking children to pre-school or school), 30-40 % of fathers perceive that a certain category was performed more often by their partner, and 35-60 % of mothers perceive that they took the lion's share of the responsibility. In contrast, only about 10% of women and men perceive that the father rather took a greater share of any childcare related duty.

As there is a limited number of hours during the day, more hours spent on child care for women takes away from working hours. This is what our survey shows in Table 1. The working hours of male and female academics without children are very similar at all levels of career. Mothers reduce their working time by four hours relative to academics without children, while fathers reduce their working hours by two hours

relative to academics without children. In sum, mothers reduce their working hours by twice as much as fathers. This finding is confirmed if we look at the household split of parental leave where in the period from 2002, female academics took on average 41 weeks of parental leave, while male academics took on average 10 weeks.

Table 1: Working hours per week across fields

Field	Gender	Non-parent	Parent	Status unknown
Medical and health sciences	F	48.7(69)	47.5(273)	NaN(168)
Medical and health sciences	M	46.8(78)	50.4(379)	54.0(179)
NAT/ENG	F	47.9(144)	44.1(215)	35.0(139)
NAT/ENG	M	48.4(319)	46.8(687)	46.0(367)
Observations		**610**	**1554**	**853**

Note: Individuals were asked: Please rate your level of agreement (on a scale from 1 to 5 where 5 is "fully agree") with the following statement: "Families usually function best if partners share childcare, household work and paid work equally.". No response: 1517. In parenthesis: Number of respondents. NaN represents cases in which all individuals in the cell did not respond to the focal question. NAT/ENG is short for. Natural Sciences and engineering.

6 Conditional Promotion Rates

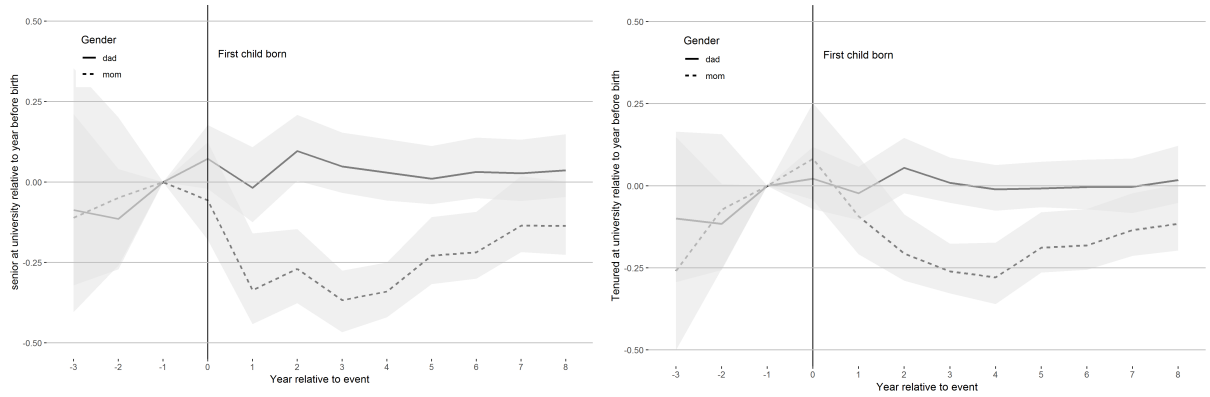
The question is then naturally if women are promoted at lower rates because i) they leave academia at higher rates than men, or because ii) they produce fewer publications.

We therefore we run our event study on tenured employment once more. First, we restrict our sample to individuals who are still employed at university eight years or more after having their first child, and in a second step we control for their scientific productivity as proxied by their annual publications. As seen from Figure 5 child penalties on tenured employment are even larger among those women who remain employed at university at 38 percentage points ($p = .000$), though controlling for scientific productivity reduces the estimated penalty by almost 50% to 22 percentage points ($p = 0.023$).

This illustrates that persistence in academia may not be enough, when working hours to conduct research are squeezed by childcare duties. However, we also see stronger convergence for survivors, indicating that promotions are delayed but not forever.

Figure 5: Promotions among survivors

(a) Survivors in academia (b) Survivors conditional on scientific output



Notes: Figure A shows the impact of childbirth (P_t) on a dummy for university employment in year t, respectively on number of publications in year t for our sample of individuals who start a PhD from 1996 to 2016 in Denmark and have a first child after enrolling into their PhD-program. In Figure A, the estimated average annual child penalty over years 1 to 8 is 38 percentage points ($p = .000$) In Figure B the estimated average annual child penalty over years 1 to 8 is 22 percentage points ($p = .023$). The figures include 90%-confidence intervals based on bootstrapped standard errors (100 replications). The estimations include fixed effects for age, year, and PhD-start age relative to event.

7 Understanding Mechanisms

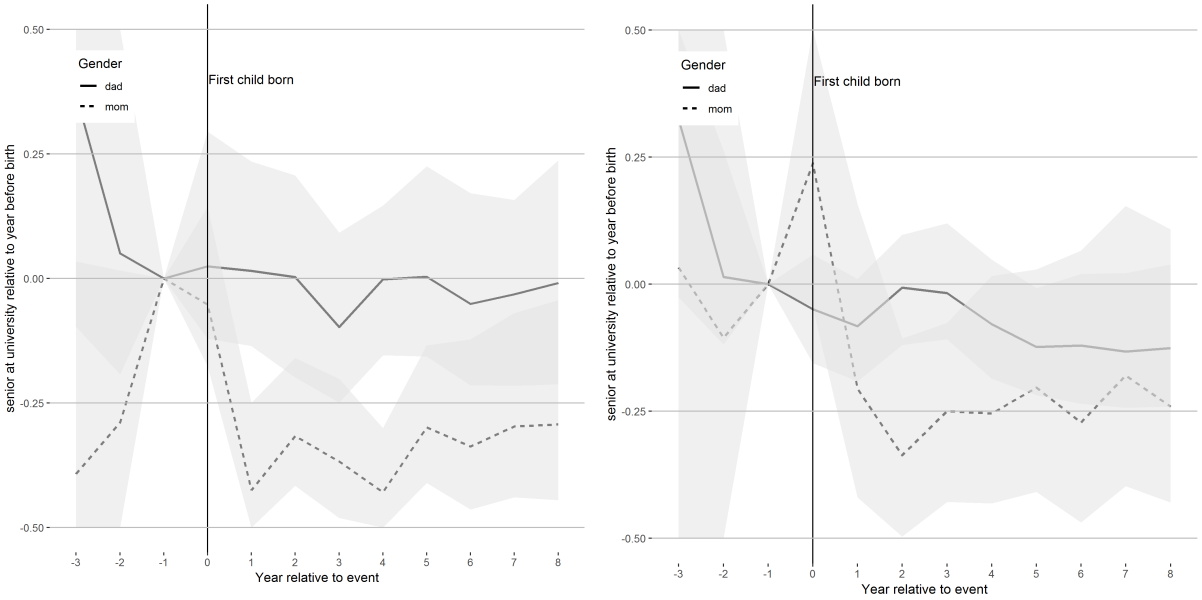
With the aim of understanding the mechanisms, we divide the sample across several margins of heterogeneity. First, we divide individual PhDs based on the nature of their scientific field of education. That is, we divide the natural science fields into *dry fields* and *wet fields*. We define dry fields as those scientific fields that allow for making research progress from behind a desk and therefore offer more flexibility in the location and time when the research is being done, such as physics, math, statistics and computer science. We define as wet fields those scientific fields, where research is done in "wet laboratories" relying heavily on access to specific research infrastructure, machinery and technical equipment, and therefore require irregular and long-hours of presence at work, such as bio-chemistry, chemistry and biology.

In Figure 6, we show that the child penalties on having an academic career and being promoted to a senior position are larger and more pronounced for the wet fields This suggests that it is the lack of flexibility of wet fields in combination with the legacy

Figure 6: Tenured employment in the STEM fields

(a) Wet fields

(b) Dry fields



Notes: Figures A and B show the impact of childbirth (P_t) on a dummy for senior academic employment by field of education at university for our sample of individuals who start a PhD from 1996 to 2016 in Denmark and have a first child after enrolling into their PhD-program. Employment as a senior is defined as having an annual salary above the cut-off equivalent to the annual salary of a full-time employed senior. In Figure A, the estimated average annual child penalty over years 1 to 8 is 36 percentage points($p = .040$). In Figure B the estimated average annual child penalty over years 1 to 8 is 19 percentage points ($p = .313$). In both figures, we have excluded PhD-employment that is employment occurring while being enrolled in a PhD-program. The figures include 90%-confidence intervals based on bootstrapped standard errors (100 replications). The estimations include fixed effects for age, year, and PhD-start age relative to event.

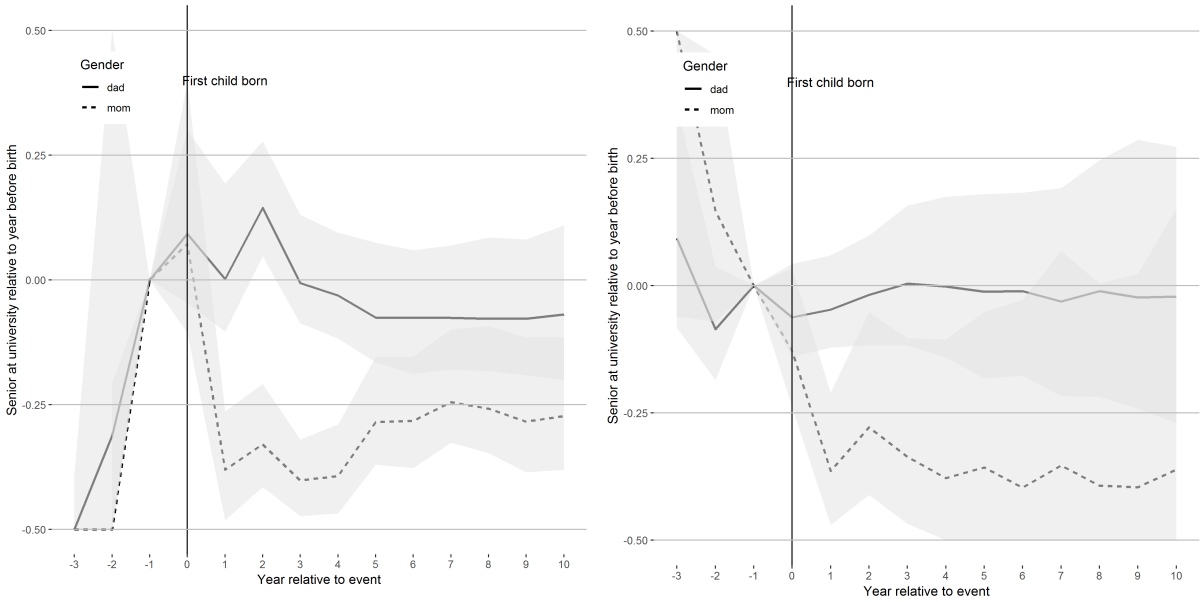
of gender norms where women continue to take on the majority of child care-taking responsibilities in the private's sphere that impedes women's academic careers.

Second, we split across the timing of birth, namely whether the researcher became a parent during the five years after the start year of the PhD (*early birth*) or whether the researcher became a parent more than five years after the start year of their PhD (*late birth*). If the researcher's goal is to secure a senior academic position in the long run, the equivalent of an associate or full professor, becoming a mother earlier in the career leads to lower child penalties (24 percentage points) than becoming a mother later in the career when women experience larger child penalties (39 percentage points). Men's likelihood of getting tenure is not affected regardless of the career stage at which they

pursue parenthood. This is visualised in Figure **??**.

Figure 7: Senior academic employment by timing of birth

(a) Early Birth (b) Late Birth



Notes: Figures A and B show the impact of childbirth (P_t) on a dummy for senior academic employment by timing of birth relative to PhD-start for our sample of individuals who start a PhD from 1996 to 2016 in Denmark and have a first child after enrolling into their PhD-program. "Early birth" is defined as having a first birth in the five years after the year of PhD-start, while "Late birth" is defined as having a first birth more than five years after the year of PhD-start. Employment as a senior is defined as having an annual salary above the cut-off equivalent to the annual salary of a full-time employed senior. In Figure A, the estimated average annual child penalty over years 1 to 8 is 29 percentage points (p = .031). In Figure B the estimated average annual child penalty over years 1 to 8 is 33 percentage points (p = .089). In both figures, we have excluded PhD-employment that is employment occurring while being enrolled in a PhD-program. The figures include 90%-confidence intervals based on bootstrapped standard errors (100 replications). The estimations include fixed effects for age, year, and PhD-start age relative to event.

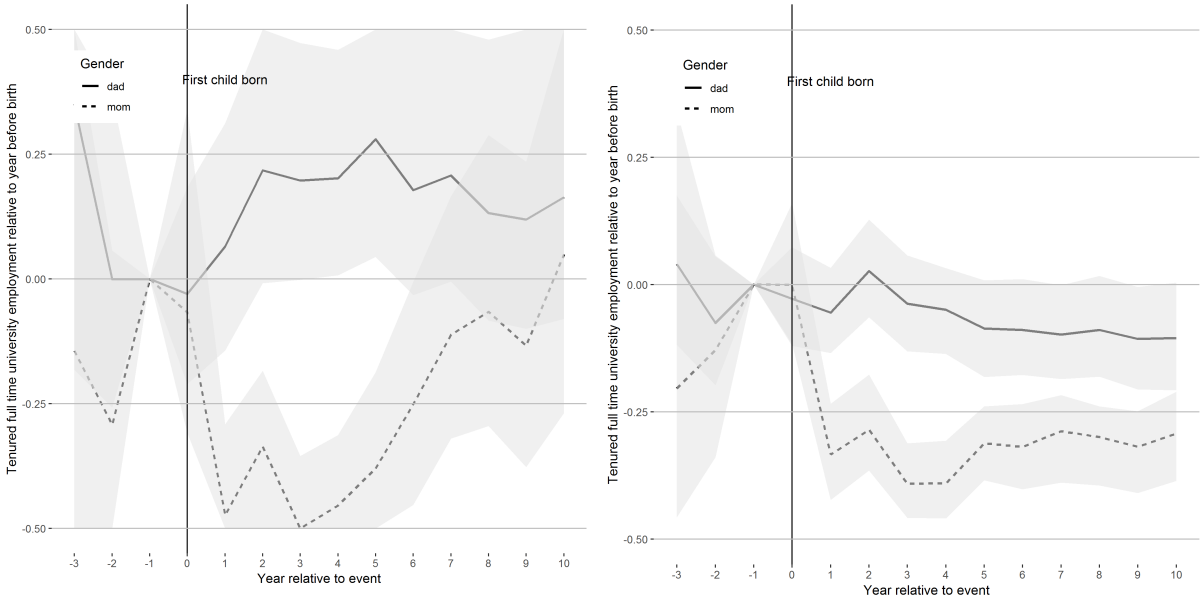
Finally, we observe gender norms of researchers, proxied by leave-taking relative to the sample distribution for same gender peers. We show this in Figure 8. Traditional mothers are defined as academic mothers taking more leave than the 75th percentile of the sample distribution of academic mothers, and traditional fathers are defined as academic fathers taking more leave than the 75th percentile of the sample distribution of academic fathers. Progressive academic mothers and fathers are defined as the inverse of traditional ones. Progressive mothers experience smaller child penalties on senior employment relative to progressive fathers, while traditional mothers experience large child penalties on senior employment relative to traditional fathers. Progressive

fathers on average have similar rates of senior employment before and after parenthood, yet for traditional academic fathers, becoming a father positively affects their likelihood of senior employment as perhaps their partners upon birth specialize even more in household management. This leads to a larger estimated average child penalty (38 percentage points) when comparing traditional mother and father academics, and a smaller estimated average child penalty when comparing progressive mother and father academics (21 percentage points).

Figure 8: Senior academic employment by leave-taking

(a) Traditional leave-taking

(b) Progressive leave-taking



Notes: Figures A and B show the impact of childbirth (P_t) on a dummy for senior academic employment by leave-taking at university for our sample of individuals who start a PhD from 1996 to 2016 in Denmark and have a first child after enrolling into their PhD-program. Traditional leave-taking is defined as mothers taking more leave than the 75th percentile of the sample distribution, and fathers taking less than the 25th percentile in the sample distribution. Progressive leave-taking is defined as the residual. Employment as a senior is defined as having an annual salary above the cut-off equivalent to the annual salary of a full-time employed senior. In Figure A, the estimated average annual child penalty over years 1 to 8 is 38 percentage points ($p = .179$). In Figure B the estimated average annual child penalty over years 1 to 8 is 21 percentage points ($p = .056$). In both figures, we have excluded PhD-employment that is employment occurring while being enrolled in a PhD-program. The figures include 90%-confidence intervals based on bootstrapped standard errors (100 replications). The estimations include fixed effects for age, year, and PhD-start age relative to event.

8 Putting our estimates in context

In this section, we consider how our results can be translated to other countries with different gender norms and different academic systems. Several features suggest that the child penalty might be larger in societies where there is less support or childcare available, but this is also likely to affect fertility rates and family size.

The first consideration is to understand whether Danish academics are different in terms of family formation, timing of first birth, and time use on childcare and access to care relative to other countries.

Family formation: Historically, women combining family and an academic career were extremely rare. During the US baby boom just 22 % of women who made it to the 'Men of Science' had children, whereas for men that number is 74 % (Kim & Moser, 2021). Today the gender gap in parenthood in the US is smaller, but not fully closed. Using data from the 1990's graduating cohort, Cheng (2020) shows that American women with PhD degrees in STEM are 10 %-point less likely to ever have children than men with PhD degrees. Of those that do become parents, new mothers are roughly half a year younger than new fathers. 73.4 % of mothers have their first child within 5 years of PhD graduation. For fathers, this number is 71.0 %. In our setting, the majority have their first child during the PhD whereas in contemporaneous US, parenthood is most common in years 1-5 after PhD completion.

More directly comparable to our estimates are number from contemporaneous Sweden reported by Ejermo (n.d.); 25 % of men with PhD's in Sweden are not (yet) fathers by age 40, whereas the number for women is just 17 %. Among university employees, 65 % of new mothers are PhD students, and 55 % of new fathers are PhD students.

We find that the vast majority of both men and women PhDs have children and we show that those who stay in academia do not delay or reduce fertility compared to those who leave academia. This is shown in Table 2. Fifteen years after the completion of their PhD, on average 87% of women and men working at universities have at least one child, as compared to 76-82% of women and men who work in other sectors. Similarly, both male and female PhDs regardless of whether they work in academia or other sectors have on average 1.8 to 1.9 children fifteen years after their PhDs.

Table 2: Fertility rates of men and women in academia

	Age at parenthood	At least one child				Number of children			
		5 years	7 years	10 years	15 years	5 years	7 years	10 years	15 years
Panel A: Women									
University	30.28	0.74	0.78	0.84	0.87	1.34	1.52	1.75	1.87
	(3.77)	(0.44)	(0.41)	(0.37)	(0.34)	(1.01)	(1.03)	(1)	(0.99)
		2290	1815	1283	734	2290	1815	1283	734
Broader Research	30.29	0.82	0.86	0.90	0.90	1.65	1.83	2.01	2.04
	(3.68)	(0.39)	(0.35)	(0.29)	(0.3)	(1.03)	(0.99)	(0.95)	(0.98)
		2745	2292	1592	857	2745	2292	1592	857
Other Sectors	30.66	0.69	0.77	0.82	0.84	1.25	1.50	1.70	1.82
	(4.15)	(0.46)	(0.42)	(0.39)	(0.36)	(1.04)	(1.03)	(1.04)	(1.04)
		5182	4674	3552	1961	5182	4674	3552	1961
Panel B: Men									
	31.05	0.64	0.73	0.81	0.87	1.11	1.36	1.66	1.94
University	(4.14)	(0.48)	(0.44)	(0.39)	(0.34)	(1.01)	(1.03)	(1.06)	(1.04)
		2711	2307	1807	1167	2711	2307	1807	1167
	31.05	0.78	0.83	0.86	0.90	1.56	1.79	1.98	2.16
Broader Research	(3.91)	(0.42)	(0.37)	(0.34)	(0.29)	(1.07)	(1.07)	(1.06)	(1.04)
		2385	2126	1604	939	2385	2126	1604	939
	31.44	0.55	0.66	0.76	0.80	0.99	1.25	1.56	1.78
Other Sectors	(4.41)	(0.5)	(0.47)	(0.43)	(0.4)	(1.05)	(1.08)	(1.1)	(1.11)
		6515	6018	4696	2823	6515	6018	4696	2823

Notes: This table reports the share of individuals who are parents and the mean number of children (standard deviations in parentheses), measured relative to PhD enrollment (in Denmark) among those who enrolled in 1996 or later. We report fertility at five, seven, ten years and fifteen years after PhD enrollment, split by employment in universities, the broader research sector, or outside research. As our sample covers individuals enrolled up until 2018, the longer time horizon implies fewer people.

These patterns are corrobrated with evidence from our own survey on academics (2017). Already at the junior level, almost half of the surveyed academics report being parents, while at the later career stages, the share of parents increases to 80-90%. Conditional on parenthood, the average academic has two or more children. Academics in Medicine are somewhat more likely to realize parenthood and, on average, they have larger families than STEM academics. These two sets of findings suggest that men and women academics in Denmark do not delay or forego having children.

Time use and family policies: Policies enabling women's labor force participation are largely different across countries. However, our analysis shows that only conservative fathers benefit from generous parental leave suggesting that family policies are insufficient in closing gender gaps, as long as childcare still falls disproportionately on women. This mirrors the findings by Antecol et al. (2018) documenting an increased gender gap in tenure rates from gender-neutral extension policies applied to new par-

ents at top 50 economic departments in the US.[5] If men with little caregiving obligations get a premium in promotion rates - relative to men who partake in parental leave and all women - it is useful to compare the prevalence of this household type across countries. In Figure 9, we report hours spend on paid work, and on childcare for a subset of European countries. Of all the countries, households where fathers do very little childcare appear to be the most uncommon in Denmark, followed by the other Scandinavian countries. Among Danish parents, there is no gender gap in the share of parents who report doing childcare daily. Only in Sweden is there also no gender gap in the share of parents who are daily involved in childcare. For all other countries, the average gap is 20 percentage points. Conditional on doing childcare daily, Danish mothers spend 6.2 hours/week more on childcare.

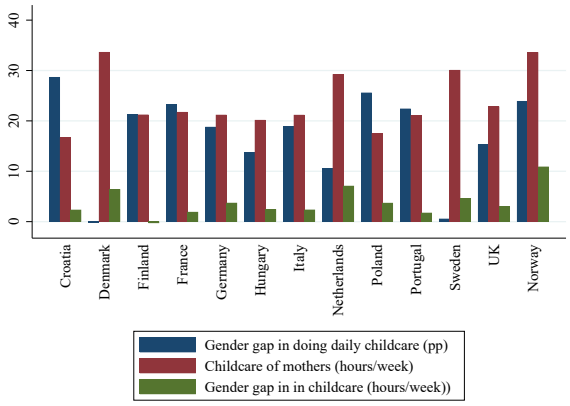
Instead, fathers are spending more time on paid work. On average, Danish fathers works 42 hours/week and Danish mothers works 38 hours/week. These numbers are slightly lower than for the average European parent in the survey, where fathers work 43 hours/week and mothers work 40 hours/week. In general, this patterns mirrors the numbers reported for academics in Table 1. Academic mothers in Denmark work 45 hours/week, and fathers work 49 hours. Non-parents work 48 hours/week. With this comparison, we see that Danish academics work roughly 20 % more than the general population.

Second, we consider the market for chores and childcare to understand if households have the option to outsource. For this considering, we pause the consideration of differences across gender. Households who have an easy time making ends would be more likely to outsource chores and perhaps also childcare. To understand the availability of services, we consider the differences between household who report that they easily or very easily make ends meet and households who have some difficulty making ends meet. In Figure 10, we report the share of high income households doing chores and childcare daily and the differences to low income households. For all countries, the share of households reporting doing chores and childcare daily are very similar across types of households with Portugal and the UK being outliers. This suggest that market-based outsourcing of chores and childcare are uncommon (or evenly distributed between the different types of household) in most countries.

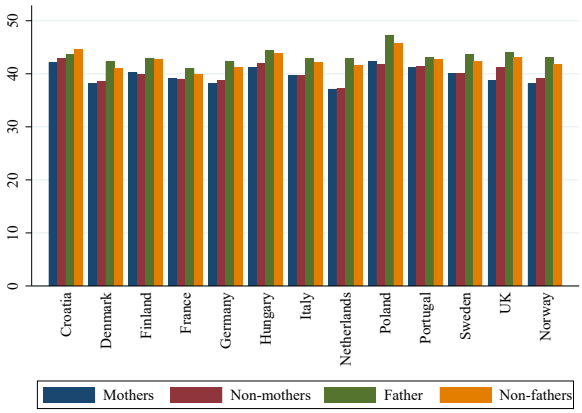
[5]They also report that most individuals in their sample become parents, and fertility appears to be higher in places where the tenure clock extension is in place.

Figure 9: Hours spend on child care and paid work

(a) Childcare



(b) Paid work

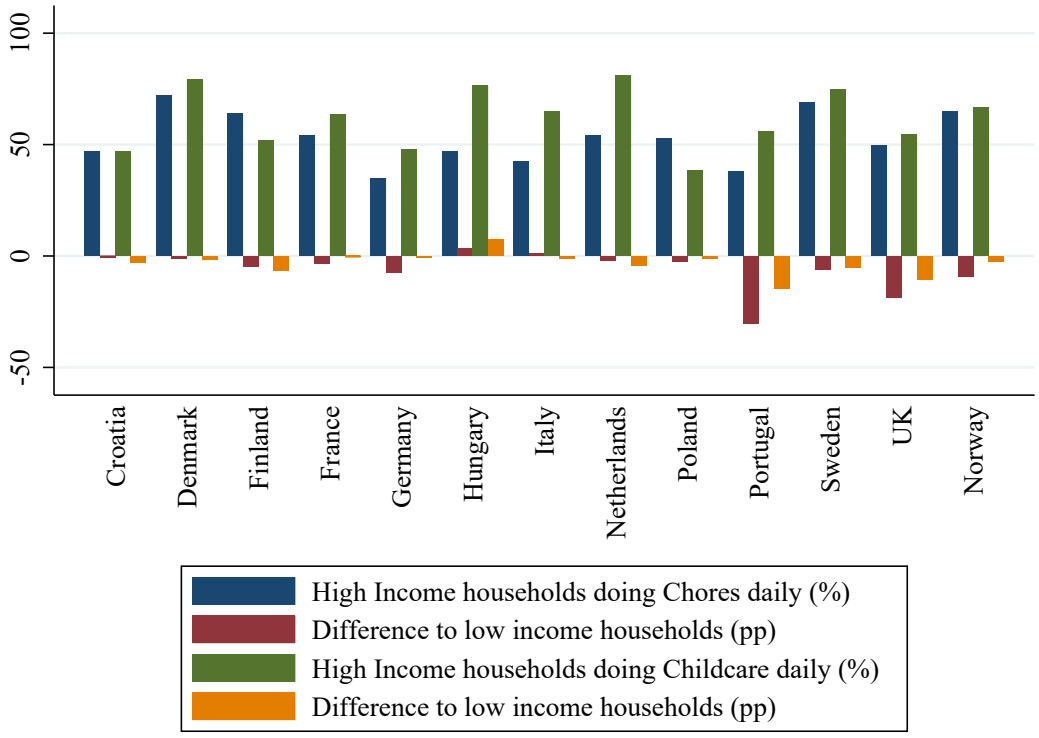


Notes: Data Source: 6TH EUROPEAN WORKING CONDITIONS SURVEY (2015). Conditional on working full-time (more than 30/hours), split by gender and by the presence of children in the household. Hours spent on childcare are only reported for parents, and are conditional on reporting doing those activities daily.

9 Conclusion

Parity is far from achieved in senior positions in academia globally. In Denmark, women's representation among tenured faculty is slightly lower than the European average (Auriol et al., 2022), but higher than in the US and UK (e.g. Bateman & Hengel (2018); Lundberg & Stearns (2019)). With data covering the early pipeline into the profession, enrollment in Ph.D. programs, we show that parenthood changes the academic trajectory for women. While men and women follow similar career trends before having a child, after becoming parents, their career paths in academia diverge. We find that mothers are 15 percentage points less likely than fathers to remain employed at universities and in the broader research sec tor. The motherhood penalty is particularly stark when we examine the likelihood of tenured employment after childbirth - while men's employment in tenured positions is unaffected by the arrival of a child, women experience on average a 25 percentage points drop in their rate of tenured employment. This drop persists even 8 years after birth. We observe that childbirth is also followed by a drop in research output as measured by annual publications relative to productivity before birth, that can explain some, but not all, of the penalty on tenured employment.

Figure 10: Chores and Childcare, by type of household



Notes: Data Source: 6TH EUROPEAN WORKING CONDITIONS SURVEY (2015). Conditional on working full-time (more than 30/hours), for all parents. Patterns for chores are similar for non-parents. High income households are classified as those who report that they (very) easily make ends meet. Low income households are those who report some difficulty making ends meet.

We investigate how differences in the field of study and field of research, stage of career of the childbirth, and couple gender norms affects these penalties. We find that women in wet fields that have less flexibility suffer high penalties, showing evidence that even within the same occupation the degree of job flexibility is particularly important for women's labour market outcomes after parenthood (Goldin (2014)). We also show that child penalties are larger for births later in the career in the years that overlap with the period to tenure, and that progressive partners that take a higher share of parental leave relatively decrease the child penalty of women academics.

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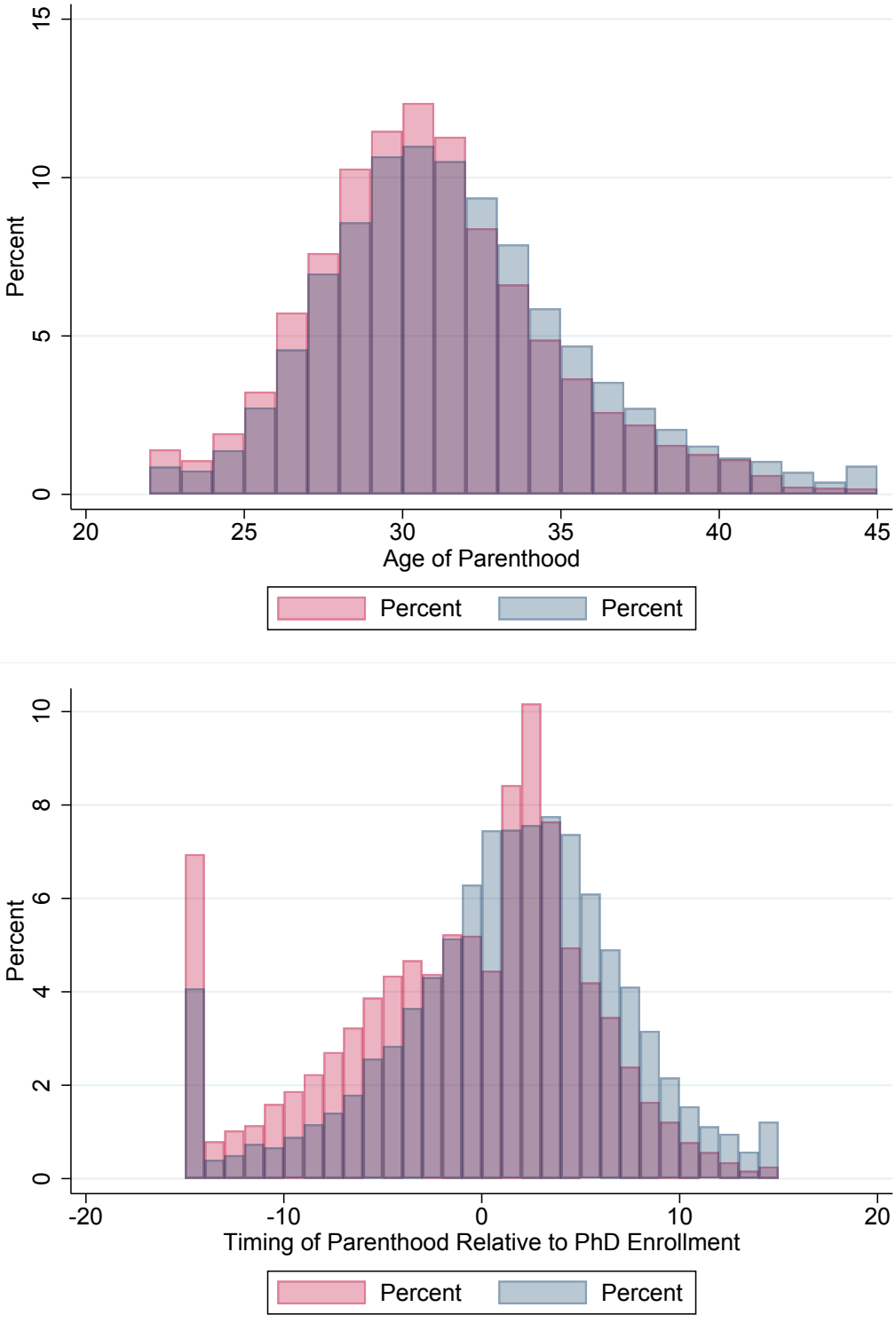
10 Appendix

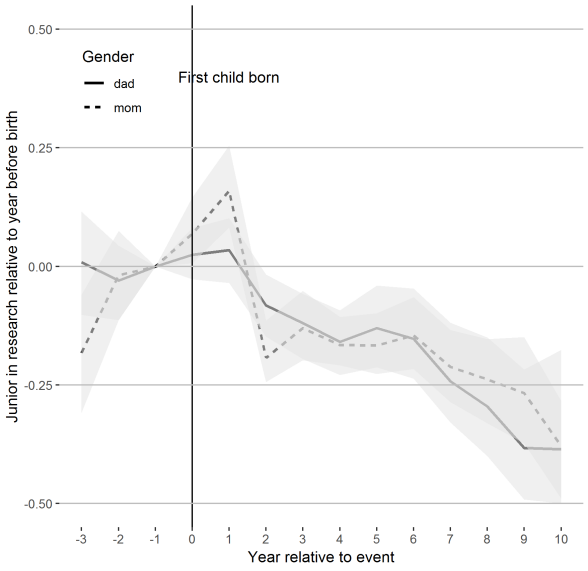
Figure 11: Age at Parenthood and Parenthood Relative to PhD Enrollment



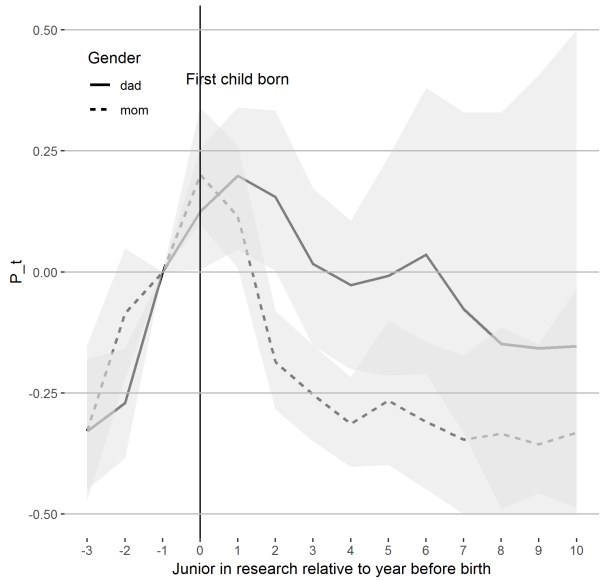
Notes: The left-hand panel shows the age at parenthood for men and women, respectively, with truncated tails to mask individual observations. The right-hand panel shows parenthood relative to enrollment for men and women, respectively.

Figure 12: Junior employment by country of origin

(a) Danish



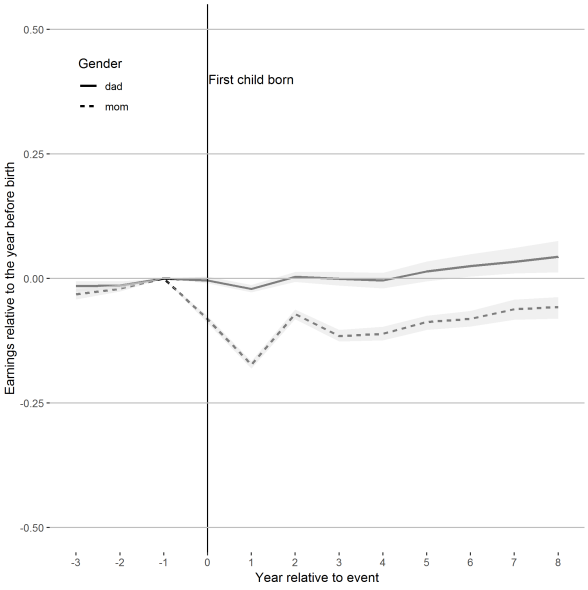
(b) Foreign



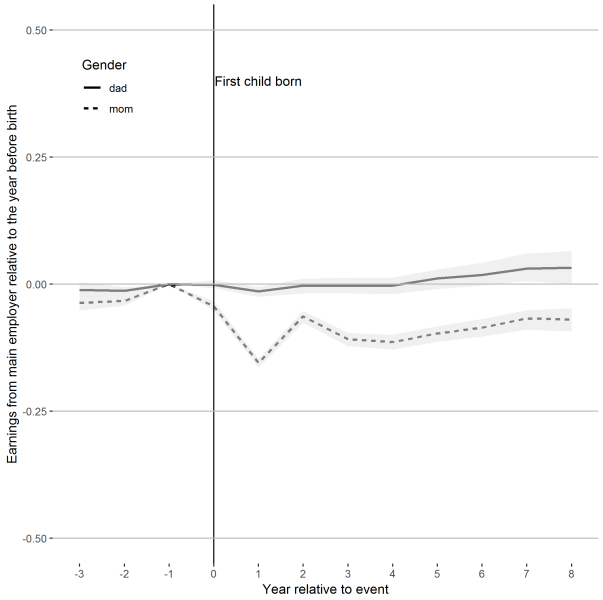
Notes: Figures A and B show the impact of childbirth (P_t) on a dummy for junior academic employment by country of origin for our sample of individuals who start a PhD from 1996 to 2018 in Denmark and have a first child after enrolling into their PhD-program. Employment as a junior is defined as having an annual salary below the cut-off equivalent to the annual salary of a full-time employed senior. In Figure A, the estimated average annual child penalty over years 1 to 8 is 3 percentage points ($p = .789$). In Figure B the estimated average annual child penalty over years 1 to 8 is 27 percentage points ($p = .011$). In both figures, we have excluded PhD-employment that is employment occurring while being enrolled in a PhD-program. The figures include 90%-confidence intervals based on bootstrapped standard errors (100 replications). The estimations include fixed effects for age, year, and PhD-start age relative to event.

Figure 13: Total earnings and earnings from main employment

(a) Total earnings

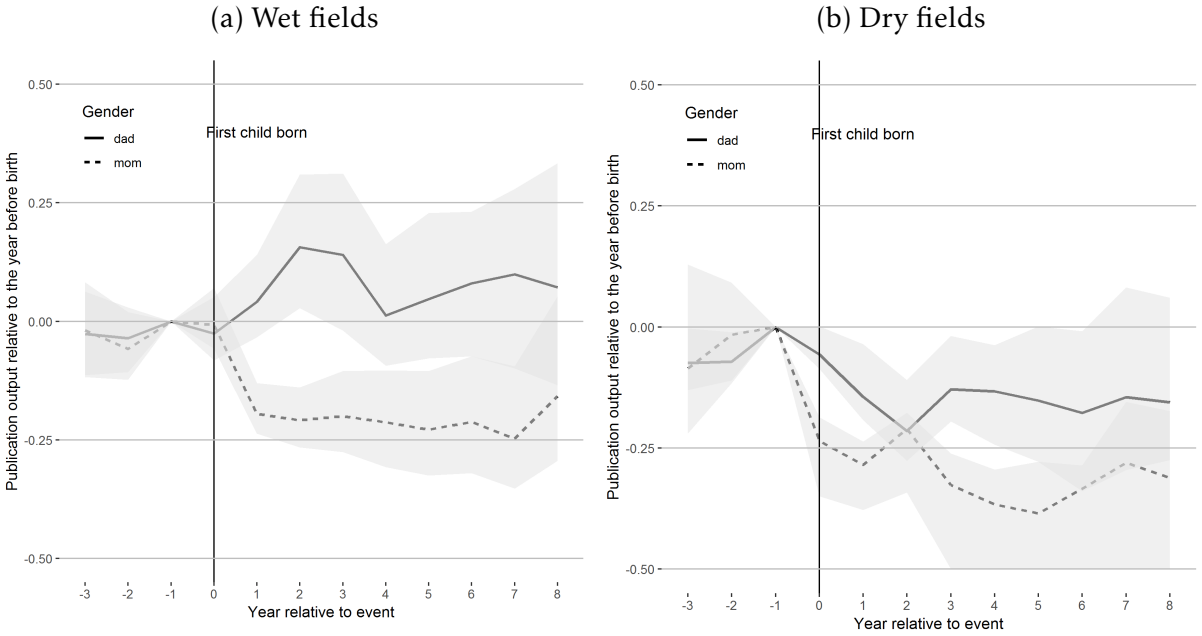


(b) Main job earnings



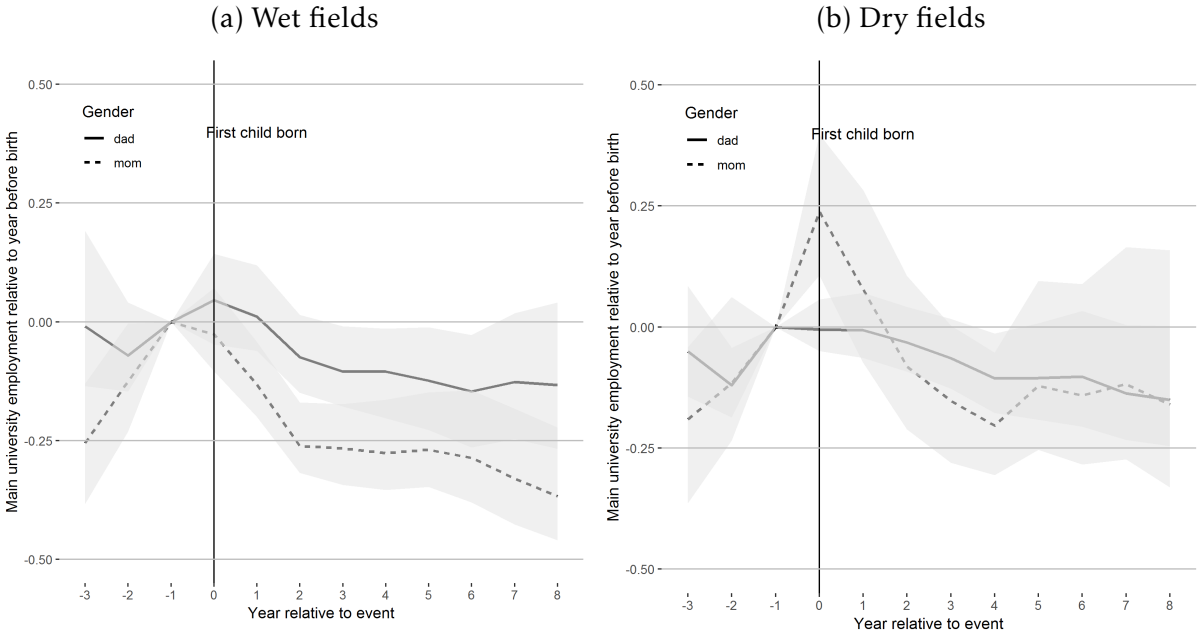
Notes: Figures A and B show the impact of childbirth (P_t) on total wage earnings and main job earnings for our sample of individuals who start a PhD 1996-2018 and have a first child after enrolling into a PhD-program in Denmark. In Figure A, the estimated average annual child penalty over years 1 to 8 is 11 percentage points ($p = .000$). In Figure B the estimated average annual child penalty over years 1 to 8 is 10 percentage points ($p = .000$). Earnings have not been corrected for earnings during PhD-employment. The figures include 90%-confidence intervals based on bootstrapped standard errors (100 replications). The estimations include fixed effects for age, year, and graduation age relative to event.

Figure 14: Publications by STEM field of education



Notes: Figures A and B show the impact of childbirth (P_t) on number of publications in year t by STEM field of education for our sample of individuals who start a PhD from 1996 to 2018 in Denmark and have a first child after enrolling into their PhD-program.In Figure A, the estimated average annual child penalty over years 1 to 8 is 34 percentage points ($p = .022$). In Figure B the estimated average annual child penalty over years 1 to 8 is 7 percentage points ($p = .672$). The figures include 90%-confidence intervals based on bootstrapped standard errors (100 replications). The estimations include fixed effects for age, year, and PhD-start age relative to event.

Figure 15: Main employment at university by field



Notes: Figures A and B show the impact of childbirth (P_t) on a dummy for employment in broader research by STEM field of education for our sample of individuals who start a PhD from 1996 to 2016 in Denmark and have a first child after enrolling into their PhD-program. In Figure A, the estimated average annual child penalty over years 1 to 8 is 15 percentage points (p = .140). In Figure B the estimated average annual child penalty over years 1 to 8 is 2 percentage points (p = .834). In both figures, we have excluded PhD-employment that is employment occurring while being enrolled in a PhD-program. The figures include 90%-confidence intervals based on bootstrapped standard errors (100 replications). The estimations include fixed effects for age, year, and graduation age relative to event.

Table 3: Family formation of PhD parents

	(1) PhD fathers			(2) PhD mothers		
	Obs	Mean	Sd	Obs	Mean	Sd
Timing of birth						
PhD-start age at first birth	7293	4.57	3.26	6076	3.70	2.67
Age at first birth	7293	32.62	3.94	6076	32.16	3.48
Coparent age at first birth	7241	31.14	3.56	5887	33.99	4.96
Family formation						
Children	7293	1.85	0.74	6076	1.78	0.69
1 child	7293	0.34	0.47	6076	0.36	0.48
2 children	7293	0.49	0.50	6076	0.51	0.50
3 or more children	7293	0.17	0.37	6076	0.13	0.34
Coparent education						
Coparent is PhD or researcher	7293	0.23	0.42	6076	0.29	0.45
Coparent is PhD	7293	0.19	0.39	6076	0.25	0.43
Coparent is Master	7293	0.47	0.50	6076	0.39	0.49
Coparent is BA or less	7293	0.27	0.45	6076	0.28	0.45
Relative age						
Coparent is older	7241	0.23	0.42	5887	0.63	0.48
Coparent is same age	7241	0.18	0.38	5887	0.16	0.37
Coparent is younger	7241	0.59	0.49	5887	0.21	0.41
Relative income						
Coparent has lower income	6619	0.64	0.48	5477	0.38	0.49
Coparent has same income	6619	0.08	0.27	5477	0.08	0.27
Coparent has higher income	6619	0.28	0.45	5477	0.54	0.50
Sector of employment						
Coparent in public sector	4387	0.64	0.48	3786	0.47	0.50
Coparent in private sector	4387	0.39	0.49	3786	0.56	0.50
Leave-taking						
Weeks of parental leave (1996-2001)*	397	4.82	6.97	263	37.24	16.68
Weeks of parental leave (2002-2018)*	5300	10.04	7.93	4342	41.14	13.40
Weeks of household leave (1996-2001)*	276	46.19	19.62	206	42.84	18.20
Weeks of household leave (2002-2018)*	2828	50.72	13.03	2803	50.04	13.03
Share of household leave (1996-2001)*	276	0.10	0.12	206	0.88	0.15
Share of household leave (2002-2018)*	2828	0.20	0.14	2803	0.80	0.14
Traditional father**	5697	0.24	0.43	4605	0.00	0.00
Traditional mother**	5697	0.00	0.00	4605	0.31	0.46

Note: This table contains descriptive information on family formation, coparent characteristics and leavetaking for cohorts of individual men and women who enrolled in a PhD-program in Denmark between 1996 and 2018, and experienced a first birth after PhD-enrollment.* Two different leave-regimes were in place during the window of observation. Benefit entitlements of both mothers and fathers increased from 2002. **Traditional mother is defined as leavetaking greater than the 75th percentile of mothers, while traditional father is defined as leavetaking lower than the 25th percentile of fathers. Progressive mother is defined as leavetaking lower than the 25th percentile of mothers, while progressive father is defined as leavetaking higher than the 75th percentile of fathers.

Table 4: Occupational outcomes of PhDs and PhD parents relative to PhD start

	PhD men			PhD women			PhD fathers			PhD mothers		
	Obs	Mean	Std	Obs	Mean	Std	Obs	Mean	Std	Obs	Mean	Std
Employment status, 5 years after PhD-start												
Industry is NA	21239	0.34	0.47	18540	0.33	0.47	7293	0.19	0.39	6076	0.24	0.42
Staying abroad	21239	0.20	0.40	18540	0.14	0.34	7293	0.12	0.33	6076	0.08	0.27
Industry, 5 years after PhD-start												
Broader research	16034	0.42	0.49	14617	0.39	0.49	6650	0.40	0.49	5550	0.33	0.47
Broader research (no hospital)	16034	0.31	0.46	14617	0.23	0.42	6650	0.33	0.47	5550	0.23	0.42
Universities	16034	0.23	0.42	14617	0.17	0.38	6650	0.23	0.42	5550	0.16	0.37
University hospitals	16034	0.11	0.31	14617	0.15	0.36	6650	0.08	0.27	5550	0.10	0.30
Research institutes	16034	0.08	0.26	14617	0.06	0.24	6650	0.09	0.29	5550	0.07	0.26
Other (non research) public	13958	0.10	0.30	12355	0.11	0.32	5904	0.09	0.29	4643	0.10	0.29
Private industry	13958	0.32	0.47	12355	0.23	0.42	5904	0.36	0.48	4643	0.27	0.44
Pharmaceutical	20062	0.04	0.19	17441	0.05	0.22	7280	0.05	0.22	6062	0.07	0.26
Chemical	20062	0.01	0.08	17441	0.01	0.08	7280	0.01	0.10	6062	0.01	0.09
Engineering	20062	0.02	0.15	17441	0.01	0.11	7280	0.04	0.19	6062	0.02	0.13
Finance	20062	0.01	0.07	17441	0.00	0.04	7280	0.01	0.09	6062	0.00	0.05
IT	20062	0.04	0.18	17441	0.01	0.09	7280	0.04	0.20	6062	0.01	0.09
Consultancy	20062	0.01	0.10	17441	0.01	0.09	7280	0.01	0.12	6062	0.01	0.09
Private clinic	20062	0.00	0.04	17441	0.00	0.07	7280	0.00	0.05	6062	0.00	0.06
Electricity	20062	0.00	0.07	17441	0.00	0.03	7280	0.01	0.09	6062	0.00	0.04
Sector, 5 years after PhD-start												
Private sector	13834	0.31	0.46	12185	0.23	0.42	5682	0.35	0.48	4360	0.27	0.45
Public sector	13834	0.74	0.44	12185	0.81	0.39	5682	0.70	0.46	4360	0.77	0.42
Academic position, 5 years after PhD-start												
Phd at university	16535	0.12	0.33	15182	0.22	0.41	6778	0.11	0.31	5757	0.25	0.43
Junior at university	16535	0.23	0.42	15182	0.18	0.38	6778	0.21	0.41	5757	0.15	0.36
Senior at university	16535	0.06	0.24	15182	0.04	0.19	6778	0.05	0.23	5757	0.03	0.16
Junior in broad research	16535	0.21	0.40	15182	0.17	0.38	6778	0.22	0.41	5757	0.18	0.38
Senior in broad research	16535	0.09	0.29	15182	0.05	0.23	6778	0.10	0.30	5757	0.05	0.22
Wage earnings (DKK100,000)	16023	444	189.76	14552	400	169.03	6562	422	155.57	5431	358	145.90

Note: This table contains descriptive information on employment status, sector of employment and academic position five years after PhD-start for cohorts of men and women who enrolled in a PhD-program in Denmark between 1996 and 2018, as well as for our sample of PhD fathers and mothers who experienced a first birth after PhD-enrollment.

Table 5: Occupation outcomes of PhD parents relative to first birth

	PhD fathers			PhD mothers		
	Obs	Mean	Std	Obs	Mean	Std
Employment, year before birth						
Industry is unknown	7051	0.13	0.33	5905	0.11	0.31
Staying abroad	7051	0.08	0.28	5905	0.06	0.24
Broad research	6721	0.20	0.40	5680	0.17	0.38
Broad research (excl. hospital)	6721	0.17	0.38	5680	0.14	0.35
Broad research (incl. PhD)	6721	0.62	0.48	5680	0.70	0.46
University	6721	0.13	0.34	5680	0.10	0.30
University hospital	6721	0.02	0.15	5680	0.03	0.18
Research institute	6721	0.04	0.20	5680	0.04	0.20
Private industry	6168	0.24	0.43	5265	0.16	0.37
Public industry, non research	6168	0.08	0.28	5265	0.08	0.27
Wage earnings (DKK100,000)	6676	369	204.35	5658	341	140.05
Academic position, year before birth						
Phd	6819	0.43	0.50	5758	0.53	0.50
Junior at university	6819	0.10	0.30	5758	0.09	0.28
Senior at university	6819	0.04	0.20	5758	0.02	0.14
Junior in broad research	6819	0.11	0.31	5758	0.10	0.30
Senior in broad research	6819	0.07	0.25	5758	0.04	0.19
Employment status and sector, birth year+5						
Industry is NA	7293	0.23	0.42	9432	0.22	0.41
Staying abroad	7293	0.10	0.30	9432	0.06	0.24
Private sector	5296	0.44	0.50	6501	0.29	0.45
Public sector employment	5296	0.58	0.49	6501	0.74	0.44
Broad research	5969	0.45	0.50	8194	0.33	0.47
Broad research (excl. hospital)	5969	0.36	0.48	8194	0.21	0.41
Broad research (incl. PhD)	5964	0.46	0.50	8127	0.59	0.49
University	5969	0.25	0.43	8194	0.14	0.35
Hospital	5969	0.10	0.30	8194	0.11	0.32
Research institute	5969	0.10	0.31	8194	0.07	0.25
Private industry	5606	0.43	0.50	7394	0.25	0.44
Public sector, non research	5606	0.08	0.27	7394	0.10	0.30
Wage earnings (DKK100,000)	6084	568	270.55	8282	419	174.80
Academic position, birth year+5						
Phd at university	6096	0.01	0.10	8381	0.28	0.45
Junior at university	6096	0.15	0.36	8381	0.12	0.33
Senior at university	6096	0.15	0.36	8381	0.05	0.22
Junior in broad research	6096	0.14	0.34	8381	0.14	0.34
Senior in broad research	6096	0.21	0.41	8381	0.07	0.26

Note: The table reports

Table 6: Publishing activity relative to PhD start for publishing PhDs and PhD parents

Publication activity, year of PhD-start												
Age at first publication	9238	30.28	5.34	7647	31.92	6.04	3991	29.41	4.11	3073	30.04	3.95
Any publication	9489	0.29	0.45	8020	0.25	0.43	4014	0.27	0.44	3113	0.24	0.43
Any publication	9489	0.29	0.45	8020	0.25	0.43	4014	0.27	0.44	3113	0.24	0.43
Publications	9489	0.54	1.83	8020	0.39	0.86	4014	0.47	2.11	3113	0.38	0.89
Total publications	9489	1.47	6.63	8020	1.04	2.47	4014	1.07	7.53	3113	0.84	2.04
Publication activity, 5 years after PhD-start												
Any publication (last three years)	9489	0.63	0.48	8020	0.56	0.50	4014	0.71	0.45	3113	0.63	0.48
Any publication, year+5 after PhD-start	9489	0.51	0.50	8020	0.43	0.50	4014	0.57	0.49	3113	0.48	0.50
Publications, year+5 after PhD-start	9489	1.38	2.68	8020	0.90	2.08	4014	1.53	3.04	3113	1.00	2.65
Total publications, year+5 after PhD-start	9489	7.22	15.91	8020	4.54	7.12	4014	7.60	19.96	3113	4.86	8.35
Publication activity, 10 years after PhD-start												
Any publication (last three years)	8216	0.33	0.47	6633	0.27	0.44	3801	0.38	0.49	2847	0.28	0.45
Any publication	8216	0.28	0.45	6633	0.21	0.41	3801	0.32	0.47	2847	0.21	0.41
Publications,	8216	1.00	2.82	6633	0.56	2.17	3801	1.12	2.80	2847	0.53	1.54
Total publications	9489	8.39	18.13	8020	4.78	11.78	4014	9.96	17.74	3113	5.42	10.52
Main field of publication												
Wet science fields	9489	0.27	0.44	8020	0.31	0.46	4014	0.29	0.46	3113	0.39	0.49
Agricultural and Bio science	9489	0.05	0.23	8020	0.07	0.25	4014	0.05	0.21	3113	0.09	0.28
Biochem, Genetics, Molecular Bio	9489	0.13	0.33	8020	0.15	0.36	4014	0.15	0.36	3113	0.19	0.39
Chemical Engineering	9489	0.01	0.11	8020	0.00	0.06	4014	0.01	0.11	3113	0.00	0.07
Chemistry	9489	0.04	0.20	8020	0.03	0.16	4014	0.04	0.20	3113	0.04	0.19
Immunology and Microbio	9489	0.01	0.11	8020	0.02	0.14	4014	0.02	0.13	3113	0.03	0.17
Neuroscience	9489	0.01	0.11	8020	0.02	0.13	4014	0.01	0.11	3113	0.02	0.14
Pharmacology, Toxicology and Pharmaceutics	9489	0.01	0.11	8020	0.02	0.13	4014	0.01	0.12	3113	0.02	0.15
Dry science fields	9489	0.35	0.48	8020	0.14	0.35	4014	0.39	0.49	3113	0.16	0.36
Computer Science	9489	0.08	0.27	8020	0.02	0.14	4014	0.08	0.28	3113	0.02	0.14
Earth and Planetary Sciences	9489	0.02	0.15	8020	0.02	0.12	4014	0.03	0.16	3113	0.02	0.13
Engineering	9489	0.06	0.24	8020	0.02	0.14	4014	0.07	0.26	3113	0.02	0.15
Materials Science	9489	0.03	0.18	8020	0.02	0.13	4014	0.04	0.19	3113	0.02	0.15
Physics and Astronomy	9489	0.07	0.26	8020	0.02	0.13	4014	0.09	0.28	3113	0.02	0.14
Decision Science	9489	0.00	0.05	8020	0.00	0.04	4014	0.00	0.05	3113	0.00	0.04
Mathematics	9489	0.02	0.14	8020	0.00	0.06	4014	0.02	0.14	3113	0.00	0.07
Energy	9489	0.02	0.15	8020	0.01	0.09	4014	0.02	0.15	3113	0.01	0.10
Environmental Science	9489	0.03	0.18	8020	0.04	0.19	4014	0.03	0.18	3113	0.04	0.20
Medicine	9489	0.27	0.45	8020	0.43	0.50	4014	0.20	0.40	3113	0.34	0.47

Note: This table contains descriptive information on publication activity relative to PhD-start and field of publishing for actively publishing researchers among cohorts of men and women who enrolled in a PhD-program in Denmark between 1996 and 2018, as well as for our sample of PhD fathers and mothers who experienced a first birth after PhD-enrollment.

Table 7: Publishing activity relative to first birth for publishing PhD parents

	(1)			(2)		
	Obs	Mean	Sd	Obs	Mean	Sd
Active or entrant to publishing						
Active in publishing before birth	3991	0.77	0.42	3073	0.69	0.46
Entry to publishing after birth	3991	0.23	0.42	3073	0.31	0.46
Active before and after birth	3991	0.60	0.49	3073	0.53	0.50
Age at first publication	3991	29.41	4.11	3073	30.04	3.95
Publication activity, year before birth						
Any publication in last three years	4014	0.27	0.44	3113	0.24	0.43
Any publication	4014	0.27	0.44	3113	0.24	0.43
Publications	4014	0.47	2.11	3113	0.38	0.89
Total publications	4014	1.07	7.53	3113	0.84	2.04
Publication activity, year 5 after birth						
Any publication in last three years	4014	0.39	0.49	3113	0.34	0.47
Any publication	4014	0.32	0.47	3113	0.25	0.43
Publications	4014	1.09	3.27	3113	0.53	1.33
Total publications	4014	9.92	26.71	3113	5.07	9.15
Publication activity, year 10 after birth						
Any publication in last three years	2625	0.27	0.44	2038	0.20	0.40
Any publication	2625	0.23	0.42	2038	0.17	0.37
Publications	2625	0.89	2.79	2038	0.49	1.91
Total publications	2625	11.58	27.22	2038	6.17	12.05

Note: This table contains descriptive information on publication activity relative to first birth actively publishing researchers among cohorts of men and women who enrolled in a PhD-program in Denmark between 1996 and 2018 and experienced a first birth after PhD-enrollment.