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Christiane Gross | Steffen Jaksztat [Eds.]

Career Paths Inside and Outside Academia

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Soziale Welt

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Preface

We would like to thank all authors of this special issue for their contributions and for their support during the review process. It was always a pleasure to read and edit the manuscripts that provide insights into various scientific fields. We are very pleased that the contributions cover a wide range in terms of content, data, theory and methodology.

As we support the open science agenda and also the author guidelines of Soziale Welt, we have tried to be as open as possible and as closed as necessary. As a result, nearly all the datasets used and syntax-files generated for this volume are treated as FAIR (findable, accessible, interoperable, re-usable). The syntax-files are usually archived in the same repository as the dataset. However, respondents' privacy and data protection rights have been ensured.

In addition to the authors, there are a number of other people without whom the publication of this book would not have come about. Our big thanks go to Catherine Bennewitz who did an excellent job in proofreading all studies compiled in this book. Furthermore, we would like to thank Tobias Wolbring and Monika Jungbauer-Gans who have supported the idea of this book from the start. We thank all anonymous reviewers for their commitment and constructive criticism that really helped to improve the manuscripts. Last but not least, we thank everyone at Nomos Verlag who gave us excellent support throughout the publication process. This publication is part of the research project "Subjective and objective professional success of PhD holders in Germany" funded by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation)—433155285.

Würzburg, Germany — Christiane Gross

Hanover, Germany — Steffen Jaksztat

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Steffen Jaksztat* and Christiane Gross**

Academic careers inside and outside academia—an overview of topics and contributions

Abstract: The scientific workforce is recognized as being key to the ability of modern economies to innovate, and in the ability of societies to solve current and avert future problems. However, the German science system is characterized by increasingly fierce competition and offers young researchers career prospects that are difficult to plan. This special issue aims to understand the social mechanisms of career decisions, chances, and paths of higher education graduates both inside and outside academia. It sheds light on employment trajectories and monetary returns, the embedding of careers in private and professional social networks, and academic recruitment processes. The contributions in this special issue provide latest research in a vibrant research field.

Keywords: academic careers, academia, PhD, post-doc, professorship

Akademische Karrieren innerhalb und außerhalb der Wissenschaft - ein Überblick über Themen und Beiträge

Zusammenfassung: Wissenschaftliche Arbeitskräfte gelten als Schlüsselfaktor für die Innovationsfähigkeit moderner Volkswirtschaften und für die Problemlösungsfähigkeit von Gesellschaften. Das deutsche Wissenschaftssystem ist allerdings von einem zunehmend härteren Wettbewerb geprägt und bietet jungen Forschenden schwer planbare Karriereperspektiven. Ziel des Sonderbandes ist es, die sozialen Mechanismen von Karriereentscheidungen und -chancen von Hochschulabsolvent:innen innerhalb und außerhalb der Wissenschaft zu verstehen. Er beleuchtet Beschäftigungsverläufe und monetäre Erträge, die Einbettung von Karrieren in private und berufliche soziale Netzwerke sowie akademische Rekrutierungsprozesse. Die Beiträge liefern aktuelle Forschungsergebnisse in einem dynamischen Forschungsfeld.

Stichworte: akademische Karrieren; Wissenschaft; PhD; post-doc; Professur

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Introduction

Many university graduates decide to stay in academia after their exams—at least for a limited period of time. In Germany, one in every fourth graduates enters the doctoral phase within the first 1.5 years following the exam (Fabian et al. 2016). However, there is a huge variation between subjects. While in medicine or the natural sciences the transition into the doctoral phase can be considered the norm, other subjects like education, economics and the humanities show considerably lower transition rates (Flöther 2021). And, of course, not all doctoral candidates successfully complete their doctorates (Jaksztat/Neugebauer/Brandt 2021).

The decision to (at least temporarily) stay in academia can be based on various considerations. While some graduates will be attracted by scientific work itself—because it offers intellectual challenge, the chance to solve scientific puzzles, to satisfy curiosity, and to further develop one's own scientific competencies—others will be attracted by the prospect of a further academic degree that can eventually improve their chances on the labor market and increase their monetary returns on education. Yet others will simply enter the doctoral phase by chance.

The scientific workforce is recognized as being key to the ability of modern economies to innovate, and in the ability of societies to solve current and avert future problems (European Commission 2022). In recent years, its great societal relevance has been clearly demonstrated, for example, by the global Covid-19 pandemic or by the numerous challenges imposed by climate change. The demand for scientifically trained staff is high and likely to continue to grow in the future.

At present, a large number of doctorate holders work outside academia—in public service, in company research and development departments, or in non-governmental organizations (Goldan/Jaksztat/Gross 2022); only a minority stays in academia in the long run. Inside and outside academia, careers can differ with regard to various aspects, for example, the employment situation, the degree to which formal academic qualifications are rewarded in terms of monetary and non-monetary returns, the relevance of further achievements for career progress (e.g., publications, international mobility experiences, raised research funds, or patents), or the career system.

Many higher education policy debates revolve around precarious employment conditions and necessary reforms of the academic career system (e.g., tenure-track professorships). The German science system is characterized by increasingly fierce competition and offers young researchers career prospects that are difficult to plan. Between 1992 and 2021, the number of professors at German universities[1] has increased from 34,700 to 50,260 (Figure 1). Within this time frame, however, the number of scientific staff below professorship status – who are largely employed on

1 Including universities of applied sciences, colleges of education, theological colleges, and art colleges.

a temporary basis – has more than doubled from 108,295 to 225,340. This restructuring has been accompanied by an increased proportion of third-party funded researcher positions. Accordingly, competition for resources and permanent positions, and the rigor of evaluation of achievements are increasing within academia (Rogge 2015).

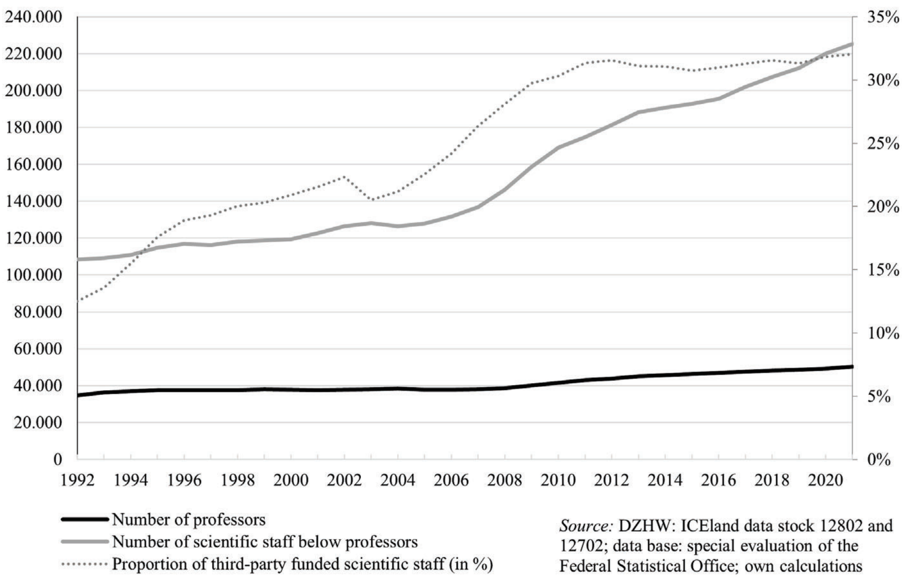

***Figure* 1: Number and funding of scientific staff at universities in Germany between 1992 and 2021**

More than in other areas of society, in academia meritocratic principles are a functional imperative of the career system. Robert K. Merton (1973 [1942]) has described this norm as 'universalism'; the recognition of academic achievements should only depend on objective performance criteria—regardless of social characteristics such as gender, social origin, or ethnicity. Although academia has established a variety of measures to ensure compliance with this principle, social inequalities remain an issue, for example with regard to promoting early career researchers or recruiting professors. There is still insufficient knowledge on potential social barriers to career success.

Individual careers both inside and outside academia are always embedded in private and professional social networks. And both can be considered as valuable social capital. As Leahey (2016) states, "academic research is increasingly social" (p. 82) and research collaborations are becoming more and more important—partly resulting from increased specialization of research. Collaborations can be beneficial with regard to various aspects, for example scientific productivity or access to funding and resources (Leahey 2016). Especially in early career phases, supportive mentoring by experienced colleagues can be helpful when adapting to new work requirements, to develop professional skills, self-confidence and clear career ambitions. Private social networks can help to cushion psychological stress or to create space for greater career involvement. However, beside these benefits, a number of conflicts can arise in all of these areas. Research collaborations may, for example, suffer from freeriding, competition, and social tensions. Mentor-mentee relationships imply dependency structures and an unequal balance of power. Conflicts between the private and the professional life spheres can arise, for example, in connection with caregiving responsibilities or reconciling two careers within one partnership. Potential conflicts are especially evident with regards to the mobility requirements often connected with a research career.

In light of this situation, this special issue aims to understand the social mechanisms of career decisions, chances, and paths of higher education graduates inside and outside academia. Who decides to stay in academia following graduation, and why? Are career decisions and chances determined by social origin, gender, migration background, age, or intersections of these dimensions? Do the returns to education change over time due to reforms such as Bologna? Are there discipline-specific determinants of career success? What are the determinants for receiving a tenured position such as a professorship? Can we analyze these determinants from different perspectives? How do couples make mutual career decisions? Are cooperation patterns in science changing? Does cooperation foster new ideas and innovations?

The content of this special Issue

The content of this book is divided into three parts. The first part is about employment trajectories and returns to higher education. The second part is about social capital and collaborations. The third part will specifically focus on academic recruitment processes and appointments to professorships.

Employment Trajectories and Returns to Higher Education

The first two chapters in this section analyze changing returns to education in the light of educational reforms based on the DZHW Graduate Panel Study. While Kroher and Leuze (2024) consider the Bologna Reform and investigate its consequences in terms of inequalities within the labor market, Euler and Trennt (2024) focus on the higher education expansion and how it affects the returns to doctoral education. The following chapters 4 and 5 examine social inequalities in employment trajectories. However, while Bartsch et al. (2024) consider gender differences and combine two sources of administrative data (from a University and the Institute for Employment Research (IAB), Goldan et al. (2024) focus on intersectional dropout from academia in Germany. The fifth and last paper by Höhle (2024) also examines dropout, but from a cross-national perspective focusing on the role of national academic careers systems and how they affect dropout from academia, with a special focus on contract types.

In chapter 2 *Martina Kroher and Kathrin Leuze* ask whether the introduction of bachelor's and master's degrees in Germany has led to increased labor market inequalities among university graduates. To address this research question, the authors use data from the DZHW Graduate Panel Study. Labor market returns are analyzed through the lens of human capital theory, signaling theory and labor market segmentation theory. The focus of this paper is on career paths outside academia in particular. The authors show that bachelor graduates earn less and have a higher risk of inadequate employment in their first job after graduation compared to graduates with master's and traditional degrees. Internal labor market segments and extracurricular qualifications are among those factors contributing to degree-specific labor market outcomes. In a longitudinal perspective, the vertical differentiation of degrees appears to have been accompanied by an increased pay gap between graduates holding different degrees.

In chapter 3 *Thorsten Euler and Fabian Trennt* explore how the monetary returns to doctoral education have developed during the expansion of higher education. To achieve this goal, the authors use data from multiple cohorts of the DZHW Graduate Panel Studies, too. They argue that doctorate holders generally play an important role in knowledge-based economies, because being trained for complex and innovative tasks makes them especially productive workers. Thus, from the perspective of human capital theory, doctorate holders are expected to receive a wage premium on the labor market. However, theoretical expectations of how wage differentials between graduates with and without doctorates have evolved in a decade of higher education expansion are less clear (i.e., growing demand vs. oversupply). The authors show that the wage premium in the private labor market sector has remained stable over time—despite a growing number of doctorate holders entering the labor market. In the public sector, by contrast, doctoral degrees are rewarded with higher wages only to a limited extent.

In chapter 4 *Simone Bartsch, Guido Buenstorf, Anne Otto and Maria Theissen* explore employment trajectories of doctorate holders in STEM fields (science, technology, engineering and mathematics). Their analyses are particularly devoted to gender differences in employment biographies (i.e., typical career paths, employment sectors, and employment volume). The authors make use of administrative data provided by the Technische Universität Berlin which was linked with the Integrated Employment Biographies (IEB) dataset of the Institute for Employment Research (IAB). Economic and sociological theories referring to social networks, identity formation, discrimination, and gender-specific norms and roles are guidelines for their empirical analyses. The study points to path dependencies between the type of doctoral training and post-graduation employment sectors. Female doctorate holders without children follow similar career trajectories to those of their male peers. However, it also suggests that gender-specific effects of family formation on employment biographies are very pronounced.

Chapter 5 by *Lea Goldan, Aaron Bohlen and Christiane Gross* takes a closer look at social inequalities in postdoctoral dropout from academia. With reference to the concept of intersectionality, the authors investigate whether dropout is associated with doctorate holders' gender, social origin, and migration background. To answer this research question, they use data from the DZHW PhD Panel 2014 which allows them to study employment trajectories over a period of five years after doctoral graduation. Their results suggest that, within this time frame, most doctorate holders leave academia to be employed in other sectors. However, there is no evidence of inequalities regarding gender, social origin, and migration background or of intersections of these dimensions.

Chapter 6 by *Ester Höhle* also focuses on dropout of doctorate holders. However, her study investigates how intentions to leave academia are influenced by characteristics of national academic career systems and individual employment contracts in particular. Career decisions are studied through the lens of social-cognitive career theory and labor market concepts. A special feature of this study is that data from ten European countries are used (EUROAC data), which allows for comparisons between different academic employment systems. The author shows that in up-or-out systems (e.g., Germany, Switzerland, Austria) postdocs more often intend to leave academia compared to postdocs in tenure systems (e.g., Netherlands, United Kingdom, Ireland). In both systems, fixed-term employment contracts are associated with leaving intentions. Although both job satisfaction and integration appear to act as mediating factors, neither indicator fully explains the effect of the contract.

Social Capital and Collaborations

Within the second part, we present contributions that cover the role of academic and private social capital and how it affects academic career decisions and knowledge production. In the first contribution, Elhalaby and Epstein (2024) have chosen a qualitative perspective on the experiences with collaboration in the life sciences; followed by the bibliometric perspective from Wieczorek et al. (2024) that considers the consolidation of thoughts/ideas as outcome. The next two contributions focus on dyadic constellations. However, while Mühleck and Schwabe (2024) analyze mentoring teams in the light of gender combinations, Schels et al. (2024) takes a closer look at how dual career couples at the high end of academic careers make career decisions, using a mixed-methods approach with data on applicants for European Research Council grants.

In chapter 7, *Christina Elhalaby and Nurith Epstein* explore how postdocs in the life sciences describe their experiences with collaborations. To address this research question, the authors have conducted qualitative interviews with physician scientists and biologists. The interview material was analyzed using qualitative content analysis. The concepts of social capital and social interdependence serve as the theoretical framework for their analyses. The authors show that the perceived benefits of collaborations generally outweigh the negative aspects. Most importantly, collaborative networks provide access to certain resources that are indispensable for conducting research projects successfully. These include other people's human capital (i.e., professional knowledge and experiences) and also technical resources. Interviewees moreover highlight learning from collaborative partners and increased productivity as positive aspects. As possible pitfalls of collaborative research, the authors identify conflicts due to competition, coordination and communication costs, prioritization issues, and freeriding.

Chapter 8 by *Oliver Wieczorek, Andreas Schmitz, Jonas Volle, Khulan Bayarkhuu, Julian Dressler and Richard Münch* studies the effects of research collaborations from a bibliometric viewpoint. Their contribution explores the association between types of collaborative research and the consolidation of thought products in sociology (i.e., theories, methods, and research foci). Their study is based on abstracts of articles published in the five most important German-speaking sociological journals between 2000 and 2019. It aims to analyze whether thought products have become more central or more peripheral within the academic discourse. The authors show that the number of institutions involved in a collaboration is positively associated with consolidation over time. Concepts used by scholars with a high centrality in collaboration networks at the beginning of the observation period tend to become more peripheral over time. Their analysis also points to gender inequalities as the proportion of female authors is negatively associated with the consolidation of thought products.

Chapter 9 by *Kai Mühleck and Ulrike Schwabe* explores whether or not doctoral candidates benefit from having a same-gender supervisor. Building on tokenism theory, identity-based motivation theory, and theories of social networks, they investigate supervisor-effects on satisfaction with mentoring, beliefs in own research abilities, and perceived career prospects. The authors address this research question using the DZHW-Nacaps data, which is a panel study with doctoral candidates at German universities. In order to account for possible selection biases in estimating the effect of same-gender matches, entropy balancing is applied. The study shows that both female and male doctoral students tend to choose supervisors of the same gender as themselves. However, contrary to expectations, female supervisors have a positive effect on satisfaction with mentoring and academic self-concept for both female and male doctoral students.

Chapter 10 by *Brigitte Schels, Sara Connolly, Stefan Fuchs, Channah Herschberg and Claartje Vinkenburg* focuses on the private social context of researchers' careers and especially on the challenges and dilemmas resulting from combining two careers within one partnership. Referring to normative expectations of the 'ideal scientist' and the concept of linked lives, the authors explore how careers are prioritized within dual career couples and how researchers reflect on the challenges in combining both careers. The study uses a mixed-methods approach combining quantitative and qualitative data on scientists who applied for the most prestigious research grants in Europe, namely the European Research Council (ERC) grants. The stories in this chapter clearly illustrate the challenges and complexities resulting from coordinating two careers which are often related to questions of prioritization, mobility requirements, and childcare responsibilities.

Academic Recruitment Processes and Appointments to Professorships

The third and last part of this special issue includes papers that examine recruitment processes and appointments to professorships. While Blome (2024) uses narrative interviews to shed light on the autobiographical perspective of professors and the relevance of social class for their careers, Habicht et al. (2024) use homepage data to investigate gender effects on academic success. Ordemann and Naegele (2024) analyze age effects on academic success using survey data. Last but not least, Petzold and Netz (2024) examine experimental data on fictitious candidates for professorships to examine how signaling values of academic performance vary between disciplines.

Building on grounded theory methodology, chapter 11 by *Frerk Blome* asks whether social class is a relevant category in academic careers. Mechanisms of upward social mobility are studied on the basis of autobiographical narrative interviews with professors from law and education from German universities. Theories of the social self and social comparison theory form the background to this contribution. The study illustrates that socially mobile professors had to deal with more uncertainties regarding their academic careers compared to their colleagues from higher social class backgrounds, who had much clearer career ambitions from the start. The socially mobile professors had to develop confidence in their own abilities to a greater extent, based on positive external evaluations of their performance and through the social comparisons enabled by these evaluations. The study also points to the fact that being encouraged and supported by authoritative others is especially important for socially mobile scholars.

In chapter 12, *Isabel M. Habicht, Martin Schröder and Mark Lutter* focus on gender effects in academic recruitment processes in German sociology. Previous studies suggest that female sociologists have a considerably higher chance of becoming tenured professors compared to their male colleagues when controlling for productivity signals such as publications. To date, however, it remains an open question whether these findings are possibly biased due to a survivor effect, i.e., a methodological artifact caused by sampling strategies excluding individuals who have already left academia. To address this question, the authors replicate Lutter and Schröder's (2016) study using an extended and updated dataset. The empirical analyses show that the female advantage in German sociology does not diminish when accounting for leaky pipeline effects. Explaining why female sociologists have greater chances of securing tenured positions remains a puzzle to be solved.

Chapter 13 by *Jessica Ordemann and Laura Naegele* discusses age as a potential source of inequality in academic recruitment processes. Referring to theoretical concepts such as age-stereotypes and age-based discrimination, they empirically explore how a scholar's biological and academic ages affect the chances of securing a tenured position in academia. The authors study the job transitions of German doctorate holders from a wide range of subjects using data from the DZHW PhD Panel 2014. The results of their event history analyses suggest that age plays a rather subordinate role for the chances of becoming tenured. On the contrary, compared to their younger colleagues, individuals who were 40 years of age and older at the time of PhD graduation become tenured postdoctoral researchers or professors at universities of applied sciences more quickly. It is possible that older doctoral graduates tend to aim at alternative pathways to tenure beyond university professorships.

In chapter 14, *Knut Petzold and Nicolai Netz* adopt a comparative perspective and ask whether certain signals of academic performance (i.e., the formal qualification, publication record, teaching experience, third party funding, as well as different signals of internationalization) are evaluated differently across disciplines. Unlike the other studies in this section, the authors explicitly focus on the perspective of gatekeepers in academic recruitment processes and explore how signals are valued in tenure decisions. Their analyses are based on a survey experiment with Germany-based university professors of German studies, selected social sciences, and chemistry, who have judged the suitability of fictitious candidates for professorships. The judgements reveal different disciplinary cultures in evaluating academic performance—especially when comparing chemistry and German studies. Differences are revealed with regard to formal qualifications, but also with regard to the acquisition of third-party funding and (international) publications.

We appreciate the wide range of theoretical and methodological approaches that together provide valuable pieces of a bigger puzzle. Enjoy!

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Degree Differentiation and Changing Career Outcomes of Higher Education Graduates in Germany: A Matter of Specialization, Extracurricular Activities or Labor Market Segmentation?***

Abstract: With the introduction of Bachelor's/Master's programs, the higher education system in Germany profoundly changed from having a one-tier to having a two-tier degree structure. So far, however, there is surprisingly little evidence on how the introduction of the new degree system has changed students' employment outcomes. This paper therefore asks 1) whether we can observe over time rising labor market inequalities in terms of wages and adequate employment between graduates holding Bachelor's, Master's and traditional degrees, and, if yes, 2) how these labor market differentials between different degree holders might be explained. By applying human capital, signaling and labor market segmentation theory we develop hypotheses on differentiated labor market outcomes. These are tested by estimating linear regression models and Blinder-Oaxaca Decompositions based on two graduate cohorts from the DZHW Graduate Panel Study, who graduated in the years 2009 and 2013. Results indicate that Bachelor graduates earn less and have lower job adequacy than traditional (for example *Diplom*, *Magister*, *Staatsexamen)* and Master's degree holders. These labor market differentials are partly explained by internal labor market segments and extracurricular qualifications, mostly in form of study-related student jobs, while gaining specific human capital through higher education seems to matter less.

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Keywords: labor market returns, higher education, wages, adequate employment, Bachelor/Master degree

Warum unterscheiden sich die Arbeitsmarkterträge unterschiedlicher Hochschulabschlüsse in Deutschland? Zur Bedeutung von beruflicher Spezialisierung, außercurricularen Aktivitäten und Arbeitsmarktsegmentierung

Zusammenfassung: Mit der Einführung von Bachelor- und Master-Studiengängen wurde das Hochschulsystem in Deutschland grundlegend von einer einstufigen zu einer zweistufigen Studienstruktur reformiert. Bislang gibt es jedoch erstaunlich wenig Erkenntnisse darüber, wie die Einführung der neuen Hochschulabschlüsse die Beschäftigungschancen von Absolvent:innen verändert hat. Dieser Beitrag geht daher den Fragen nach, ob 1) sich im Zeitverlauf zunehmende Ungleichheiten auf dem Arbeitsmarkt in Bezug auf Löhne und adäquate Beschäftigung zwischen Absolvent:innen mit Bachelor-, Master- und traditionellen Abschlüssen beobachten lassen, und falls ja, 2) wie ungleiche Arbeitsmarkterträge zwischen den verschiedenen Hochschulabschlüssen erklärt werden können. Anhand von Humankapital-, Signal- und Arbeitsmarktsegmentationstheorie werden Hypothesen zu möglichen Einflussfaktoren entwickelt, die mit Hilfe von linearen Regressionsmodellen und Blinder-Oaxaca-Dekompositionen auf Basis von zwei DZHW Absolventenkohorten aus den Jahren 2009 und 2013 überprüft werden. Die Ergebnisse zeigen, dass Bachelor-Absolvent:innen weniger verdienen und eine geringere Beschäftigungsadäquanz aufweisen als Absolvent:innen traditioneller Abschlüsse (z.B. Diplom, Magister, Staatsexamen) und mit Masterabschlüssen. Diese Arbeitsmarktunterschiede lassen sich zum Teil durch interne Arbeitsmarktsegmente und außercurriculare Qualifikationen, vor allem in Form von fachbezogenen Studierendenjobs, erklären, während der Erwerb von spezifischem Humankapital durch Hochschulbildung selbst weniger wichtig zu sein scheint.

Stichworte: Arbeitsmarkterträge; Hochschulbildung; Löhne; adäquate Beschäftigung; Bachelor/Master Abschlüsse

1. Introduction

In 1999, 29 European countries joined forces to create the European Higher Education Area (EHEA) for promoting students' mobility and employability as well as the competitiveness of higher education systems in Europe (Bologna Declaration 1999). As a consequence of this so-called Bologna Process, member states agreed to implement specific structural elements in their national higher education systems.

Probably the best-known reform was the introduction of the two-cycle degree system with consecutive Bachelor's and Master's programs (Bologna Declaration 1999).[1]

In Germany, the Bologna Process profoundly changed higher education: While the traditional degrees, namely so-called *Diplom*, *Magister* and *Staatsexamen* (state examinations), comprised one long cycle lasting four to five years, the Bologna Process introduced a two-cycle degree system with three-year Bachelor's and two-year Master's degrees (Eurydice 2010). In contrast to other countries with previous one-cycle systems, such as Italy and Portugal, which adopted the two-cycle degrees very rapidly within two or three academic years (Kroher/Leuze/Thomsen/Trunzer 2021), the implementation process in Germany extended over a much longer time period (see Figure 1). This leads to a gradual increase in Bachelor's degree holders from 2002 onward, with stronger growth rates occurring only after 2008, while the Master's degree was implemented even more slowly, particularly after 2009. In 2012, Bachelor's degree holders for the first time constituted the majority of graduates from German higher education, while the long degrees from the traditional one-cycle system steadily decreased. The remaining traditional degrees are mainly found in the form of state examinations for classic professions, such as medicine and law.[2]

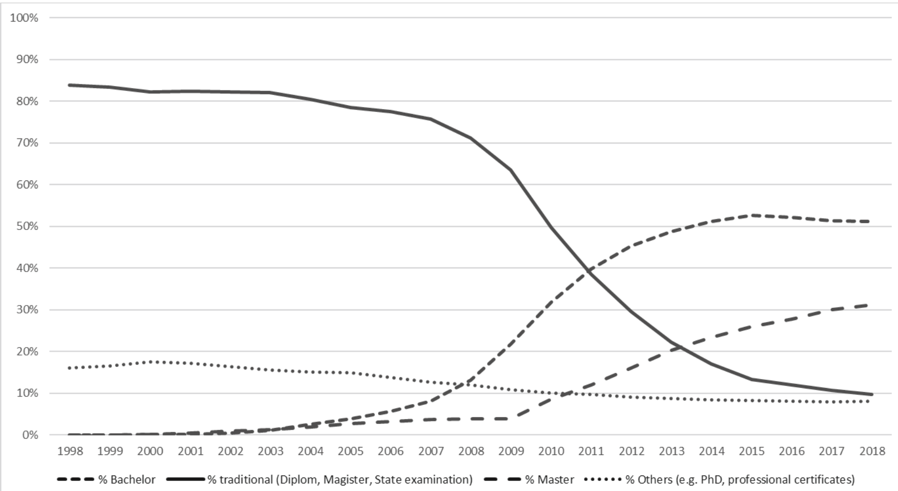
Institutionally, the introduction of Bachelor's and Master's degrees meant a change from a horizontally differentiated to a vertically differentiated degree structure in German higher education (Leuze 2010). Since the traditional degrees of *Diplom*, *Magister* and state examination were rather similar in length and setup, they did not result in stratified labor market outcomes, but mostly differed in terms of the labor market segments that graduates worked in. However, comparisons with traditionally vertically differentiated two-tier degree systems, such as that of the UK, indicate that Bachelor's degree holders have lower labor market returns and work in different segments than those holding a Master's degree (Leuze 2010; Leuze 2011). Therefore, it is likely that the introduction of a two-tier degree system in German higher education also changes the labor market outcomes of different degree holders. In the following, we therefore investigate 1) whether we can observe rising labor market inequalities between graduates holding Bachelor's, Master's and

1 At the Ministerial Conference Berlin 2003, the doctoral level was included as a third cycle of the new degree system (Berlin Communiqué 2003). However, since the purpose of this article is to look at the effects of the Bologna reform for the majority of students, we focus only on the first two cycles (Bachelor's & Master's) and will therefore refer to the "two-cycle system" throughout the paper.

2 These traditional state examinations provide training for future medical doctors and law professionals, both of whom are often employed in the public sector. They never changed to the two-cycle degree structure, since the related professional associations as well as state agencies argue that certification is based on a well-established system and requires at least five years of training, ensuring immediate entrance into the respective professions.

traditional degrees over time, and, if yes, 2) how these labor market differentials between different degree holders might be explained.

Figure 1: Degrees Obtained in German Higher Education (1998–2018)



Source: Autorengruppe Bildungsberichterstattung 2020: Tab. F5–10web, authors' illustration.

In the following, we address these questions by focusing on the wages and the adequate employment[3] of graduates holding a significant first job after graduation. Accordingly, our paper scrutinizes career paths outside academia, which are pursued by the majority of higher education graduates in Germany. Looking at empirical studies since the implementation of the Bologna Process, surprisingly few investigated the consequences of the Bologna Process for students' employment outcomes (see Kroher/Leuze/Thomsen/Trunzer 2021 for an overview). Those studies reveal rather mixed evidence. On the one hand, mostly cross-sectional studies indicate that graduates with a Bachelor's degree tend to have lower wages (Alesi/Schomburg/Teichler 2010; Neugebauer/Weiss 2017; Trennt 2019), lower occupational prestige (Neugebauer/Weiss 2017) and less adequate employment (Fabian/Quast 2019; Grotheer 2019; Noelke/Gebel/Kogan 2012) than those hold-

3 The analysis of adequate employment scrutinizes whether graduates hold a job matching their higher education degree, either in terms of the vertical position they obtain (vertically adequate employment) or whether the content of their work matches the knowledge and skills acquired in higher education (horizontally adequate employment) (Fehse/Kerst 2007). We include both aspects and investigate whether graduates are both vertically and horizontally adequately employed, which we therefore label adequate employment in the following. While such a focus is common in German research on graduate employment (Fabian/Quast 2019; Grotheer 2019), the international literature more often examines inadequate employment, such as education and skills mismatches (Levels/van der Velden/Allen 2014) or overeducation (Di Stasio/Bol/van de Werfhorst 2016; Verhaest/van der Velden 2013).

ing traditional or Master's degrees. On the other hand, one longitudinal study finds no strong increases in wage differentials between Bachelor's and Master's degrees over time, while students' socioeconomic background and extracurricular qualifications obtained during higher education, such as studying abroad or having a study-related job, matter more (Lörz/Leuze 2019).

Thus, it remains an open question whether the introduction of the two-tier degree structure actually changed the labor market returns of different degree holders and, if yes, how these labor market differentials might be explained. Theoretically, we apply human capital, signaling and labor market segmentation approaches to develop hypotheses on the labor market returns of different degree holders. Our empirical analyses are based on two graduate cohorts from the Graduate Panel Study conducted by the German Centre for Higher Education Research and Science Studies (DHZW), who graduated in the years 2009 and 2013. To investigate differences in labor market returns by degree obtained and the empirical contribution of relevant covariates, we model the log hourly wage and the adequacy of the first employment position after graduation by means of linear regression and decomposition analyses.

2. State of Research

Empirical evidence on how the Bologna Process affects the employment outcomes of students remains surprisingly scarce. In the following, we give a brief overview on general changes occurring in German higher education as a consequence of the Bologna Process, before we review existing evidence on how labor market returns changed through the introduction of a two-tier degree structure. We predominantly focus on Germany, but provide additional evidence for other countries where available (for an encompassing review see Kroher/Leuze/Thomsen/Trunzer 2021).

Just like all over the world, we can observe an enormous increase in higher education enrolment rates over the past 50 years in Germany (see Schindler 2012). The proportion of those holding higher education entry certificates rose from 36 % in 1995 to more than 50 % in 2018 (Autorengruppe Bildungsberichterstattung 2020: 183), so that today about 45 % of an age cohort enrol in higher education (Autorengruppe Bildungsberichterstattung 2020: 190). However, studies investigating whether the Bologna Process has further increased higher education enrolment are inconclusive (Horstschräer/Sprietsma 2015; Neugebauer 2015). Horstschräer and Sprietsma (2015), for example, do not find any differences in the overall numbers of first-year students at German higher education departments in the pre-reform and post-reform period, yet effects differ across fields of study. In contrast, there is evidence that the introduction of the two-tier degree system has led to new inequalities in German higher education. Today, about 90 % of the Bachelor graduates at universities enrol in a Master's degree compared to about 40 % at universities of applied sciences (Autorengruppe Bildungsberichterstattung 2020: 196). However, graduates from less privileged family backgrounds tend to have lower probabilities of starting a Master's degree than those from more privileged families (Auspurg/Hinz 2011; Lörz/Quast/Roloff 2015; Lörz/Quast/Roloff/Trennt 2019; Neugebauer 2015; Neugebauer/Neumeyer/Alesi 2016). This points towards unintended consequences of the Bologna Process, namely that the introduction of the two-cycle degree structure rather increases than decreases social inequalities in higher education participation.

One major goal of the Bologna process was to increase the employability of higher education graduates in Europe. Generally, higher education graduates have considerably better employment prospects than degree holders from lower educational levels across Europe. Higher educational attainment increases employment rates (OECD 2020: 81, 84), reduces the likelihood of working part-time (OECD 2020: 74) and strongly decreases the risk of being unemployed (OECD 2020: 83). Moreover, higher educational attainment is accompanied by increasing monetary rewards (OECD 2020: 89). Yet this earnings advantage for highly-educated workers varies considerably by level of tertiary attainment. In most European countries, workers with a Master's or traditional degree earn more than those with a Bachelor's degree, who in turn earn more than those with a short-cycle tertiary degree or vocational education and training (OECD 2020: 88).

Only a few studies investigated whether the structural change from a formerly one-tier to a two-tier degree system in the course of the Bologna Process actually changed the labor market returns of higher education graduates in Germany. Regarding wage differentials, most cross-sectional studies on Germany find that Bachelor's degree holders earn less than graduates with Master's or traditional degrees (Alesi/Schomburg/Teichler 2010; Dill/Hammen 2011; Neugebauer/Weiss 2017; Trennt 2019) and thus confirm international findings (Glauser/Zangger/Becker 2019; Raudenská/Mysíková 2020; Sciulli/Signorelli 2011). In contrast, Müller and Reimer (2015) only find a persistent earnings gap between Bachelor graduates and graduates holding traditional degrees in three out of seven investigated fields of study (namely humanities, natural sciences, and engineering) in the German federal state of Bavaria. Comparing the wage returns of three different graduate cohorts from 2001 to 2009 five years after graduation, Lörz and Leuze (2019) also find no clear-cut wage differentials between Bachelor's and Master's degree holders, while graduates' socio-economic background and extracurricular qualifications, such as studying abroad or having a study-related job, seem to matter more. Related to this, Glauser et al. (2019) show that in Switzerland only the returns to a Bachelor's degree decreased between subsequent cohorts, while the returns to a Master's degree are quite stable over time. Thus, while cross-sectional evidence points towards clear wage differentials between pre- and post-reform degrees, results from more longitudinal designs are not as straightforward. Moreover, even if wage differences are observed, studies mostly focus on describing them, but do not seek to explain them. An exception is the study by Trennt (2019), showing that graduates with a Master's degree earn higher wages than those with a Bachelor's degree since the former work more often in large firms and are more often adequately employed. Yet these factors only explain a small fraction of the observed wage differential.

Even less empirical evidence exists on the non-monetary labor market outcomes of graduates with different degrees. In this regard, studies for Germany find that Bachelor graduates, especially those from universities, take longer to find permanent employment (Grotheer 2019) than graduates holding Master's or traditional degrees. Moreover, Bachelor graduates from German universities (but not from universities of applied sciences) have higher risks for unemployment than those graduating from vocational education and training (Neugebauer/Weiss 2018). Regarding the adequacy of employment, about 60 percent of German graduates are adequately employed about one year after graduation (Fabian/Quast 2019: 419) and German graduates have lower risks of overqualification in general when compared to other European countries (Verhaest/van der Velden 2013). At the same time, studies point towards a higher risk of inadequate employment for Bachelor graduates compared to those holding Master's and traditional degrees (Fabian/Hillmann/Trennt/Briedis 2016; Fabian/Quast 2019; Grotheer 2019; Rehn/Brandt/Fabian/Briedis 2011). Inadequate employment seems to be most prevalent for Bachelor graduates from universities, while Master's graduates generally face lower risks even when compared to graduates holding traditional degrees (Grotheer 2019). Again, very few studies sought to explain these differentiated outcomes in adequate employment. They find that having a study-related job and working in the internal labor market play an important role in this regard, while studying abroad seems to matter less (Fabian/Quast 2019). A longitudinal analysis of how the adequacy of employment changed for different degree holders during the course of the Bologna Process is largely missing so far for Germany. Therefore, in the following we develop hypotheses on how wages and adequate employment might have changed between graduates holding different degrees and how we might explain these differentiated labor market returns.

3. Theoretical Background

As theoretical bases of our analyses we use the human capital theory (Becker 1962; 1964), Spence's signaling theory (Spence 1973; Spence 1974), and labor market segmentation theory (Doeringer 1967; Doeringer/Piore 1985).

3.1 Human Capital Theory

The human capital approach is often used to explain labor market differences between different educational groups (Becker, 1962; 1964). Its central assumption is that workers differ in their productivity determined by their knowledge, skills and abilities, the so-called human capital. According to this perspective, more investment in human capital leads to higher productivity, which in turn results in higher labor market returns, especially higher wages, but possibly also adequate employment. Investments in human capital can take place via general schooling, vocational training, work experience, further education, or, as in this paper, higher education. In the following, we differentiate between the quantity and the quality of human capital, which are both suited to explaining the labor market returns of different degree holders (Leuze/Strauß 2009; Lörz/Leuze 2019).

The quantity of human capital refers to the time invested in education. Individuals invest continuously in their own human capital over the life course until the returns to investment are lower than its costs. With regard to higher education, for example, the investment decision to continue with a Master's course after finishing a Bachelor's degree depends on whether students are able to afford the longer study duration of a Master's program or not (Lörz/Quast/Roloff 2015). Since Bachelor's programs typically last for three years and Master's degree courses for an additional two years, this longer investment in the quantity of human capital should increase graduates' individual productivity and thus also future labor market outcomes. Moreover, as the study duration of traditional degrees in Germany is rather similar to a combined Bachelor's and Master's study duration, particularly at universities (Autorengruppe Bildungsberichterstattung 2020: 195), they should result in a similar quantity of human capital to a Master's degree, and in similar labor market returns accordingly. Therefore, *immediately after graduation, graduates of Master's and traditional degrees should have higher labor market returns than Bachelor graduates (H1).*

However, it might be that with the expansion of higher education, not only the quantity of human capital, but also more qualitative aspects of education become increasingly important for labor market outcomes. From the perspective of human capital theory, students have the opportunity to invest in general or specific human capital (Becker 1962). While general human capital is acquired primarily through formal education, firm-specific human capital is built up in particular through work experience (on-the-job training) in a specific firm. In addition, a third form of human capital is of central importance for describing the German labor market, namely occupation-specific human capital (Estevez-Abe/Iversen/Soskice 2013), which is acquired for specific occupations. Since both firm- and occupation-specific human capital can only be used in particular work contexts, their investment is more costly. Accordingly, both forms of specific human capital are more positively related to income and further labor market returns than is general human capital, which is applicable in a broad array of different work contexts (Becker 1962; Estevez-Abe/Iversen/Soskice 2013).

In higher education research, these qualitative differences are often associated with different fields of study (Leuze/Strauß 2009) or higher education institutions (Leuze 2011; Reimer/Pollak 2010), arguing that fields of study transferring applicable knowledge for particular occupations and universities of applied sciences provide graduates with more specific human capital. In line with this reasoning we assume that returns to different degree types might also stem from different investments in specific human capital. While the newly introduced Bachelor's degree offers a broad knowledge base for the respective discipline, a Master's degree aims at providing more specialized knowledge, sometimes focusing only on specific sub-disciplinary areas. Therefore, the knowledge, skills and abilities acquired through Master's degree courses should be per se more specific than those gained in a Bachelor program.

Yet, specific human capital might additionally be obtained through practical training in the course of higher education studies, mostly through internships (Trennt 2019). In the course of the Bologna Process, mandatory internships have been established in most degree courses, both at the Bachelor's and Master's level (Fabian/Hillmann/Trennt/Briedis 2016: 67f.). Since Master's students often have to undertake a second internship in the course of their study, which is probably even more tailored to their future occupational area, they acquire more specific human capital through practical training than do Bachelor graduates. Internships should also increase the specific knowledge of students doing traditional degree courses, simply because these courses last longer and give more room for internships (Fabian/Quast 2019). Accordingly, *due to their lower acquisition of specific human capital, Bachelor students should have lower labor market returns than graduates holding Master's or traditional degrees (H2).*

3.2 Signaling Theory

Labor market returns of different degrees might not only depend on the human capital acquired, but also on the signals of productivity associated with them (Spence 1973; Spence 1974). Signaling theory rejects the assumption of human capital approaches that employers have knowledge about the productivity of applicants even before hiring. Rather, they use observable characteristics of the applicants as indications of their productivity potential—so-called 'signals', such as educational qualifications.[4] According to Spence (1973), employers associate certain performance expectations with certain signals, which ultimately determine related labor market returns: Signals that promise high productivity bring with them higher returns and vice versa. Employers' signal-related productivity expectations result from their previous experiences on the labor market, for example by observ-

4 Spence (1973: 357) subsumes all characteristics that can be directly manipulated by the individual, such as educational attainment, under the term 'signals'. Characteristics that are observable, but unalterable by individuals, such as gender, age or socio-economic background, are labeled indices. Even though both are considered by employers in the hiring process to assess the productivity of applicants, we focus on signals as direct investments of students to discuss their explanatory power for differentiated labor market returns. Indices, in contrast, are merely considered as control variables in the statistical models.

ing the productivity of hired employees with certain signals. High-performing individuals will invest in the acquisition of signals promising higher returns, which in turn confirms the existing productivity expectations of employers and generates an informal "feedback loop" (Spence 1973: 359). From this perspective, obtaining a Master's degree does not increase productivity, but appears as a mere signal of a priori higher performance that is comparatively easy for employers to observe (Spence 1973). Employers should base their productivity expectations of Master's degree holders on the fact that they are more similar to the long traditional degrees and accordingly offer higher labor market returns, which again support H1.

However, in view of the steadily growing number of higher education graduates in the course of educational expansion, who in many cases have techniqually equivalent qualifications due to the Bologna reform, it seems necessary for employers to resort to further signals. Therefore, students might increasingly strive to acquire additional signals in the course of their studies in order to distinguish themselves from other applicants when seeking a job. These further signals could be investments in extracurricular additional qualifications, such as studying abroad or a study-related student job. International student mobility might serve as a signal for increased achievement, motivation and cross-cultural competences, which is why graduates with such experience are rewarded by employers with higher labor market returns, both in terms of wages (Kratz/Netz 2018) and adequate employment (Fehse/Kerst 2007). This should also hold true for study-related student jobs: Rather than working in non-study-related jobs—for example as waitress or shop assistant—which merely serve to earn money, gaining practical professional knowledge for the future occupational area through a study-related job should also serve as signal of productivity. This should particularly hold true in the German labor market, where occupation-specific knowledge is particularly important for labor market returns (Estevez-Abe/Iversen/Soskice 2013). Employers might therefore associate study-related student jobs with engagement and more specific knowledge, which again should result in higher labor market returns (Sarcletti 2007).

In the case of the new degree programs, Bachelor graduates have less time to acquire these additional extracurricular qualifications as signals due to the shorter duration of their studies compared to graduates of a Master's degree or traditional program. Therefore, the share of Bachelor graduates that were not internationally mobile and did not have a study-related student job is lower than that of graduates holding Master's (Fabian/Hillmann/Trennt/Briedis 2016) or traditional (Rehn/Brandt/Fabian/Briedis 2011) degrees. Adding to this, Bachelor students studying abroad more often proceed with a Master's degree (Lörz/Quast/Roloff/Trennt 2019), which again increases the productivity expectations for Master graduates. By implication, *due to their lower acquisition of extracurricular qualifications, Bachelor students should have lower labor market returns than graduates holding Master's or traditional degrees (H3).*

3.3 Labor Market Segmentation

Finally, it might be the case that some aspects of current employment are more important than others for differentiated labor market returns. The theoretical notion of labor market segmentation implies that the labor market is divided into several segments, all of which offer specific career prospects, while mobility between the segments is restricted (Doeringer 1967; Doeringer/Piore 1985). For analyzing the labor market returns of different higher education programs, we differentiate between internal and external labor market segments. An external labor market is assumed to function in line with the neoclassical market logic, where pricing, allocation and training decisions are controlled directly by mechanisms of labor demand and supply. An internal labor market, on the other hand, is "governed by a set of institutional rules which delineate the [its] boundaries […] and determine its internal structure" (Doeringer 1967: 207). Recruitment from the external labor market ideally takes place only once, when external applicants are employed for a restricted number of job positions, which constitute "ports of entry" (Doeringer/Piore 1985: 2) to the internal labor market. Since employees are recruited not only for the position at hand, but for a specific career ladder building up on the initial position, the screening process at this first stage strongly depends on education credentials, which constitute important signals for employers to assess the suitability of applicants. Therefore, we assume that higher education degrees should be particularly relevant for recruitment at such ports of entry.

On the one hand, internal labor market segments are often found within a particular firm (firm-internal labor markets) (Doeringer 1967). Large companies have specific entry ports and thereafter provide mobility along specified career paths. At the same time, they pay higher wages and offer stronger wage increases. Small firms, by contrast, do not provide such sheltered career ladders, which makes mobility between firms more likely and results in a shorter job tenure, with more market-driven wages. When hiring to firm-internal labor markets, employers seek to employ applicants most suitable for proceeding up the internal career ladders. For doing so, they should use higher degrees as signals in the hiring process. Since in the course of the Bologna process, employers have less experience with the productivity of Bachelor graduates, while Master graduates are comparable to those holding traditional degrees, Bachelor graduates will either start at lower entry positions or are not hired at all. Therefore, *due to their lower probability of working in large firms, Bachelor students should have lower labor market returns than graduates holding Master's or traditional degrees (H4a).*

On the other hand, graduate labor markets are to a large extent segmented along the axis of public and private sectors (Leuze 2010). In the literature, public sectors have often been identified as the prototype of internal labor markets, i.e., with explicitly defined "ports of entry" at the lower end of the job hierarchy, stable employment relationships and calculable promotion schemes. As a consequence, employment in the public sector is even more strongly protected from market competition than are the firm-internal labor markets in the private sector (Becker 1993). Historically, direct ties between German universities and the public sector ensured that traditional higher education qualifications gave the holder the right to apply for particular employment positions in the public sector (Becker 1993; Leuze 2010). Today, a Master's degree gives access to the same positions in the public sector as does a traditional degree, with similar pay scales and chances for promotion. The Bachelor's degree, by contrast, gives access only to lower-level positions in the public sector, with accompanying lower wage levels (Bundesverwaltungsamt 2019; KMK 2000). Therefore, *due to their lower probability of working in the public sector, Bachelor students should have lower labor market returns than graduates holding Master's or traditional degrees (H4b).* Yet, since wages paid in the public sector are generally lower than those paid in the private sector, it might also be the case that this type of firm-internal labor market only explains the employment adequacy of different degree holders and not their wages.

4. Data and Methods

4.1 Data and Operationalization

To analyze labor market differences between graduates with Bachelor's, Master's and traditional degrees, we use data from the DZHW Graduate Panel, a survey conducted every four years for investigating the transition from higher education to work. The data for each graduation cohort are collected about one, five and ten years after graduation. Since this paper focuses on the development and change of labor market returns in the course of the Bologna Process, we first use the cohorts 1997 to 2013 to describe the development of labor market returns of different degree holders over time. However, to analyze possible explanations, we need a sufficient number of graduates holding the new Bachelor's and Master's degrees. Therefore, our multivariate analyses only consider the cohorts 2009 and 2013, since a sizeable share of Bachelor graduates entered the labor market only after 2008, and Master graduates are only observable in cohorts 2009 and 2013.[5] The Stata do-file for variable codings and the statistical analyses is available upon request at the Research Data Centre for Higher Education Research and Science Studies (FDZ-DZHW)[6].

To assess the influence of different higher education degrees, we look at the first significant job held about one year after graduation. We operationalize labor market returns in two different ways: first, objectively in the form of hourly wages and second, as a subjective assessment of the job adequacy. Measurement of hourly wages is based on graduates' reported gross monthly income, which we deflate to prices from 2015 and convert into gross hourly wages by means of the contrac-

5 The graduate cohort of 2013 is the most recent cohort available as scientific-use file.

6 https://doi.org/10.21249/DZHW:kroher2023:1.0.0

tual work hours. Additionally, we take the natural logarithm due to the strongly skewed wage distribution to achieve better modeling properties of this dependent variable (Petersen 1989). For better interpretation of the results from the log hourly wage regressions, we present predicted exponentiated coefficients, which represent differences in Euro for a one-unit change of the independent variable. To ensure that graduates obtained a first significant job after graduation, we further restricted our sample by excluding graduates with marginal part-time work, i.e., who either received monthly wages lower than €400 (2009) and €450 (2013) or worked less than 15 hours per week. Furthermore, we do not consider hourly wages of less than five Euros due to possible measurement error. Although these restrictions lead to a strongly reduced sample, they are deemed necessary to ensure that we analyze only graduates who successfully entered the labor market.[7]

To draw a more complex picture of labor market returns, we further analyze the subjective assessment of the adequacy of the first job after graduation. We use three variables to address the different dimensions of adequacy: Respondents indicate whether their first job matches their higher education qualification in terms of 1) their professional position, 2) their level of the work tasks and 3) the content of their field of study on a five-point Likert scale. For each graduate, we computed the mean of these three items, thereby generating a metric variable of subjective job adequacy, ranging from 1 to 5. Higher values indicate more adequate employment. Finally, we applied the same sample restrictions as for the wage sample to ensure that graduates obtained a first significant job.

Our main independent variable is the higher education degree obtained. We differentiate between traditional degrees such as *Diplom* and *Magister* and the newly established Bachelor's and Master's degrees, but exclude state examinations and teacher training, since those were not completely reformed in the course of the Bologna process and are therefore not comparable to the other degrees. We operationalize H1 on the quantity of human capital only by means of the degrees obtained rather than by including measures on the length of study, since the latter also measures whether students finish their studies on time. The quality of human

7 From the full sample (2009: 11,155, 2013: 8,477), we first excluded all participants who have not worked since graduation (2009: 19 percent, 2013: 16 percent). Of those working, only 73 percent in 2009 and only 53 percent in 2013 have information on the hourly wage, which mainly results from a large proportion of missing values on the monthly income variable (2009: 24 percent, 2013: 44 percent) and to a smaller extent from information on weekly hours worked. Such a large number of missing values is rather common for income information, especially for income from self-employment and respondents working part-time or having higher education qualifications (Riphahn/Serfling 2005). As a consequence, we might have higher nonresponse rates at the lower and the upper tier of the income distribution; this should be kept in mind when interpreting our results. To ensure that graduates obtained a first significant job after graduation, we excluded respondents with wages lower than €400 and €450 respectively, working hours lower than 15 hours and hourly wages lower than €5, which further reduced the wage sample to 57 percent in 2009 and 48 percent in 2013.

capital (H2) is operationalized by two variables: 1) occupation-specific content taught in the course of study and 2) whether compulsory internships were part of the degree course. For the first variable, we built an index based on respondents' assessments of four items on a) the topicality of the content taught in relation to practical requirements, b) the linking of theory and practice, c) the practice of professional tasks and d) the preparation for the future occupation. The internship variable is dichotomous (yes/no) and measures whether students had to undertake mandatory internships as part of their degree course.[8] Additional signals obtained in the course of higher education (H3) were also measured by two variables: The first asks whether or not respondents had a student job during higher education, and if yes, whether the student job was related or unrelated to their respective subject. The second indicates students' experience abroad during their studies with a dichotomous variable (yes/no). Finally, internal labor market segments (H4a and 4b) are captured by two variables: The firm size of the current workplace distinguishes between small, medium and large firms (H4a), while the second measures whether or not graduates work in the public sector (H4b).

We use further control variables relating to graduates' wages and adequate employment: 1) further human capital measurements, namely type of higher education institution (university of applied sciences/universities), graduates' field of study (grouped in eleven categories) and whether respondents completed an apprenticeship before enrolling in higher education; 2) socio-demographic indices influencing the productivity expectations of employers, namely gender (women/men), age and parental education background (parents without higher education/parents with at least one higher education degree). Finally, time trends are considered by controlling for the graduate cohort (2009 and 2013). Listwise deletion of missing cases for all variables results in a sample size of 6,032 cases for the wage sample and 5,996 for the adequacy sample.[9] The distribution of all variables for both samples is presented in appendix table A.

8 Depending on the data set we use, there are slight differences between the questions addressing internships, and also experiences abroad. The corresponding questions on internships and study abroad are not asked consistently and uniformly in a way that they refer to the last study. We find the items in the section with questions about the last study program, but it is not always explicitly referred to in the question. We are aware of the problem that these questions are not clearly defined but they are the best proxy we can use.

9 We excluded those individuals with a degree in teacher training or with a state examination (2009: 18 percent, 2013: 21 percent) and those who worked as freelancers (2009: 2 percent, 2013: 5 percent). Our independent variables mostly have a very small number of missing values (less than 5 percent of those in employment). A higher number of missing values are found only for the employment sector (2009: 16 percent, 2013: 34 percent) and the firm size (2009: 18 percent, 2013: 35 percent). Overall, these sample restrictions and the listwise deletion of missing values on the independent variables further reduced the sample to 3,576 (wage) / 3,596 (adequacy) in 2009 and 2,436 (wage) / 2,420 (adequacy) in 2013.

4.2 *Methods and Analytic Strategy*

The analysis starts with a descriptive overview of the development of wages and job adequacy over time, first in general and then by the different higher education degrees. For doing so, we use the sample of our two cohorts and additionally include graduates from the 1997 to 2005 cohorts to cover a time span prior to the Bologna Process as well. Thereafter, we estimate linear regression models for both dependent variables for our relevant cohorts 2009 and 2013.

Our analytical strategy proceeds in two steps: In a first step, we investigate how labor market returns have changed over the cohorts and whether these changes are attributable to differences in human capital, signals and/or segmentation. This model performs a stepwise regression analysis on the pooled model with interaction effects between degrees and cohorts. We assess whether observable differences in labor market returns between different degree holders diminish once we add our theoretically relevant independent variables step by step. Model 1 (m1) serves as baseline, representing the interaction effects between the different degrees and cohorts on wages and job adequacy, while model 2 (m2) additionally includes all control variables. Model 3 (m3) adds the variables on occupation-specific human capital, model 4 (m4) the signaling variables and model 5 (m5) the variables on internal labor market segments. Finally, model 6 (m6) represents the full model with all preceding variables. Results of these analyses are presented as margin plots comparing the labor market returns of different degree holders over time. We expect that once we control for our relevant independent variables, labor market differentials between different degree holders should decrease and the lines in the graph will converge.

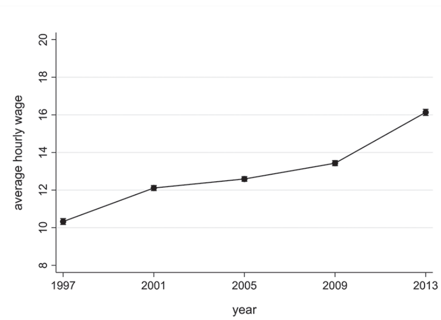
However, such a graphical representation of possible mediator effects does not indicate how much of the gross return gap between different degree holders is explained by the respective variables of interest. Therefore, in a second step we additionally estimate Blinder-Oaxaca decompositions in order to quantify the effect of the different explanatory variables on the degree wage and adequacy differentials (Jann 2008). Technically, the method is based on a so-called counterfactual model, explaining the labor market returns of Bachelor degree holders by inserting coefficients of traditional or Master's degree holders into the equation. It decomposes the overall return gap into an 'explained' part, which is based on differences in observable characteristics (also called differences in endowments) between Bachelor's and traditional/Master's degree holders, and into an 'unexplained' part, which relates to effect differences between the various degrees. Since the Blinder-Oaxaca decomposition is applicable to two groups only, we decompose first return differences between Bachelor's and traditional degrees and second between Bachelor's and Master's degrees. For both analyses, estimations are based on the pooled samples of cohorts 2009 and 2013 because the sample sizes per cohort are too small to estimate robust results, which made pooling necessary.

5. Results

5.1 Descriptive Results

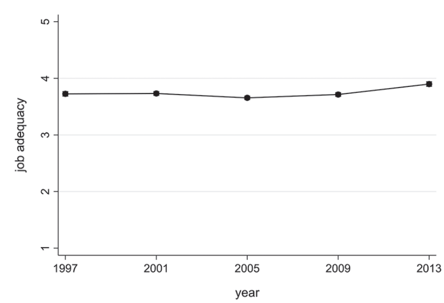
We first take a closer look at the development of labor market returns. As can be seen in Figures 2a and 2b there is an increasing trend in hourly wages and a relatively stable trend for the adequacy of the first job, albeit on a quite high level. In recent cohorts, students earn substantially more in their first job after graduation, even in constant prices of 2015, while there are only slight changes in the job adequacy. It seems that in every cohort most graduates find a job that is well suited for their level of higher education.

Figure 2a: Development Hourly Wages in General



Source: DZHW Graduate Panel (1997 to 2013), authors' illustration.

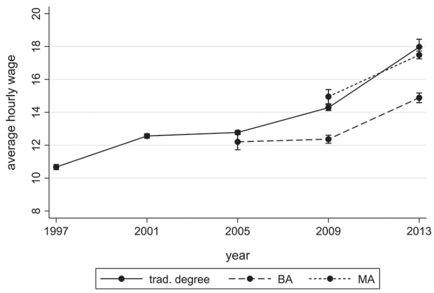
Figure 2b: Development Job Adequacy in General



Source: DZHW Graduate Panel (1997 to 2013), authors' illustration.

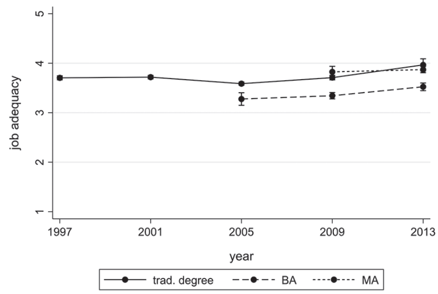
Estimating these average labor market returns by different types of degrees (see Figures 3a and 3b), we find a clear advantage for most cohorts of graduates holding traditional and Master's degrees. Figure 3a shows a distinct difference in the average hourly wages of graduates with a Bachelor's degree compared to those with a Master's or traditional degree for the cohorts 2009 and 2013. Even though wages for all degree holders rise over time, it seems that taking part in a Bachelor's program results in systematically lower wages, which supports previous findings for Germany (Trennt 2019) and other countries (Kroher/Leuze/Thomsen/Trunzer 2021). However, in 2005, where only a selected group of Bachelor graduates entered the labor market and Master's degrees of the new two-tier degree structure were not yet available, hardly any wage differentials are found. The picture is different for the subjective evaluation of job adequacy (see Figure 3b). Here, Bachelor graduates report from the beginning lower levels of job adequacy when compared to traditional and Master's degree holders, which again supports previous findings for Germany (Fabian/Quast 2019; Grotheer 2019). By contrast, the two other types of degrees have a similar wage level and level of job adequacy and hardly differ from each other. These merely descriptive findings support our hypothesis 1, according to which we assumed that Bachelor's degree holders receive lower labor market returns than both traditional and Master's degree holders, due to their lower investment in human capital.

Figure 3a: Development Hourly Wages by Type of Degree



Source: DZHW Graduate Panel (1997 to 2013), authors' illustration.

Figure 3b: Development Job Adequacy by Type of Degree



Source: DZHW Graduate Panel (1997 to 2013), authors' illustration.

However, apart from the length of the respective degree courses, it remains an open question as to whether additional, more qualitative aspects differ, which might explain differentiated labor market returns. Tables 1a and 1b show the descriptive results of our relevant sample variables, first for the pooled sample, and then differentiated by cohorts and degrees. Supporting our graphical findings, the hourly wage increases quite strongly, while the adequacy of the first job rises only moderately. At the same time, the number of traditional degrees decreases over time, while the new degrees—especially the Bachelor's degree—increase. Overall, the strongest wage differences are found between Bachelor's and Master's degrees, while individuals with a traditional degree earn only slightly more than those with a Bachelor's degree. Differences in adequate employment are fairly similar, with the highest values found for Master's degree holders, followed by graduates with a traditional and then a Bachelor's degree.

Table 1a: Descriptive Results (shares or *means* with *standard deviations*): Wage Sample

	pooled wage sample	2009	2013	trad. degrees	BA	MA
hourly wage	*14.99* *(5.33)*	*13.78* *(5.16)*	*16.78* *(5.07)*	*14.85* *(5.11)*	*13.42* *(5.10)*	*17.06* *(5.25)*
log hourly wage	*2.64* *(0.37)*	*2.56* *(0.37)*	*2.77* *(0.33)*	*2.64* *(0.35)*	*2.53* *(0.37)*	*2.78* *(0.35)*
degrees						
traditional degrees	40.95	59.57	13.46	---	---	---
BA degree	32.05	30.98	33.62	---	---	---
MA degree	27.00	9.45	52.91	---	---	---
cohort						
2009	---	---	---	86.72	57.63	20.87
2013	---	---	---	13.28	42.37	79.13
occupational specificity	*3.16* *(0.83)*	*3.13* *(0.84)*	*3.22* *(0.81)*	*3.10* *(0.82)*	*3.17* *(0.84)*	*3.25* *(0.81)*
internship(s)						
no internship	20.41	19.22	22.17	16.64	11.17	37.08
internship(s)	79.59	80.78	77.83	83.36	88.83	62.92
stay abroad						
no stay abroad	68.34	65.29	72.82	59.92	75.58	72.50
stay abroad	31.66	34.71	27.18	40.08	24.42	27.50
student job						
no student job	11.12	10.76	11.66	10.57	12.57	10.25
no subject related student job	19.73	21.64	16.91	19.27	25.87	13.14
subject related student job	69.15	67.60	71.43	70.16	61.56	76.61
sector						
private sector	66.81	64.32	70.48	65.02	72.84	62.37
public sector	33.19	35.68	29.52	34.98	27.16	37.63
firm size						
small firm	20.28	23.14	16.05	21.62	22.25	15.90
medium firm	39.59	40.46	38.30	38.42	43.46	36.77
large firm	40.14	36.40	45.65	39.96	34.30	47.33
N	6,032	3,596	2,436	2,470	1,933	1,629

Source: DZHW Graduate Panel (2009 and 2013).

Table 1b: Descriptive Results (shares respectively *means* with *standard deviations*): Adequacy Sample

	pooled adequacy sample	2009	2013	trad. degrees	BA	MA
adequacy	*3.69 (1.20)*	*3.63 (1.20)*	*3.79 (1.18)*	*3.76 (1.15)*	*3.44 (1.26)*	*3.89 (1.13)*
degree						
traditional degrees	41.03	*59.62*	*13.55*	---	---	---
BA degree	32.00	*30.90*	*33.64*	---	---	---
MA degree	26.97	*9.48*	*52.81*	---	---	---
cohort						
2009	---	---	---	86.67	57.58	20.96
2013	---	---	---	13.33	42.42	79.04
occupational specificity	*3.16 (0.83)*	*3.13 (0.83)*	*3.22 (0.82)*	*3.10 (0.82)*	*3.17 (0.84)*	*3.25 (0.81)*
internship(s)						
no internship	20.41	19.27	22.11	16.67	11.20	37.04
internship(s)	79.59	80.73	77.89	83.33	88.80	62.96
stay abroad						
no stay abroad	68.40	65.30	72.98	59.92	75.61	72.73
stay abroad	31.60	34.70	27.02	40.08	24.39	27.27
student job						
no student job	11.14	10.77	11.69	10.53	12.61	10.33
no subject related student job	19.68	21.59	16.86	19.19	25.90	13.05
subject related student job	69.18	67.65	71.45	70.28	61.49	76.62
sector						
private sector	66.74	64.23	70.45	64.96	72.75	62.34
public sector	33.26	35.77	29.55	35.04	27.25	37.66
firm size						
small firm	20.30	23.15	16.07	21.59	22.25	16.02
medium firm	39.54	40.44	38.22	38.41	43.46	36.61
large firm	40.16	36.41	45.70	40.00	34.29	47.37
N	5,996	3,576	2,420	2,460	1,919	1,617

Source: DZHW Graduate Panel (2009 and 2013).

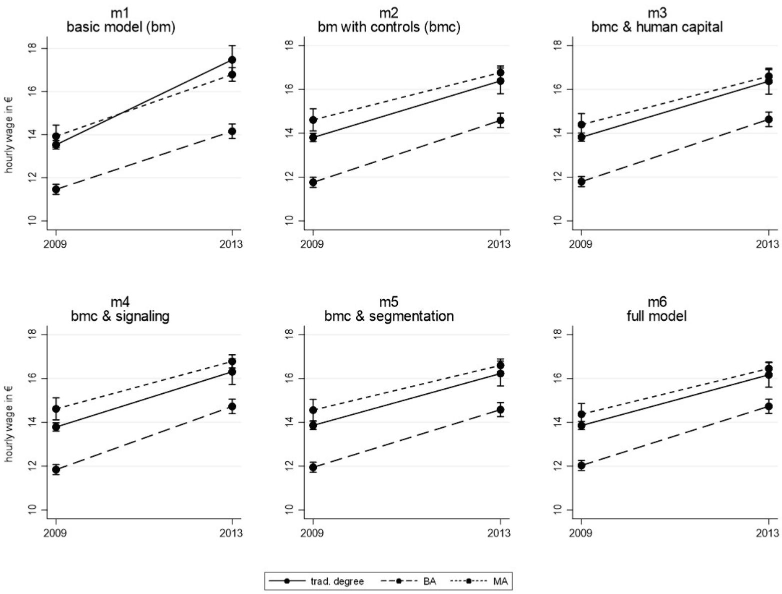
Regarding our independent variables of interest, the occupational specificity reported is fairly stable over time; highest in the Master's degree and lowest in traditional programs, with the Bachelor's degree ranging in between. Mandatory internships, by contrast, seem to rise over time and are reported most often by Bachelor graduates and least by Master graduates. Thus, both variables only partly follow the assumed distribution between different degrees. Staying abroad while studying seems to decline over time and is found most among traditional degree holders and least among Master's degree holders. Having a subject-related student job remains fairly stable over time and is indicated predominantly among individuals holding a Master's degree, followed by those holding a Diplom or Magister. Graduates from Bachelor programs, by contrast, most often report a student job not related to their subject. Thus, the acquisition of additional signals only follows the expected distribution for subject-related student jobs, but not for staying abroad. The variables on internal labor market indicate that the majority of students are employed in the private sector, with the highest share among Bachelor degree holders and the lowest among Master graduates. Employment mostly takes place in medium and large firms, with Master graduates working most often in large firms, while Bachelor degree holders are more often found in medium firms. Interestingly, working in small firms is most common for traditional and Bachelor's degrees. Accordingly, working in internal labor markets mostly follows the predicted distribution among different degrees. Overall, there are hardly any differences in the two samples regarding our independent variables of interest.

5.2 Regression Analyses: Mediation

To test whether these observed descriptive differences between degree holders also contribute to differentiated labor market returns, we first run several linear regression models with a stepwise introduction of relevant covariates. The coefficients of the wage regressions can be read as difference in Euro of hourly wages, while the coefficients of the regressions on job adequacy indicate a change in scale points.

Figure 4a displays the results of all six wage models as margins plots. As with Figure 3a, the basic model comprises only the degrees, cohorts and their interactions, but this time models the log hourly wage. The remaining models add the control variables (m2) and the theoretically relevant independent variables separately (m3-m5), before estimating the full model (m6). If our dependent variables mediate the effect between degree and wages, the lines of the respective graphs should converge, i.e., the predicted wages of Bachelor graduates should draw closer to the predicted wages of the other two degrees. However, this is not the case. According to Figure 4a we observe a small convergence of predicted wages in the full model (m6), especially in 2013. Nevertheless, the gap between graduates holding Bachelor's degrees and those with Master's or traditional degrees remains substantial and hardly changes once the relevant mediator variables are considered. Accordingly, none of our included independent variables are capable of closing the gap—or in other words none can explain this gap.

Figure 4a: Regression Analyses on the Hourly Wage of the First Job

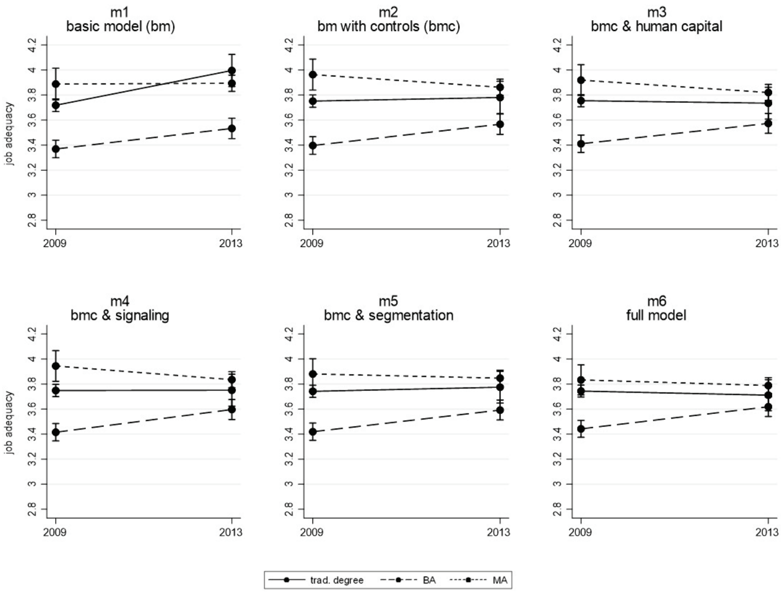


Source: DZHW Graduate Panel (2009 and 2013), authors' illustration.

Comparing the regression models for the adequacy of employment, a slightly different picture evolves (see Figure 4b). Here, the gap between Bachelor's degree holders and holders of the other degrees closes more firmly, once specific human capital, additional signals and internal labor market segments are controlled, leading to a stronger convergence of the predicted job adequacy, particularly for cohort 2013. In the full model (m6), Bachelor's graduates are only slightly more inadequately employed compared to traditional and Master's graduates. Interestingly, Master's graduates were initially also more adequately employed than traditional degree holders in 2009, yet these differences diminish in 2013.

Consequently, we conclude that over time wages increase for all degree types, but the gap between the different degrees remains relatively stable even when adding other explanatory factors. In contrast, Bachelor's students can take matters into their own hands in terms of job adequacy and find careers suitable for their education through specific human capital, additional signals and when working in internal labor markets. However, it remains an open question as to which groups of variables have the highest explanatory power in this regard.

Figure 4b: Regression Analyses on the Adequacy of the First Job



Source: DZHW Graduate Panel (2009 and 2013), authors' illustration.

5.3 Regression Analyses: Decomposition models

In the following, we therefore examine the contribution of each variable group by decomposing the labor market gap between different degree holders. Table 2a presents results from the Blinder-Oaxaca decompositions of the wage differentials, comparing Bachelor's graduates first with traditional degree holders and then with Master's degree holders. Both decompositions are based on the full models including all relevant variables of interest and the control variables. The wage regressions, which form the basis of these analyses, can be found in the appendix, Table B1.

Results indicate that graduates with a Bachelor's degree earn significantly less compared to those with a traditional or a Master's degree, however the gap is much higher in comparison to Master's graduates. A closer look at the wage difference shows that individuals holding a traditional degree earn about 11.0 percent higher wages than Bachelor's graduates, while those with a Master's receive a wage premium of 25.3 percent.

Looking at the explanatory power of our relevant variables, we find some support for our theoretical assumptions, yet not always for all types of degrees. Regarding the relevance of occupation-specific human capital, a higher reported occupational specificity in higher education indeed increases wages (see appendix Table B1), but does not contribute to wage differentials by degree. Contrary to our expectation, mandatory internships are accompanied by lower wages when comparing the Bachelor's degree to traditional degrees (see appendix Table B1). Since Bachelor graduates report mandatory internships more often than the other two degree groups, this contributes to the wage gap between Bachelor's and traditional degrees. Yet both findings are not in line with our theoretical considerations and thus do not support hypothesis 2.

Additional signals, such as experience abroad or having a study-related student job, indeed come along with higher wages (see appendix Table B1), but again only partly contribute to the degree wage gap. Since individuals with traditional degrees gain more experience abroad than Bachelor's degree holders, this partly explains their wage differentials, while with a Master's degree international student mobility does not contribute to the wage gap. In contrast, graduates with both traditional and Master's degrees more often have study-related student jobs, while Bachelor's degree holders have student jobs not related to their subject. The positive signal of a study-related job therefore explains part of the wage penalty incurred by Bachelor's graduates, thus partly supporting hypothesis 3.

Finally, the two hypotheses on internal labor markets are also partly confirmed, mainly regarding the firm size (hypothesis 4a). Since graduates with traditional and Master's degrees work more often in large firms than do Bachelor's degree holders, this has an impact on the degree wage gap. Additionally, Bachelor's graduates earn less than Master's graduates since the former more often work in small firms. Public sector employment, in contrast, does not contribute to the degree wage gap (hypothesis 4b).

Table 2a: Blinder-Oaxaca Decompositions of the Wage Differences Between Different Degrees

	log hourly wage BA vs trad.	%	**log hourly wage BA vs MA**	%
log hourly wage trad. / MA graduates	2.639*** (0.007)		2.782*** (0.009)	
log hourly wage BA graduates	2.529*** (0.009)		2.529*** (0.009)	
difference	0.110*** (0.011)	100	0.253*** (0.012)	100
explained	-0.009 (0.011)	-8.18	0.102*** (0.016)	40.32
unexplained	0.120*** (0.014)	109.09	0.152*** (0.018)	60.08
explained in detail				
control variables	0.014 (0.007)		0.007 (0.012)	
occupational specificity	-0.001 (0.001)		0.001 (0.001)	
internships (ref.: no internship)	0.003* (0.001)		0.007 (0.004)	
experience abroad (ref.: no stay abroad)	0.006** (0.002)		0.001 (0.001)	
student job				
no student job	0.001 (0.001)		-0.001 (0.001)	
not study related student job	0.002** (0.001)		0.009*** (0.002)	
study related student job	0.004*** (0.001)		0.007*** (0.002)	
public sector (ref.: private sector)	-0.001 (0.001)		0.002 (0.002)	
firm size				
small firm	0.001 (0.001)		0.006*** (0.001)	
medium firm	0.001 (0.001)		0.001 (0.001)	
large firm	0.005*** (0.001)		0.014*** (0.002)	
year (ref.: 2009)	-0.041*** (0.006)		0.049*** (0.007)	
N	4,403		3,562	

Source: DZHW Graduate Panel (2009 and 2013).

Note: ref = reference category. *** p < 0.001, ** p < 0.01, * p < 0.05. Standard errors in parentheses.

Overall, the relevant independent and control variables explain about 40 percent of the wage differentials between Bachelor's and Master's degrees. Even though rather similar factors explain the wage gap between graduates holding traditional and Bachelor's degrees, their explanatory power is offset by controlling for cohort differences. Cohort effects decrease the wage gap between traditional and Bachelor's degrees, indicating that their wages become more similar over time. In contrast, cohort effects increase the degree gap over time, which implies rising wage inequalities between Bachelor's and Master's degree holders.

A somewhat different picture emerges if we look at the decomposition models for job adequacy (see Table 4b). The regressions on adequate employment, which form the basis of these analyses, are found in the appendix, Table B2. Overall, Bachelor degree holders report lower levels of job adequacy than those with a traditional (0.317 scale points) or Master's (0.454 scale points) degree. The occupation-specific content of studies increases adequate employment in both models (see appendix Table B2), yet contributes to both gaps in the opposite direction. In accordance with hypothesis 2, Master's degree holders gain more occupation-specific knowledge through their studies than Bachelor's degree holders, which partly explains the adequacy gap. However, since traditional degrees provide less occupation-specific knowledge than do Bachelor programs, this decreases rather than explains the adequacy gap. Mandatory internship also increases the adequacy of employment (see appendix Table B2), yet does not explain differences between short and long degrees, since the former more often report mandatory internships. Accordingly, our data lend only weak support to hypothesis 2, just as was the case for wages.

Since experience abroad does not increase the adequacy of employment, it cannot contribute to degree differentials and thus does not serve as an additional signal. In contrast, study-related student jobs increase the job adequacy of graduates when compared to student jobs not related to the field of study. Since Bachelor's graduates more often reported the latter, they have lower levels of adequate employment, which supports hypothesis 3. Accordingly, a study-related student job might indeed serve as a signal for future employers, thereby increasing the adequacy of employment for traditional and Master's graduates.

Finally, both variables on internal labor markets point in the assumed direction: Working in large firms (hypothesis 4a) and in the public sector (hypothesis 4b) increases the adequacy of employment. Since both traditional and Master's graduates work more often than Bachelor graduates in the public sector and in large firms, both forms of internal labor markets contribute to the gap in adequate employment. Overall, about 47–48 percent of the observed disadvantage of Bachelor's graduates in adequate employment can be explained by the respective independent and control variables.

Table 2b: Blinder-Oaxaca Decompositions of the Job Adequacy of Degrees

	job adequacy BA vs trad.	%	job adequacy BA vs MA	%
job adequacy trad. / MA graduates	3.755*** (0.023)		3.893*** (0.028)	
job adequacy BA graduates	3.439*** (0.029)		3.439*** (0.029)	
difference	0.317*** (0.037)	100	0.454*** (0.040)	100
explained	0.149*** (0.035)	47.00	0.217*** (0.051)	47.80
unexplained	0.167*** (0.048)	52.68	0.237*** (0.061)	52.20
explained in detail				
control variables	0.084*** (0.024)		0.072 (0.038)	
occupational specificity	-0.015** (0.006)		0.022** (0.008)	
internships (ref.: no internship)	-0.006 (0.004)		-0.023 (0.014)	
experience abroad (ref.: no stay abroad)	0.015* (0.007)		0.001 (0.002)	
student job				
no student job	0.001 (0.001)		-0.001 (0.001)	
not study related student job	0.012*** (0.004)		0.033*** (0.008)	
study related student job	0.017*** (0.004)		0.030*** (0.007)	
public sector (ref.: private sector)	0.031*** (0.007)		0.059*** (0.011)	
firm size				
small firm	0.001 (0.001)		0.008* (0.003)	
medium firm	-0.001 (0.002)		0.001 (0.003)	
large firm	0.005* (0.002)		0.017*** (0.005)	
year (ref.: 2009)	0.008 (0.021)		-0.001 (0.025)	
N	4,379		3,536	

Source: DZHW Graduate Panel (2009 and 2013).
Note: ref=reference category. *** p < 0.001, ** p < 0.01, * p < 0.05. Standard errors in parentheses.

6. Discussion and Conclusion

The Bologna Process introduced a two-tier degree structure into the formerly one-tier degree system in German higher education. Even though its implementation proceeded only gradually, the majority of graduates today hold Bachelor's and Master's degrees, while only a small fraction of graduates still finish with traditional degrees, mainly in the form of state examinations. Since the introduction of a two-tier degree structure changed the German higher education system from a horizontally differentiated to a vertically differentiated one, this paper set out to analyze whether this structural change is accompanied by more stratified labor market returns for different degree holders, thus focusing on graduate careers outside academia.

Based on human capital theory, we assumed that graduates holding a Bachelor's degree, with a study duration of about three years, receive lower labor market returns, while graduates with a Master's degree should receive similar returns to those holding traditional degrees, due to the comparable length of both degree courses. However, it might be the case that not the degree per se, but rather associated aspects are more relevant. First, since Bachelor programs aim at providing rather broad undergraduate education, while Master's and traditional degrees provide more specialized degree profiles, it might be that occupation-specific human capital in the form of occupation-specific knowledge, gained through higher education and mandatory internships, is more important for understanding vertically differentiated labor market returns. Second, obtaining extracurricular qualifications, such as studying abroad or gaining practical work experience through study-related student jobs, is easier in degree courses of longer duration, which might send additional signals to employers. Third, longer degree types might provide better access to internal labor market segments found in large firms or in the public sector, which also might explain labor market differentials between degree holders.

We tested our hypotheses based on two DZHW graduate cohorts entering the labor market in 2009 and 2013. More specifically, we modeled the log hourly wage and the adequacy of the first job by applying linear regression and decomposition techniques. Descriptive evidence indicates a clear advantage of graduates with traditional and Master's degrees when compared to Bachelor's degree holders, both in terms of wages and in terms of a more subjective assessment of adequate employment. The assumed explanatory factors, however, only partially contribute to our understanding of differentiated labor market returns. The most robust findings are related to internal labor market segments. For both wages and adequate employment, working in the internal labor market of large firms is beneficial. Since Bachelor's graduates have lower chances of starting their work life in larger firms, this partly explains their labor market disadvantages. Apparently, both traditional and Master's degrees serve as relevant certificates for entering firm-internal labor markets, while a Bachelor's degree is not sufficient. Regarding adequate employment, this also holds true for firm-internal labor markets in the public sector, where graduates with traditional and Master's degrees have better employment prospects.

But signals acquired in addition to higher education also support the better labor market returns of long degrees. While studying abroad is particularly beneficial for the wages of traditional degree holders, having a study-related student job benefits the employment prospects of both traditional and Master's graduates. Apparently, with longer durations of study it becomes easier to obtain a student job directly related to the content of study. This might, on the one hand, serve as an important signal to future employers, but it also might increase graduates' occupation-specific labor market experience and possibly establish networks for successful labor market entry. Even though our results indicate that study-related student jobs currently disadvantage Bachelor's graduates, they also open the road for their advancement. Labor market prospects should also increase for Bachelor's graduates, if they work in study-related student jobs while studying.

In contrast, gaining occupation-specific knowledge through higher education itself or through mandatory internships does not systematically and consistently increase labor market differentials between different degree holders. Both findings might be related to measurement problems. Regarding occupation-specific knowledge, our index is based on very broad questions on the connection between higher education and the labor market, resulting in very little variation between the different degree holders. Moreover, mandatory internships are reported less often by Master's degree holders, which might be related to the placement of this question within the questionnaire, referring only to the last degree obtained. Therefore, future research should apply more theoretically-driven indicators on the occupation-specific knowledge gained in higher education and its relation to the labor market.

Overall, our findings support existing empirical studies comparing the labor market outcomes of pre- and post-reform degrees. Regarding wage differentials, most cross-sectional studies on Germany confirm that Bachelor's degree holders earn less than graduates with Master's or traditional degrees (Alesi/Schomburg/Teichler 2010; Dill/Hammen 2011; Neugebauer/Weiss 2017; Trennt 2019). Moreover, studies point toward a higher risk of inadequate employment for Bachelor's graduates compared to those holding Master's or traditional degrees (Fabian/Hillmann/Trennt/Briedis 2016; Fabian/Quast 2019; Grotheer 2019; Rehn/Brandt/Fabian/Briedis 2011). Just like these studies we find a clear-cut hierarchy of labor market returns, showing that graduates holding a post-reform first-level Bachelor's degree receive lower labor market returns than both graduates with traditional, pre-reform degrees or those with post-reform second-level Master's degrees.

However, our analyses add two important findings to this field of literature: Regarding the longitudinal development, it seems that labor market inequalities between Bachelor's and Master's degree holders increase over time, particularly as regards wage differentials. Since the majority of graduates today obtain Bachelor's and

Master's degrees, this indicates rising labor market inequalities between different groups of graduates due to the vertical differentiation of degrees. Considering that graduates from less privileged family backgrounds tend to have lower probabilities of starting a Master's degree than those from more privileged families (Auspurg/Hinz 2011; Lörz/Quast/Roloff 2015; Lörz/Quast/Roloff/Trennt 2019; Neugebauer 2015; Neugebauer/Neumeyer/Alesi 2016), the Bologna Process apparently not only has unintended consequences in terms of higher education participation, but also in terms of social stratification. Increasing social inequalities in labor market outcomes among different social groups are likely to occur due to the introduction of the two-cycle degree structure. This might also apply to proceeding with a PhD and resulting academic careers thereafter, which were already highly socially stratified even before the Bologna Process occurred. Therefore, the social stratification of careers both inside and outside academia should be closely monitored in future research.

Second, while many previous studies described labor market differentials between different degree holders, they did not seek to explain them. An exception is the study by Trennt (2019), reporting that graduates with a Master's degree earn higher wages than those with a Bachelor's degree since the former work more often in large firms and are more often adequately employed. Our results complement these findings by pointing towards the importance of internal labor market segments and extracurricular qualifications obtained via study-related student jobs as signals. Even though we are able to explain about 40 percent of the observed labor market differentials between graduates holding short and long degrees, the larger proportion remains unaccounted for. One simple explanation holds that it is merely the quantity of human capital that makes the differences. However, our results show that differentiated labor market returns are mostly able to be explained by aspects of the labor market rather than through explanations related to human capital. Therefore, future research should pay close attention not only to the segments worked in by graduates, but also to the occupations they hold and the hierarchical position therein.

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Appendix

Table A: Descriptive Results (shares respectively *means* with standard deviations): Wage and Adequacy Sample

	Pooled wage sample	Pooled adequacy sample
hourly wage	*14.99* *(5.33)*	
log hourly wage	*2.64* *(0.37)*	
adequacy of employment		*3.69* *(1.20)*
degrees		
traditional degrees	40.95	41.03
BA degree	32.05	32.00
MA degree	27.00	26.97
occupational specificity	*3.16* *(0.83)*	*3.16* *(0.83)*
internship(s)		
no internship	20.41	20.41
internship(s)	79.59	79.59
stay abroad		
no stay abroad	68.34	68.40
stay abroad	31.66	31.60
student job		
no student job	11.12	11.14
no subject related student job	19.73	19.68
subject related student job	69.15	69.18
sector		
private sector	66.81	66.74
public sector	33.19	33.26
firm size		
small firm	20.28	20.30
medium firm	39.59	39.54
large firm	40.14	40.16
type of university		
university of applied sciences	40.63	40.66
university	59.37	59.34
field of study		
humanities	3.53	3.54
linguistic and language	3.23	3.22
social sciences	14.92	14.88
law & economics	25.36	25.32
education	4.54	4.55
maths & natural sciences	9.43	9.44
medicine & health	2.93	2.95
architecture & engineering	25.10	25.17
agriculture & forest sciences & food technology	4.09	4.09
informatics	5.27	5.29
arts & music	1.57	1.57
gender		
female	52.09	52.03
male	47.91	47.97
age	*26.60* *(2.61)*	*26.60* *(2.61)*
social origin (education parents)		
no one higher education	50.22	50.22
at least 1 higher education	49.78	49.78
apprenticeship before college		
no apprenticeship	71.58	71.61
apprenticeship	28.42	28.39
N	6,032	5,996

Source: DZHW Graduate Panel (2009 and 2013).

Table B1: OLS-Regression: Full Model: Wage Sample

	log hourly wage BA vs trad.	log hourly wage BA vs MA
BA degree (ref.: trad. / MA)	-0.131*** (0.012)	-0.159*** (0.014)
cohort (ref.: 2009)	0.180*** (0.012)	0.178*** (0.016)
occupational specificity	0.022*** (0.006)	0.018** (0.007)
internship (ref.: no internship)	-0.033* (0.015)	-0.006 (0.013)
stay abroad (ref.: no stay abroad)	0.035*** (0.011)	0.034** (0.012)
student job (ref.: subject related job)		
no student job	-0.045** (0.015)	-0.031 (0.017)
no subject related student job	-0.065*** (0.012)	-0.069*** (0.013)
sector (ref.: private sector)	0.004 (0.011)	0.021 (0.012)
firm size (ref.: large firm)		
small firm	-0.173*** (0.013)	-0.186*** (0.015)
medium firm	-0.116*** (0.011)	-0.130*** (0.017)
university (ref.: univ. of applied sciences)	-0.050*** (0.012)	-0.069*** (0.013)
field of study (ref.: humanities)		
linguistic and language	-0.018 (0.036)	-0.034 (0.039)
social sciences	0.072** (0.027)	0.089** (0.032)
law & economics	0.221*** (0.027)	0.247*** (0.031)
education	0.165*** (0.033)	0.193*** (0.038)
maths & natural sciences	0.198*** (0.030)	0.142*** (0.034)
medicine & health	0.137*** (0.038)	0.164*** (0.039)
architecture & engineering	0.281*** (0.028)	0.297*** (0.032)
agriculture & forest sciences & food technology	0.082* (0.034)	0.126** (0.039)
informatics	0.265*** (0.034)	0.301*** (0.036)
arts & music	0.036 (0.045)	0.010 (0.051)
gender (ref.: female)	0.073*** (0.011)	0.075*** (0.012)
apprenticeship (ref.: no apprenticeship)	0.030* (0.013)	0.034* (0.014)
social origin (ref.: no one higher education)	0.015 (0.010)	0.022* (0.011)
age	0.003 (0.002)	0.005* (0.002)
N	4,403	3,562
adjusted R^2	0.274	0.362

Source: DZHW Graduate Panel (2009 and 2013).

Note: ref=reference category. *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$. Standard errors in parentheses.

Table B2: OLS-Regression: Full Model: Adequacy Sample

	adequacy BA vs trad.	adequacy BA vs MA
BA degree (ref.: trad. / MA)	-0.225***	-0.268***
	(0.041)	(0.050)
cohort (ref.: 2009)	0.092*	0.098*
	(0.043)	(0.042)
occupational specificity	0.228***	0.267***
	(0.023)	(0.025)
internship (ref.: no internship)	0.122*	0.171***
	(0.053)	(0.048)
stay abroad (ref.: no stay abroad)	0.036	-0.024
	(0.038)	(0.044)
student job (ref.: subject related job)		
no student job	-0.127*	-0.058
	(0.054)	(0.060)
no subject related student job	-0.386***	-0.415***
	(0.042)	(0.049)
sector (ref.: private sector)	0.370***	0.476***
	(0.039)	(0.044)
firm size (ref.: large firm)		
small firm	-0.161***	-0.180***
	(0.047)	(0.054)
medium firm	-0.122**	-0.158***
	(0.039)	(0.043)
university (ref.: univ. of applied sciences)	0.082	0.141**
	(0.044)	(0.048)
field of study (ref.: humanities)		
linguistic and language	-0.253	-0.025
	(0.130)	(0.144)
social sciences	0.393***	0.449***
	(0.098)	(0.115)
law & economics	0.418***	0.482***
	(0.097)	(0.112)
education	0.174	0.166
	(0.118)	(0.138)
maths & natural sciences	0.625***	0.474***
	(0.108)	(0.125)
medicine & health	-0.041	0.146
	(0.135)	(0.142)
architecture & engineering	0.707***	0.756***
	(0.099)	(0.116)
agriculture & forest sciences & food technology	0.343**	0.463**
	(0.123)	(0.144)
informatics	0.682***	0.875***
	(0.120)	(0.133)
arts & music	-0.263	-0.019
	(0.162)	(0.188)
gender (ref.: female)	0.043	0.053
	(0.039)	(0.043)
apprenticeship (ref.: no apprenticeship)	-0.057	0.030
	(0.045)	(0.050)
social origin (ref.: no one higher education)	0.060	0.049
	(0.035)	(0.039)
age	-0.020**	-0.026**
	(0.007)	(0.008)
N	4,379	3,536
adjusted R^2	0.156	0.176

Source: DZHW Graduate Panel (2009 and 2013).

Note: ref=reference category. *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$. Standard errors in parentheses.

Thorsten Euler* and Fabian Trennt**

More or less the same?

An exploration of the evolution of the PhD wage premium in a decade of higher education expansion.***

Abstract: The expansion in higher education over the last decade or more has led to an increase in the number of tertiary education graduates entering the labor market, both with and without doctoral degrees. On the one hand this process has been accompanied by concerns of graduate oversupply; on the other hand, proponents of higher education expansion point towards an increasing demand for highly-skilled workers in a knowledge-based economy, especially concerning PhD holders, as they are the driving forces of innovation. Against this backdrop we ask to what extent higher education expansion has affected the earnings of PhD graduates in comparison to higher education graduates without doctoral degrees. Our analysis is based on the 1997, 2001, 2005, and 2009 cohorts of the German Centre for Higher Education and Science Studies (DZHW) graduate panel studies. Within these, surveys were conducted for each respective cohort about ten years after graduation. In accordance with human capital theory, we find a constant PhD wage premium between the different cohorts for those employed in the private sector. In the public sector, we detect a stable but insignificant PhD wage premium. Descriptive and analytic results show a significant wage growth for the 2009 cohort, regardless of sector and PhD state.

Keywords: higher education expansion; labor market returns; graduates; wages; doctoral degree

Alles beim Alten?

Eine Untersuchung der Entwicklung der Lohnprämien von Promovierten in Zeiten der Bildungsexpansion

Zusammenfassung: Im Zuge der Ausweitung hochschulischer Bildung in den letzten Jahrzehnten drängt eine steigende Zahl von Hochschulabsolvent*innen – mit und ohne Doktortitel – auf den Arbeitsmarkt. Einerseits wurde dieser Prozess

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von der Sorge eines Überangebots an Hochschulabsolvent*innen begleitet, andererseits verweisen die Befürworter*innen der Expansion des Hochschulwesens auf die steigende Nachfrage nach hochqualifizierten Arbeitskräften in einer wissensbasierten Wirtschaft. Dies gilt insbesondere für promovierte Beschäftigte als treibenden Kräfte der Innovation. Vor diesem Hintergrund stellen wir die Frage, inwieweit sich die hochschulische Bildungsexpansion auf die Einkommen von Promovierten im Vergleich zu Hochschulabsolvent*innen ohne Doktortitel ausgewirkt hat. Unsere Analyse basiert auf Daten des Absolventenpanels des Deutschen Zentrums für Hochschul- und Wissenschaftsforschung (DZHW). Dort wurden Hochschulabsolvent*innen der Abschlussjahrgänge 1997, 2001, 2005 und 2009 jeweils etwa zehn Jahre nach ihrem Studienabschluss befragt. Im Einklang mit der Humankapitaltheorie finden wir einen konstanten Einkommensgewinn für Promovierte aller Kohorten in der Privatwirtschaft. Im öffentlichen Dienst hingegen lässt sich nur ein insignifikanter Lohnvorteil feststellen. Deskriptive und analytische Ergebnisse zeigen einen signifikanten Lohnzuwachs für die Abschlusskohorte 2009, unabhängig von Sektor und Promotionsstatus.

Stichworte: Bildungsexpansion; Arbeitsmarkterträge; Hochschulabsolvent*innen; Löhne; Promovierte

Introduction

Higher education is on the rise worldwide (Schofer/Meyer 2005). Although a latecomer to this trend, Germany is no exception (Alesi/Teichler 2013). Over the last two decades a growing number of people have become eligible to further their learning at an institution of tertiary education (Autorengruppe Bildungsberichterstattung 2018). Consequently, there has been an increase in the number of higher education graduates, in the proportion of tertiary degrees among those eligible to study, and also in the proportion of young people entering the labor market (Autorengruppe Bildungsberichterstattung 2018). Regarding those graduating, the rate of expansion has been fairly steady, while the development with respect specifically to doctoral degrees has been more erratic[1] (Konsortium BuWiN 2017).

Insofar as education is perceived as a means to generate earnings (Becker 1962; Mincer 1958; Spence 1973) or gain access to different social classes (Breen/Goldthorpe 1997) questions arise concerning the labor market consequences of this differential shift in labor supply. Critical observers believe that the recent educational expansion went too far, and they anticipate an excess of tertiary education graduates on the labor market (Di Paolo/Mañé 2016; Nida-Rümelin 2014; Schleglmilch 1987). Assuming a constant demand for higher education graduates, they predict poorer employment prospects for recent graduate cohorts. In Germany about 13 percent of all doctoral degree holders report that they are employed in

1 For a more detailed discussion see section 2.

jobs that do not require such a high level of education (PhD), which marks a middle position in comparison to other OECD countries (Auriol 2010: 14). Technological progress, however, changes skill demand (skill-biased technological change); the ability to cope with uncertain situations becomes more and more important while routine-based tasks will increasingly be carried out by machines and algorithms (Frey/Osborne 2017). So whereas computer technology substitutes for the latter, it complements non-routine complex tasks, thereby making incumbents of respective jobs more productive (Autor/Levy/Murnane 2003), which should in turn lead to higher rewards on the labor market. As tertiary graduates are said to possess those necessary skills (Acemoglu/Autor 2011) the negative consequences of computerization should be less severe for them (Dengler/Matthes 2015). This should particularly hold true for PhD graduates who are trained for complex and innovative tasks and processes (i.e. performing non-routine tasks) (Arbeitskreis Deutscher Qualifikationsrahmen 2011; Bogle/Dron/Eggermont/van Henten 2010; Diamond/Ball/Vorley/Hughes/Moreton/Howe/Nathwani 2014) – skills that are very important for countries such as Germany, who are poor in natural resources. As such, PhD holders are in a crucial position in shaping a knowledge-based economy (Di Paolo/Mañé 2016; Neumann/Tan 2011). Because educational decision making depends on expected returns to education (Breen/Goldthorpe 1997; Esser 1999), transparent, research-based information on returns to education are of utmost importance for a knowledge-based economy to guarantee an unbiased allocation of human capital. In the absence of this information a growing share of graduates might refrain from taking up PhD studies if the level of perceived returns is below that of actual returns. Vacancies demanding PhD skills would not be able to be staffed, which would lead to a reduction in innovation and future economic growth. In contrast to that, perceived returns exceeding actual returns would attract too many PhD candidates, resulting in a growing share of PhD holders occupying jobs where PhDs are unnecessary.

While we already have some insight into the labor market rewards that are associated with a PhD degree (Goldan/Jaksztat/Gross 2022) and the underlying mechanisms (Goldan 2021; Trennt/Euler 2019), a systematic longitudinal analysis with respect to this degree is quite rare and still lacking for the German context. Most of the existing research focusing on monetary returns of higher education graduates with and without a doctorate suggests that a PhD degree pays off (Engelage/Hadjar 2008; Falk/Küpper 2013; Heineck/Matthes 2012; Mertens/Röbken 2013; O'Leary/Sloane 2005; Trennt/Euler 2019; Wouterse/van der Wiel/van der Steeg 2017)[2]. The only longitudinal studies available that focus on changes in the returns to education due to the educational expansion in Germany do not distinguish PhD holders from other graduates. The results of relevant work are differentiated mainly

2 In contrast, Pedersen (2016) sees no wage differentials between these two groups. According to her, the differing results are due to the method used (some kind of (propensity score) matching algorithm) which eliminates unobserved heterogeneity.

by gender and analytical perspective[3]. With the exception of the late 1990s, no general decline in the monetary returns to education is reported (Gebel/Pfeiffer 2010; Göggel 2007; Lauer/Steiner 2004). More or less constant returns to higher education can also be observed with respect to access to the service class (Klein 2011; Müller/Brauns/Steinmann 2002). However, taking into consideration that the various birth cohorts might be affected differently by educational expansion, Lauer/Steiner (2004) and Boockmann/Steiner (2006) find slightly lower returns for the more recent cohorts. These results are more pronounced for women than for men. With a special focus on tertiary education graduates, Reinhold/Thomsen (2017) detect a rising wage premium from 1990 onwards for labor market entrants with higher education, in contrast to that for medium and low-skilled workers. However, the results found by Henseke (2018) suggest that this only holds true for men, while there is no wage premium for women of more recent cohorts compared to their predecessors.

To the best of our knowledge, up to this day there is only one paper that combines the analysis of wage differentials between higher education graduates and PhD holders with a longitudinal perspective. For Switzerland, Engelage/Hadjar (2008) detect no general trend in the development of the differences in earnings, risk of unemployment, or vertical job adequacy between tertiary graduates with and without a PhD. They specifically report rising advantages in earnings for academics with a doctoral degree in law while the wage differential between engineers with and without a PhD is smaller in more recent cohorts (Engelage/Hadjar 2008). While this work offers valuable insight into the development of the labor market perspectives for doctoral degree holders in Switzerland it remains unclear whether these results can be transferred to the German labor market, as expansion of higher education has been more gradual in Switzerland compared to Germany (Engelage/Hadjar 2008).

Against this backdrop we ask whether higher education expansion has been accompanied by rising, falling, or constant monetary returns to doctoral education in Germany. As the German doctorate – in contrast to many other countries – not only qualifies its holder for research activities within academia but also for many jobs outside (Enders 2002; Franck/Opitz 2007) – especially in departments of research and development in the private sector (Konsortium BuWiN 2017; Buenstorf/Heinisch 2020) – we additionally differentiate our analysis by sector of employment. To answer this question, we use the third waves of the DZHW graduate panel studies 1997, 2001, 2005, and 2009 cohorts. The surveys took place about ten years after the respondents' respective graduation from an institution of higher education in Germany. At this point in time most of the (planned) doctoral

3 As the studies differ among other things with respect to observed periods and cohort classification, a direct comparison is very difficult and should therefore just be understood as a tendency.

studies have already been finished. Besides covering a relevant period of higher education expansion, the data includes some basic variables that explain selection into a PhD degree course, enabling us to consider possible compositional changes between the cohorts. Both aspects make the data suitable to answer the research question. This paper is structured as follows: In the subsequent section (2) we present a theoretical framework to explain why there should be a differential in wages between tertiary graduates with and without a PhD degree and why this difference could have changed during the last decade(s). Section 3 describes the data and the research method. Afterwards (4) we present the empirical results of our analysis. We finish with a discussion and further research perspectives in section 5.

Theoretical Framework

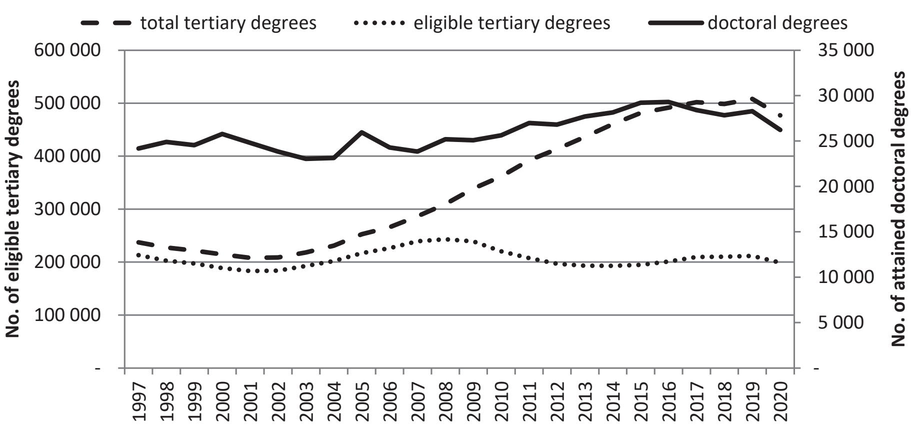
Human capital theory (HCT) postulates that (individual) differences in earnings are exclusively based on differences in marginal productivity (Becker 1962; Mincer 1958). According to this approach, productivity is a function of human capital (i.e., skills and knowledge). It is assumed that human capital itself is not invariable or determined but can be altered (increased) by either investment in education or through on-the-job training. To maximise lifetime profits, individuals voluntarily (if applicable) stay in the educational system (i.e., invest in their personal human capital stock) as long as the additional return exceeds the additional costs of education, and the foregone earnings due to lack of time while learning (opportunity costs). As doctoral degree holders spend more time in the higher educational system compared to graduates without a doctoral degree the former should accumulate more personal human capital which later is converted into higher wages. Thus, we conclude that:

> H1: Graduates with a doctoral degree receive higher wages compared to graduates without a doctoral degree.

However, the central topic of this paper is changes in earnings differential between graduates with and without doctoral degrees, due to changes in the labor market supply of graduates. Therefore, we need to look deeper into the assumption that individuals are always paid by marginal productivity. Being rooted in neoclassical labor market theory, HCT assumes that demand and supply of labor strive to be at equilibrium (Sesselmeier/Blauermel 1998). For this statement to be true, companies must be able to easily adjust their production to new labor supply (McGuinness 2006). Likewise, people are willing and able to adapt educational decision-making to expected returns to education. Hence – from a human capital point of view – it can be argued that changes in wage differentials between graduates with and without doctoral degrees should not be expected, as changes in labor supply would be balanced by either companies or individuals adjusting their decisions based on foreseeable labor market conditions.

Contrary to this, critics argue that in reality companies are not able to adjust production as swiftly as in theory. Instead, they are subject to complexity in work procedures, underlying path dependencies, and rigid institutional arrangements (McGuinness 2006). This argument is supported by the Job Competition Theory (JCT) which states that earnings depend on job characteristics and hence positions (Thurow 1979). Based on this, job positions require certain skills to be exercised. These requirements persist regardless of labor supply. As most work-relevant skills are acquired through training-on-the-job, applicants are selected by the employer according to the expected cost of training. Since these costs are not directly visible, companies utilize background characteristics (education, grades etc.) as a proxy and rank applicants accordingly – a mechanism that resembles the argumentation of signalling theory (Arrow 1973; Spence 1973). Those with the lowest anticipated training costs get the best paid jobs (Thurow 1979). From this perspective, a rising supply in PhD graduates might be accompanied by declining returns because doctoral degree holders increasingly compete for non-doctoral positions with lower wages. However, as this paper tackles wage differentials between graduates with and without doctoral degrees we must also take into account the labor market supply of non-PhD graduates. If supply of this group also exceeds demand, they will compete for less-well-ranked jobs with lower wages, too. Additionally, if PhD holders compete for non-doctoral positions they will oust non-PhD graduates from the best jobs, too.

Figure 1: Higher education expansion in Germany 1997–2020



Source: Statistisches Bundesamt 2022.

Note: Own depiction. Eligible tertiary degrees: Diploma, Magister, Master, State examination.

Therefore, in order to derive hypotheses on the evolution of the PhD-wage-benefit one has to examine the actual supply of tertiary degree holders with and without additional PhDs. As can be seen in figure 1, since its low point around the year

2001, the total number of tertiary degrees completed at German higher education institutions has been rising constantly. Only at the end, in 2020, do all graphs show a sharp drop which can most likely be attributed to the deterioration in study conditions and the delayed completion of exams due to the Covid pandemic.

However, most of the increase needs to be understood in light of the so-called Bologna Process and the transition from the traditional German one-tier system into a two-tier degree system with consecutive Bachelor's and Master's degrees (Bologna Declaration 1999). On the one hand a new group of graduates emerges, completing their studies and leaving the academic system with a Bachelor's degree. On the other hand, even those graduating with consecutive Master's degrees must first achieve a Bachelor's degree. As a result, graduates who previously would have studied a single traditional degree (Diploma, Magister, State examination) began to complete an equivalent Master's degree, building upon an additional previous degree (Bachelor). If we focus only on degrees that generally[4] qualify the holder to pursue doctoral studies (Diploma, Magister, State examination, Master) we can observe the fact that the number of degrees eligible for further doctoral studies has remained fairly constant. It climaxed in 2008 before levelling out to between 200,000 and 210,000 during the last decade. At the same time the number of PhDs attained at German higher education institutions has been rising from about 23,000 in 2003 to more than 29,000 in 2016 (figure 1). Consequently, the ratio of PhD holders compared to eligible graduates increased. Therefore, according to JCT we derive the following hypothesis:

> H2: The PhD wage premium declines for more recent cohorts due to a higher ratio of PhD degrees compared to degrees eligible to pursue a PhD.

A further theoretical strand putting a stronger focus on job characteristics to explain wage differentials is the so called task based approach (TBA) (Autor/Handel 2013). Contrary to JCT it assumes that employers are able to redesign production processes, especially in response to evolution of technology (Autor/Handel 2013). Its main perception lies in the idea of computerization leading to a shift in labor demand in favor of highly-qualified people and a rising polarisation of wages favoring higher education graduates (Autor/Handel 2013). The underlying mechanism is that (non-manual) routine tasks usually performed by less-well-educated employees have been substituted by computer programs while non-routine cognitive tasks performed by highly educated persons are complemented by computer technology making them more productive (Autor/Levy/Murnane 2003). At the same time demand for problem-solving, communication, and improving production (i.e., managing tasks) skills is enhanced (Autor/Levy/Murnane 2003). From this point of view rising wage differentials between groups with different levels of education are conceivable. But employing this argument for possible changes in wage differentials

4 Despite this general mechanism, there are other paths for pursuing a PhD such as fast-track PhD programs that require only a Bachelor's degree.

between graduates with and without PhD degrees assumes substantial differences in skill endowment between these groups. Arbeitskreis Deutscher Qualifikationsrahmen (2011) argues that the additional scientific knowledge and autonomy of attaining a PhD should strenghten the value of the PhD by pushing forward innovation compared to the previously more passive mode of studying a degree. A second argument in favor of PhD holders in this respect may be that this degree indicates managerial skills, as it requires students to carry out complex and tedious tasks while often balancing these with additional employment (Franck/Opitz 2007). Thus, we suggest that:

H3: The wage premium of PhD holders increases for recent cohorts (due to the rising importance of non-routine cognitive tasks and the productivity involved).

However, the ability or need to adapt to changes in labor market supply might differ between private- and public-sector employers, since in the private sector market forces (i.e., competition between companies for market share or customers) probably induce a stronger urge to change compared to public sector companies (Robertson/Seneviratne 1995). Following this reasoning we would expect mechanisms according to JCT be more pronounced in the public sector, while an explanation based on TBA should be more suitable for the private sector. Additionally, according to Doeringer (1967) the private and public sectors each employ different labor market mechanisms. While the public sector is more focused on credentials and objective requirements for job allocation, the private sector is more flexible and oriented at individual performance. Finally, workplaces in the public sector are often subject to tedious decision-making processes while the goal-setting in private companies can be adjusted swiftly.

Summing up, the discussion suggests following hypotheses concerning the evolution of wage differentials between higher education graduates – with and without PhD degrees – alongside higher education expansion in the public and private sectors. JCT assumes compensation according to job characteristics and a more rigid relation of labor demand and supply, allowing changes in wage differentials depending on actual relation on labor market (im)balances between the groups. Contrary to this, TBA suggests a rising demand for non-routine skills and productivity-enhancing technology for those skills and assumes that organisations adapt to technological change. The ability to adapt to changes in labor supply should depend on sector of employment (i.e., private vs. public). So TBA should be more appropriate for the private sector while JCT may paint a more accurate picture for the public sector. This leads to the following hypotheses:

H4: The wage premium of PhD holders between different labor market entry cohorts declines over time in the public sector (according to JCT and slow adaption).

H5: The PhD wage premium between different labor-market entry cohorts in the private sector increases over time (according to TBA and stronger adaption).

Data & Methods

Data

To answer our research question, we use data from the 1997, 2001, 2005, and 2009 cohorts of the DZHW Graduate Panel Study, a survey conducted by the German Centre for Higher Education Research and Science Studies (DZHW).[5] Since 1989, every four years a representative sample of graduates who attained an academic (tertiary) degree from a state-approved institution[6] of higher education in Germany in the respective academic year of the cohort (i.e., winter term 2008/2009 and summer term 2009 for the 2009 cohort) is drawn. Graduates are invited to participate in three surveys ("waves") about one, five, and ten years after graduation respectively. Originally, respondents were only comprised of graduates with the traditional degrees Diploma, Magister, and State examination. For the 2005 cohort an additional non-representative sample of graduates with a Bachelor's degree was deliberately drawn. Due to its deviating sampling procedure and limited representativeness this sample was excluded from our analysis. This ensures greater homogeneity between cohorts and improved comparability of respondents. The 2009 cohort consists of graduates with traditional degrees or Bachelor's degrees, with the latter predominantly having obtained a Master's degree by the time of the third survey (Autorengruppe Bildungsberichterstattung 2020: 196f.; Briedis/Klüver/Trommer 2016).

For our analysis we use data collected in the first (about one year after graduation) and third (about ten years after graduation) wave of each cohort. Data from the first wave includes non-time-dependent information such as the gender of the respondent, educational background of parents, and the final grade of the higher education entrance certificate. Time-dependent information such as the attainment of a PhD, current hourly wages, and professional experience were utilized from the third wave. The third survey was chosen as most graduates pursuing a PhD have finished studying at this point of time and graduates (with and without PhD) have generally had time to establish themselves on the labor market (Euler/Trennt/Trommer/Schaeper 2018).

Like most other (panel) data the DZHW-graduate panel studies suffer from item- and unit-nonresponse that might bias the results if it occurs non-randomly (Schnell/Hill/Esser 2013). In order to mitigate this problem we calculated panel attrition weights (Enders 2010) for the respective cohorts by following the procedure described in Baillet/Franken/Weber (2019). Additionally, we handled missing data by including them as separate categories except for our main independent variable (PhD state) and the dependent variable. We decided against multiple

5 The Stata do-file used for our analyses is available via the DZHW Research Data Centre: https://doi.org/10.21249/DZHW:euler2023:1.0.0

6 Some specialized institutions (Berufsakademien, Fern-, Bundeswehr- und Verwaltungsfachhochschulen) were not part of the population and hence not included in the sample.

imputation for dealing with missing data (Enders 2010; Schafer/Graham 2002) as the proportion of missing data[7] is quite low (table A1) and therefore should not be problematic concerning possible biased results (Bennett 2001; Schafer 1999). Apart from those two exceptions we performed complete case analysis. All in all, our pooled data comprises 33,469 observations (1997=9,583; 2001=8,122; 2005=10,160; 2009=5,604). Almost half of them (n=16,032) participated in the third wave (1997=5,471; 2001=4,734; 2005=3,760; 2009=2,067). Due to different wage-generating mechanisms (no employer for signalling etc.) we excluded graduates in self-employment from our analysis. We also dropped graduates with a degree in human or dental medicine. Within these subjects most graduates pursue a doctoral degree and this would therefore account for a substantial share of all PhDs in the sample. As a doctorate in these subjects usually differs significantly from those in other subjects (requirements, scope of work etc.), the PhDs would become not comparable[8]. Additionally, we excluded graduates from universities of applied sciences (UAS) as these institutions predominantly (especially for the older cohorts) do not have the right to award doctorates. Graduates with a degree from a university of applied sciences are usually unable to pursue a doctorate at their alma mater and face stricter requirements when applying for doctoral studies at another university. This substantial heterogeneity concerning the possible selection into a doctorate could potentially produce bias in the analysis. Therefore our models will only be based on graduates from universities (and equivalent), and will omit graduates in human or dental medicine. Finally, as we perform separate analyses for respondents employed in the private sector from those in the public sector, we also excluded observations with no information on work sector.

Excluding observations with missing values on our dependent (gross hourly wages) and main independent (PhD status) variable(s) leaves us with 8,312 observations (1997=3,042; 2001=2,447; 2005=1,584; 2009=1,239). They are distributed into 4,353 (1997=1,736; 2001=1,227; 2005=823; 2009=567) observations in the private sector and 3,959 (1997=1,306; 2001=1,220; 2005=761; 2009=672) in the public sector.

Dependent Variable

Our dependent variable is the natural logarithm of gross hourly earnings. To compensate for inflation between cohorts they were standardized against prices from 2010[9]. Gross hourly wages were calculated based on self-reported gross monthly earnings and actual working hours per week of the main employment. Using the

7 Note that table A1 (in the appendix) shows the proportion of missing data for the respective variables only for observations with information on the dependent variable. As the dependent variable shouldn't be imputed (Hippel 2016) we consider the amount of missing values conditional on non-missing values on the dependent variable as the decisive size.

8 In other countries a differentiation exists between medical doctorates (M.D.s in the U.S. system) and scientific doctorates (PhD).

9 Foreign currencies were converted into Euro according to their purchasing power.

natural logarithm approximates the skewed distribution to a normal distribution and thus helps to fulfill the assumption of ordinary least squares (OLS) regression (Sauer/Valet/Liebig 2016).

Independent Variable

Our main independent variable is the attainment of a PhD. It distinguishes between graduates having successfully finished their PhD studies (PhD holders) at the time of the third survey (within the cohort) and graduates without a PhD degree at that point in time (including ongoing, suspended, or discontinued PhD studies).

Control Variables[10]

Besides our central independent variable, several controls are included in our models. They serve two main purposes. First, they are included with respect to variables relevant for selection into a PhD degree course (Jaksztat 2014; Jaksztat/Lörz 2018) or its completion (Jaksztat/Neugebauer/Brandt 2021). Secondly, they represent factors relevant for wage determination (e.g., job experience). These variables can partially be found of importance for both. We included the following variables in our models: We control for gender (male, female), parental education according to the CASMIN-scheme (Brauns/Scherer/Steinmann 2003) aggregated into three categories (high[3a,3b], medium[1c,2b,2a,2c_gen,2c_voc], low[1a,1b]), parenthood (no, yes), final grade of the higher education entrance certificate standardized at the federal state level and aggregated by quartiles (higher values/quartiles indicate poorer performance and field of study (see table A1 for categories). Besides this we also consider labor market experience and labor market experience squared in years as proxy for human capital acquired on the job. This also accounts for slight differences in field time of the third waves, diverging times of respondents' graduation within the respective academic year, and phases within the ten-year timespan that weren't suitable for acquiring human capital (e.g., unemployment or parental leave). In the appendix, table A1 shows the unweighted distribution of our control variables as well as our dependent and independent variable by cohort and sector of employment. It can be seen, that while the ratio of graduates with and without a PhD is fairly stable between sectors and cohorts, other variables are subject to bigger differences. This applies especially for the gender ratio and the proportion of fields of study. While women are more likely to be found in the public sector, the private sector is more attractive for engineers, and graduates of linguistic and cultural studies comprise the largest group within the public sector.

10 Gender, parental education, field of study, and final grade in the higher education entrance certificate also entered the panel attrition model calculation for the attrition weight. The attrition model also includes the age (aggregated by quartiles) of the respondent.

Methods

Our main goal is to determine whether a PhD wage premium (i.e., wage differences between graduates with and without a doctoral degree) exists, and whether it differs depending on sector and/or cohort. For this aim we must ensure that the cohorts we are comparing are as equal as possible concerning characteristics that influence selection into a PhD degree and also determine the wages. In order to take these into account we rely on OLS regressions with log gross hourly wages as the dependent variable. We are aware that selection on unobservables might confound the relationship between a PhD degree and wages as well as possible differences in PhD wage premiums across cohorts. Accordingly, our results are at best interpreted as robust correlations rather than true causal effects. However, by including covariates like field of study or final grade in the higher education entrance certificate we are confident of capturing some of the most relevant unobservables such as aptitude, motivation, and interests.

We calculate individual cohort-specific models, an integrated model with pooled data and an interaction term between cohort and PhD state, and finally a three-way interaction model with an interaction term between cohort, PhD state, and sector. We estimate all models twice: without (a) and with (b) control variables. All models employ panel attrition weights and cluster[11] robust standard errors. Due to the logarithmic dependent variable, model coefficients are exponentiated to facilitate interpretation. As such, coefficients can be interpreted as changes of the gross hourly wage in percent if the respective variable changes (for example: PhD holders of the 1997 cohort earn 8.4 % more than graduates without a PhD; table 1, model b). Regression coefficients are reported for both the cohort-specific and the integrated model (tables 1 and 2 in the following section; tables A2-A5 in the appendix). For the three-way interaction model predictive margins and average marginal effects (AME) are presented (figures 3 and 4 in the following section).

Results

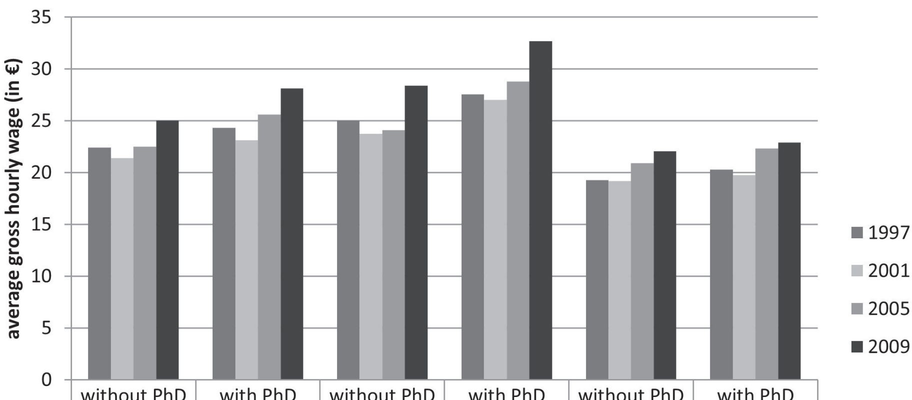
Beginning with a few descriptive findings on wage differences between higher education graduates with and without PhD degrees, figure 2 shows weighted gross hourly wages by cohort and sector of employment as well as across sectors (total). It can be seen that PhD holders – in accordance with hypothesis H1 – generally achieve higher gross hourly wages compared to graduates without PhD degrees. This wage premium persists across sector of employment and cohorts. For the public sector of the 1997 cohort, the difference in gross hourly wages is rather small

11 Clusters are determined by higher education institution and field of study and reflect the sampling design which in the first place drew a random sample of subjects at specific institutions (primary sampling units (PSU)) and then sampled all graduates within each PSU (secondary sampling units (SSU)). With the clusters we take unobserved heterogeneity between universities and between subjects within universities respectively into account.

at about €0.56. Employees in the private sector achieve higher wages than graduates working in the public domain. The average pay is generally higher in the private sector. As a result, despite having a wage premium within their respective sector, PhD holders in the public sector still earn less than graduates without a PhD in the private sector.

On the evolution of wage differentials between graduates with and without PhD degrees the overall trend shows several developments, especially considering that these numbers already account for inflation. First, gross hourly wages slightly decrease from the 1997 to the 2001 cohort in both sectors and also in total. This applies for graduates both with and without PhDs. Second, the average pay increases for the 2005 and 2009 cohorts. Again, this applies for graduates both with and without a PhD, in both sectors, and in total. Third, the increase in hourly wages is most profound for the 2009 cohort, rising about €2.51-€2.54. Comparing graduates with and without a PhD, PhD holders earn on average €1.75-€1.88 more than persons without a doctorate for the 1997 and 2001 cohort and on average €3.09 (€3.07-€3.10) per hour for the two more recent cohorts. Following our hypotheses, this trend opposes H2 but is in accordance with H3.

Figure 2: Average gross hourly wages of respondents by PhD status, sector, and year (in Euro)



	total		private sector		public sector	
	without PhD	with PhD	without PhD	with PhD	without PhD	with PhD
1997	22.41	24.29	25.01	27.55	19.27	20.30
2001	21.37	23.12	23.74	27.00	19.18	19.74
2005	22.49	25.59	24.11	28.76	20.88	22.31
2009	25.03	28.10	28.38	32.68	22.04	22.90

Source: DZHW graduate panel studies 1997, 2001, 2005, 2009.
Note: Own calculations. Weighted data. Wages standardized against prices from 2010.

Looking at sectors separately, we can examine these general trends (higher earnings for PhD holders, decrease for all in the 2001 cohort, increase for all in the more recent cohorts) in both sectors, too. Nevertheless, there are differences. First, there is a wage premium for the private sector. Private-sector graduates both with and without PhDs earn more than their respective counterparts in the public sector (€6.45-€9.78 with a PhD; €3.23-€6.34 without a PhD). This difference is high enough to even result in public-sector PhD holders still having a lower wage than private employees without a doctorate. Second, the overall increase in hourly wage is more profound in the private sector. In the 2009 cohort in the private sector, PhD holders earn €5.13 and graduates without a doctorate earn €3.37 more than their counterparts in the earlier 1997 cohort. For the public sector, this wage increase lies at only around €2.60 for PhD holders and €2.77 for graduates without a doctorate respectively. Third, within the sectors, the PhD wage premium varies. In the 2009 cohort, private PhD holders earn €4.30 more than graduates without a doctorate while the public PhD wage premium is only €0.86. As a result, hypothesis H4 should rejected and H5 supported.

Table 1: OLS regression of log hourly wages (across sectors; private sector; public sector) on PhD status (extracted from tables A2, A3, and A4).

	1997		2001		2005		2009	
	a	b	a	b	a	b	a	b
				Model across sectors				
PhD	1.094	1.084	1.080	1.058	1.132	1.088	1.126	1.098
	(0.024) ***	(0.019) ***	(0.026) **	(0.021) **	(0.029) ***	(0.027) ***	(0.039) ***	(0.046) *
N	3,042	3,042	2,447	2,447	1,584	1,584	1,239	1,239
				Model private sector only				
PhD	1.125	1.089	1.148	1.119	1.188	1.141	1.174	1.124
	(0.032) ***	(0.027) ***	(0.043) ***	(0.035) ***	(0.049) ***	(0.044) ***	(0.064) **	(0.061) *
N	1,736	1,736	1,227	1,227	823	823	567	567
				Model public sector only				
PhD	1.040	1.058	1.030	1.025	1.072	1.053	1.043	1.057
	(0.026)	(0.026) *	(0.023)	(0.025)	(0.028) **	(0.029)	(0.037)	(0.044)
N	1,306	1,306	1,220	1,220	761	761	672	672

Source: DZHW graduate panel studies 1997, 2001, 2005, 2009.

Note: Own calculations. Weighted data. Exponentiated coefficients. Standard errors in parentheses. Control variables not shown. a = without control variables; b = with control variables. * p<0.05, ** p<0.01, *** p<0.001.

This first descriptive view could be an indication against the oversupply argument of the JCT that predicts competition for jobs with lower earnings in the face of higher education expansion. Nevertheless, the overall economic situation and unobserved influences should also be considered. While the 2001 cohort was surveyed shortly after the global financial crisis, the 2009 cohort entered the labor market in a continuous phase of a positive economic climate and a growing lack of professionals. Additionally, the composition of respondents within cohorts, PhD status, and sectors could vary in attributes that are correlated with income.

To answer our hypotheses more specifically, we therefore focus on the results of the OLS regression models (table 1 depicting only the main independent variable, tables A2, A3, and A4 in the appendix depicting all variables). These are presented in two model specifications respectively: model specifications a) show the regression of log gross hourly wages on the attainment of a PhD degree without any control variables, and therefore reflect a basic model. Model specifications b) include the complete set of control variables. In the following, testing of the hypotheses will predominantly focus on the latter coefficients, as these present a more comprehensive picture.

Across sectors all cohorts show a highly significant wage effect of the attainment of a PhD. Depending on the cohort, PhD holders report between around eight and 13 percent higher wages than graduates without a PhD in model a). Including the control variables reduces the wage premium of PhD holders to between around six and ten percent respectively. All coefficients remain significant. By this account, our first hypothesis (H1) can be confirmed. PhD holders do indeed receive higher wages on average than graduates across both sectors without a PhD. Concerning hypotheses H2 and H3 a first glance indicates a rather inconclusive picture as the PhD wage premium across sectors remains between eight and ten percent for most cohorts.

Table 1 additionally shows the individual cohort-specific models by different sectors. As can be seen, the PhD wage premium in the private sector is higher than across sectors. In model a) it lies between twelve and 19 percent. When including control variables, it is slightly reduced to between nine and 14 percent. Overall, the PhD wage premiums in the private sector are significant for all cohorts and present higher coefficients compared to the results across sectors. In contrast to this, the public sector shows a different picture. Table 1 shows that there is only a significant PhD wage premium for model a) in the 2005 cohort and for model b) in the 1997 cohort. In all other cohorts PhD holders do not receive significantly higher wages compared to their peers without a doctoral degree. The coefficients are also much lower compared to the private sector. This seems to indicate that the relevance of a PhD for hourly wages in the public sphere is rather low. Beyond that, neither the private nor public sector present a conclusive trend of PhD wage premiums over time for hypotheses H4 and H5.

Briefly looking at the control variables we can examine some expected results (tables A2, A3, and A4 in the appendix). Respondents who studied fields like engineering, law, and mathematics/sciences receive significantly higher wages compared to former students of linguistic and cultural studies in the overall model (table A2). Graduates in the lower quartiles of the final school grade face a wage penalty; the same applies to women. Parenthood shows a positive coefficient concerning earnings. Additional years of job experience increases wages but only significantly for the first and last cohort (table A2). For the individual sectors (table A3 and A4) we mostly find similar results. Nevertheless, there are some differences. While grad-

Table 2: OLS regression of log hourly wages (pooled cohorts) with interaction term cohort and PhD status (extracted from table A5).

	cross sector		private sector		public sector	
	a	b	a	b	a	b
cohort (ref: 1997)						
2001	0.958	0.990	0.940	0.977	1.002	1.011
	(0.024)	(0.013)	(0.032)	(0.020)	(0.015)	(0.014)
2005	1.009	1.022	0.964	0.989	1.079	1.066
	(0.024)	(0.015)	(0.032)	(0.021)	(0.019) ***	(0.017) ***
2009	1.112	1.190	1.120	1.245	1.140	1.157
	(0.033) ***	(0.022) ***	(0.046) **	(0.034) ***	(0.023) ***	(0.022) ***
PhD	1.094	1.076	1.125	1.085	1.040	1.046
	(0.024) ***	(0.019) ***	(0.032) ***	(0.027) ***	(0.026)	(0.024)
cohort & PhD (ref: 1997 & PhD)						
	0.987	0.982	1.020	1.038	0.990	0.979
2001 & PhD	(0.032)	(0.024)	(0.048)	(0.037)	(0.034)	(0.030)
	1.035	1.004	1.056	1.045	1.032	1.006
2005 & PhD	(0.035)	(0.028)	(0.053)	(0.043)	(0.037)	(0.035)
	1.029	1.045	1.044	1.066	1.003	1.026
2009 & PhD	(0.042)	(0.037)	(0.064)	(0.048)	(0.044)	(0.043)
N	8,312	8,312	4,353	4,353	3,959	3,959
adj. R^2	0.035	0.254	0.046	0.336	0.040	0.122

Source: DZHW graduate panel studies 1997, 2001, 2005, 2009.

Note: Own calculations. Weighted data. Exponentiated coefficients. Standard errors in parentheses. Control variables not shown. a = without control variables; b = with control variables. * p<0.05, ** p<0.01, *** p<0.001.

uates of mathematics/sciences receive higher wages in the private sector compared to former students of linguistic and cultural studies, this does not hold true for the public sector. Additionally, engineers show a significant wage premium in the private sector while this premium is lower in the public sector and insignificant for the last two cohorts. Women have a significant disadvantage on income in the private sector, but not in the public sector; respondents profit continuously from parenthood in the public sector, while only for the 1997 cohort in the private sector. Finally, neither the final school grade nor job experience seems to be of relevance within the public sector. This supports the idea of a strong credentialism and unimportance of individual performance indicators within the labor-market mechanism of the public sector.

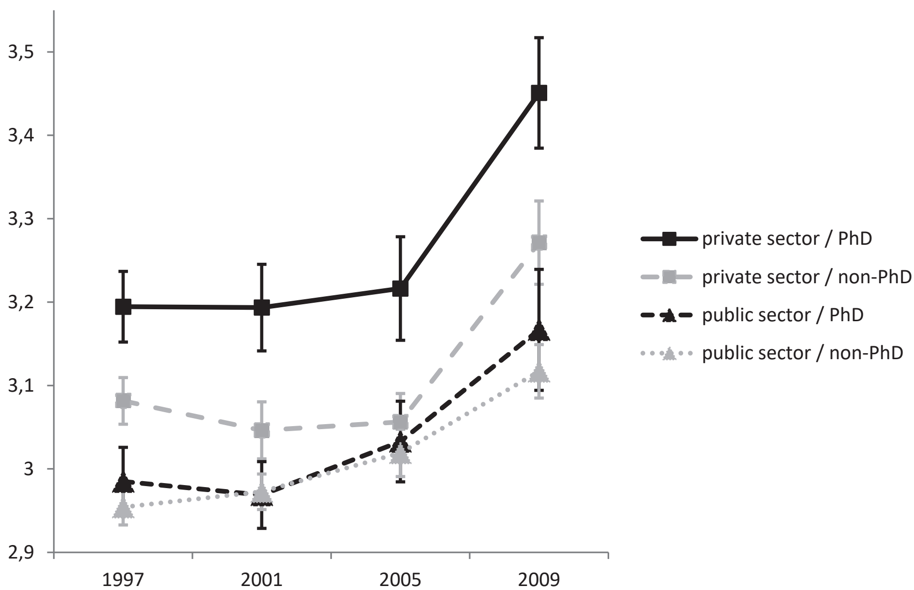
Following the individual cohort-specific models, analysis of the integrated model with pooled data and a modelled interaction of PhD state and cohort (1997 as base category) allows a longitudinal perspective on the potential PhD wage premium (table 2 depicting only the main independent variable, table A5 in the appendix depicting all variables). It also enables us to evaluate our hypotheses concerning trends over time. In the complete model, a constant PhD wage premium across sectors of around 7.6 percent can be found supporting hypothesis H1 (table 2). There is also a significant wage increase for the 2009 cohort compared to the 1997 cohort. For the integrated model more fields of study show relevant results on wage with social sciences, mathematics/sciences, health sciences, engineering, and law being associated with higher incomes and veterinary medicine and arts associated with lower earnings compared to linguistic and cultural studies (table A5). Final school grades, gender and parenthood generally show significant effects on income. Contrary to the individual cohort-specific models, job experience is a significant contributor to hourly wage overall and for both sectors (table A5).

Concerning our hypotheses on the evolution of the PhD wage premium irrespective of sector of employment (H2, H3) we detect a slight increase over time that is most pronounced in the last cohort (2001=-1.8 %; 2005=+0.4 %; 2009=+4.5 %). However, as all effects are not significant, we must reject both H2 (decrease of the PhD wage premium) and H3 (increase of the PhD wage premium). Thus, across sectors, a rising supply of PhD holders seems to be counterbalanced by an equally rising demand in the course of technological change, resulting in stable returns to PhD holders compared to graduates without PhD degrees. Because this stability might be due to contrasting developments in the private and public sector, we additionally run the analysis for each sector.

Comparing sectors, the PhD wage premium is higher and only significant for the private sector (8.5 %) while it is insignificant for the public sphere. Concerning cohorts, the 2009 cohort shows a significant increase in wages compared to the 1997 cohort (private=+24.5 %; public=+15.7 %). Additionally, this holds true for public employees of the 2001 cohort (+6.6 %). While PhD holders in the private sector experience a continuous increase in wage premiums (2001=+3.8 %; 2005=+4.5 %; 2009=+6.6 %) the evolution of the PhD wage effect in the public sector is inconclusive (2001=-2.1 %; 2005=+0.6 %; 2009=+2.6 %). As none of these results are significant, this can only be interpreted as a trend. Consequently, both hypotheses H4 and H5 must also be rejected. To sum it up, while the public sector experienced a general increase in wages, PhD holders do not profit additionally from their degree. In contrast to this, in the private sector no significant wage hike appears until recently, although private-sector PhD holders enjoy a significant advantage in remuneration when compared to private-sector workers without PhDs.

Finally, a three-way interaction model was conducted (table not reported). Based on the model, predictive margins were estimated for cohort, PhD status, and sector (figure 3). As can be seen, PhD holders in the private sector and non-PhD holders in the public sector experience a constant positive trend on average wages. In contrast, PhD holders in the public sector and non-PhD holders in the private sector show a slight decrease of wages between the 1997 and 2001 cohorts and a later positive development.

Figure 3: Predictive margins of log hourly wages of graduates separated by cohort, sector and PhD status (only model b)

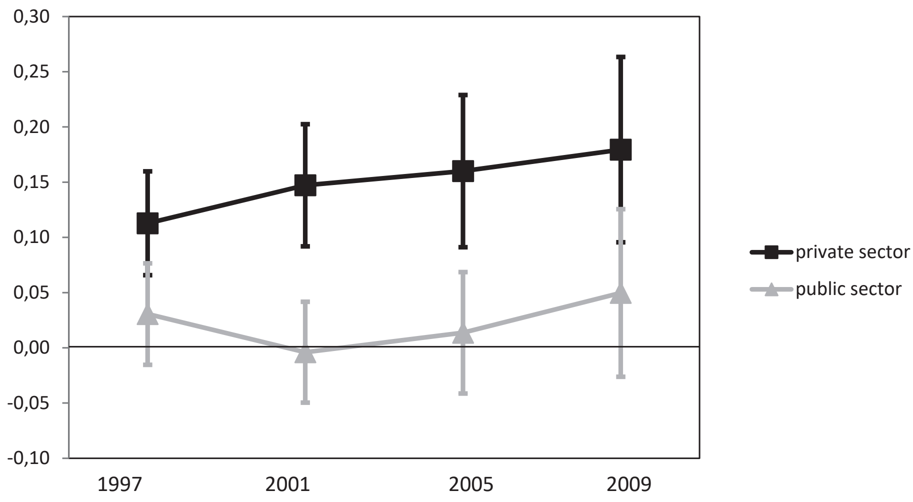


Source: DZHW graduate panel studies 1997, 2001, 2005, 2009
Note: Own calculations. 95 % confidence interval band.

Generally, employees in the private sector tend to receive higher hourly wages than their colleagues in the public sphere. For non-PhD holders this applies for the 1997, 2001, and 2009 cohorts where the average wage of private employees is significantly higher compared to public-sector workers. Meanwhile private PhD holders constantly earn significantly more than public PhD holders. For the 1997 and 2001 cohorts the latter even earn significantly less than graduates without a PhD in the private sector.

Focusing solely on the development of the PhD wage premium the average marginal effects in figure 4 show a continuous increase of the PhD wage premium for employees in the private sector from 11 percent for the 1997 cohort to 18 percent for the 2009 cohort. The wage premium is significant for all cohorts. In contrast the PhD wage premium for the public sector decreases heading into the 2001 cohort even resulting in a 0.4 percent lower hourly wage than publicly employed graduates without a PhD degree. For later cohorts the public PhD holder wage premium rises again but remains insignificant for all cohorts.

Figure 4: Difference in log hourly wages of PhD holders compared to non-PhD graduates by cohort and sector (only model b)



Source: DZHW graduate panel studies 1997, 2001, 2005, 2009.
Note: Own calculation. Baseline 0 = graduates without PhD. 95 % confidence interval band.

Additionally, we can see that PhD holders in the private sector earn significantly more in absolute terms than their counterparts in the public sector (figure 3). Considering relative terms within the sectors, private PhD holders also show a significantly higher PhD wage premium (relative to graduates without a doctoral degree in the private sector) than PhD holders in the public sector for the 2001 and

2005 cohorts (figure 4). This difference is insignificant for the oldest and youngest cohort.

Concerning our fourth and fifth hypotheses, figure 4 presents a slow widening of the wage gap (i.e., an increase of the wage premium) between graduates with and without a PhD in the private sector. PhD holders in the public sector between the 2001 and 2009 cohorts experience a slightly steeper wage increase compared to those without a PhD degree. While these changes over time present a trend for the trajectory of PhD wage premiums, these developments are all not significant between cohorts. As such our fourth and fifth hypotheses, which state that the wage premium of PhD holders should decrease in the public sector (H4) and increase in the private one (H5), must both be rejected for the more recent cohorts. Here again, the wage premiums remain rather stable over time. However, the overall positive wage development (figure 4) and at least the positive direction of the development in the private sector suggests that skill-biased technological change might be slightly more beneficial for PhD holders compared to graduates without PhD degrees.

Discussion & Outlook

The discourse on the expansion of higher education revolves around a growing demand for highly-skilled labor in a knowledge-based economy and concerns that the pace of expansion has gone too far resulting in an oversupply of graduates of higher education. As Germany lacks natural resources, innovation and a knowledge-based economy are crucial for future economic growth. Due to their prominent role in putting forward innovations, PhD holders receive particular attention in the public and scientific debate on the development of the quaternary sector. To encourage capable higher education graduates into pursuing a PhD degree, at least constant returns to a PhD degree are a prerequisite. Our analyses show that despite a growing number of PhD holders entering the labor market over the last decade relative returns in terms of wages have not declined. While we detect insignificant returns for those employed in the public sector, we see a constant PhD wage premium for doctoral degree holders in the private sector. Findings suggest that neither graduates of higher education with a PhD degree, nor those without, experience increasingly lower wages as supported by the oversupply argument. This indicates that growing supply has been accompanied by a growing demand for skills associated with a tertiary education that includes a PhD degree as well as one that does not. Possibly this has also been influenced by the overall positive economic situation during the last decade. Findings concerning the public sector are more vague. While wages for graduates with and without PhDs slowly increase, returns to a PhD degree mostly remain insignificant in the public sector.

Besides this we must take some limitations into account. Basically, our analytical strategy is based on a causal approach. In order to identify a causal effect of a

PhD degree on wages as well as a causal effect of cohort (i.e., higher education expansion) on PhD wage premium change we must first rule out that (changing) returns are due to personal characteristics that influence both the selection into a PhD degree and also earnings. We are confident that our set of control variables captures the most relevant confounders. However, as selection on unobservables is always difficult to rule out with observational data we consider our results at best to be robust correlations rather than true causal effects. As an alternative to the attrition weight that we are using, the models have also been calculated employing entropy balancing[12] to account for possible selection effects. No fundamental divergence of results could be found. Besides this, our interaction model relies on the assumption that the effects of all covariates except for PhD state do not differ across cohorts. Allowing all covariates to interact with cohort would result once again in separate models. Another limitation concerns the sectoral aggregation; as a doctoral degree is mandatory for a scientific career at universities or publicly-funded research institutes it might be beneficial to divide the public sector into academic and non-academic employment. Unfortunately, our data does not permit the identification of people engaged in research activities at universities or research institutes. Further research with alternative data could address this issue. Although we covered quite a broad period of time (12 years) with substantial expansion of higher education in Germany (in terms of PhD holders and also graduates without a doctoral degree) an extension to cohorts before 1997 would be beneficial. Additionally, the necessity to incorporate a broad period of time following graduation – to account for the time to finish a PhD and enter the labor market – prevented us from using more recent cohorts of graduates. These are nevertheless of special interest as this paper had to focus on the PhD wage premium between PhD holders and graduates with traditional degrees. These results could have differed for graduates fully incorporated into the Bologna process and the transformation of the German higher education system.

Nevertheless, our analyses provide a sustainable insight into the development of wages for German higher education graduates in the early 21st century. It furthermore presents robust results supporting a wage premium for PhD holders compared to non PhDholders. This advantage on incomes can be found in the private sector and to a lesser extent in the public sector. For the former, an increase over time can be observed. Whether these effects are generally true for the sectors overall or only apply in particular circumstances (e.g., certain branches, region, etc.) must be evaluated in future research.

12 This is a matching approach that balances treatment and control group by reweighting the control group so that the mean, variance and skewness of covariates is the same in both groups (Hainmüller 2012).

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Appendix

Table A1: Distribution and means of variables by cohort and sector of employment (in %)

	1997		2001		2005		2009	
	private	public	private	public	private	public	private	public
hourly wage[a] (€)	25.5	19.3	23.8	19.0	24.7	21.1	21.8	21.8
log hourly wage[a]	3.2	2.9	3.1	2.9	3.1	3.0	3.2	3.0
PhD status								
no PhD	81.5	82.1	78.6	77.0	77.2	76.2	77.2	82.0
PhD	18.5	17.9	21.4	23.0	22.8	23.8	22.8	18.0
field of study								
linguistic/ cultural studies	10.6	40.3	14.6	44.7	14.5	44.5	20.3	46.7
sport	0.3	2.6	0.6	1.3	0.5	1.3	0.2	1.3
social sciences	2.9	4.4	5.4	6.9	7.2	9.7	7.9	10.7
math./sciences	27.8	21.7	30.8	21.5	25.2	19.2	28.6	19.8
health sciences	0.0	0.0	0.0	0.0	0.0	0.5	0.4	0.9
vet. med.	2.0	2.0	1.4	1.7	3.6	2.5	3.0	1.5
agri-, forest-, nutrion studies	1.8	1.5	4.0	2.3	4.4	1.4	3.4	1.8
engineering	21.6	6.0	22.2	8.0	20.9	6.8	12.3	2.5
arts	1.0	5.5	1.2	3.9	1.8	3.3	1.9	3.1
law	6.4	8.0	4.3	5.2	4.0	5.9	4.8	6.0
economics	25.5	8.1	15.5	4.4	18.0	4.7	17.3	5.7
final school grade								
1st quartile	29.7	26.7	33.3	30.2	34.6	31.8	32.1	30.7
2nd qartile	24.9	24.1	26.1	26.1	26.1	26.8	26.5	23.5
3rd quartile	22.9	22.5	22.2	22.8	20.7	21.2	23.1	23.2
4th quartile	17.2	21.9	17.0	19.0	17.7	18.9	17.6	21.7
missing	5.3	4.7	1.4	1.9	0.9	1.3	0.7	0.9
gender								
male	64.6	39.1	46.9	30.5	49.2	32.5	42.0	28.9
female	35.0	60.9	53.1	69.5	50.8	67.5	58.0	71.1
missing	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
parenthood								
no	42.0	38.0	43.0	37.8	35.5	37.1	40.7	35.7
yes	57.8	61.9	57.0	62.1	64.0	62.7	58.4	63.4
missing	0.2	0.2	0.0	0.1	0.5	0.3	0.9	0.9
parental education								
low	0.8	0.8	0.9	0.7	1.2	1.2	2.1	1.9
medium	29.6	30.8	27.5	25.9	38.3	37.1	35.6	38.2
high	68.4	67.2	70.9	73.0	60.1	61.0	61.2	57.7
missing	1.2	1.2	0.7	0.4	0.4	0.8	1.1	2.1
experience[a] (years)	9.6	9.1	9.3	9.0	9.8	9.6	8.5	8.5
experience squared[a]	93.6	85.9	88.9	82.9	97.4	94.6	75.2	74.9
N	1,736	1,306	1,227	1,220	823	761	567	672

Source: DZHW graduate panel studies 1997, 2001, 2005, 2009.

Note: Own calculations. Unweighted data. a = continous variable; mean.

Table A2: OLS regression of log hourly wages (across sectors)

	1997		2001		2005		2009	
	a	b	a	b	a	b	a	b
PhD	1.094	1.084	1.080	1.058	1.132	1.088	1.126	1.098
	(0.024) ***	(0.019) ***	(0.026) **	(0.021) **	(0.029) ***	(0.027) ***	(0.039) ***	(0.046) *
field of study (ref.: linguistic/cultural studies)								
sport	—	0.998	—	0.999	—	1.004	—	1.085
		(0.036)		(0.074)		(0.104)		(0.088)
social sciences	—	1.066	—	1.090 **	—	1.000	—	1.086
		(0.035)		(0.036)		(0.031)		(0.046)
math./ sciences	—	1.121	—	1.120	—	1.081	—	1.194
		(0.024) ***		(0.027) ***		(0.031) **		(0.059) ***
vet. med.	—	0.900	—	0.890	—	0.875	—	0.946
		(0.020) ***		(0.019) ***		(0.054) *		(0.033)
health sciences	—	—	—	—	—	1.098	—	1.224
						(0.041) *		(0.039) ***
agri-, forest-, nutrion studies	—	0.990	—	1.060	—	0.975	—	1.137
		(0.038)		(0.052)		(0.077)		(0.070) *
engineering	—	1.211	—	1.189	—	1.156	—	1.321
		(0.048) ***		(0.043) ***		(0.044) ***		(0.066) ***
arts	—	0.962	—	0.967	—	0.894	—	0.946
		(0.045)		(0.053)		(0.047) *		(0.058)
law	—	1.161	—	1.116	—	1.172	—	1.271
		(0.042) ***		(0.036) ***		(0.043) ***		(0.051) ***
economics	—	0.998	—	0.999	—	1.004	—	1.085
		(0.036)		(0.074)		(0.104)		(0.088)
final school grade (ref.: 1st quartile)								
2nd quartile	—	0.969	—	0.963	—	0.947	—	0.963
		(0.016)		(0.019)		(0.022) *		(0.031)
3rd quartile	—	0.944	—	0.933	—	0.925	—	0.936
		(0.016) ***		(0.018) ***		(0.024) **		(0.031) *
4th quartile	—	0.926	—	0.929	—	0.922	—	0.949
		(0.016) ***		(0.019) ***		(0.026) **		(0.030)

	1997		2001		2005		2009	
	a	b	a	b	a	b	a	b
missing	—	0.805 (0.032) ***	—	0.946 (0.059)	—	0.955 (0.044)	—	0.896 (0.117)
gender (ref.: male)								
female	—	0.920 (0.013) ***	—	0.908 (0.016) ***	—	0.932 (0.020) ***	—	0.886 (0.023) ***
missing	—	1.018 (0.151)	—	—	—	—	—	—
parenthood (ref.: no)								
yes	—	1.068 (0.014) ***	—	1.051 (0.016) **	—	1.063 (0.021) **	—	1.052 (0.026) *
missing	—	0.926 (0.070)	—	2.297 (0.055) ***	—	1.422 (0.240) *	—	1.183 (0.190)
parental education (ref.: low)								
medium	—	1.046 (0.125)	—	1.065 (0.083)	—	0.846 (0.064) *	—	1.068 (0.077)
high	—	1.039 (0.123)	—	1.110 (0.088)	—	0.843 (0.064) *	—	1.099 (0.081)
missing	—	1.085 (0.143)	—	1.208 (0.131)	—	0.883 (0.119)	—	1.026 (0.093)
experience (years)	—	1.140 (0.053) **	—	1.080 (0.048)	—	1.066 (0.045)	—	1.126 (0.050) **
experience squared	—	0.996 (0.003)	—	0.999 (0.003)	—	1.000 (0.003)	—	0.996 (0.003)
N	3,042	3,042	2,447	2,447	1,584	1,584	1,239	1,239
adj. R^2	0.008	0.268	0.007	0.231	0.020	0.219	0.014	0.233

Source: DZHW graduate panel studies 1997, 2001, 2005, 2009.

Note: Own calculations. Weighted data. Exponentiated coefficients. Standard errors in parentheses. * p<0.05, ** p<0.01, *** p<0.001.

Table A3: OLS regression of log hourly wages (private sector)

	1997		2001		2005		2009	
	a	b	a	b	a	b	a	b
PhD	1.125	1.089	1.148	1.119	1.188	1.141	1.174	1.124
	(0.032) ***	(0.027) ***	(0.043) ***	(0.035) ***	(0.049) ***	(0.044) ***	(0.064) **	(0.061) *
field of study (ref.: linguistic/cultural studies)								
sport	—	0.966	—	0.906	—	0.756	—	0.947
		(0.097)		(0.072)		(0.070) **		(0.071)
social sciences	—	1.162	—	1.194	—	0.948	—	1.120
		(0.067) *		(0.094) *		(0.059)		(0.091)
math./ sciences	—	1.223	—	1.202	—	1.125	—	1.284
		(0.047) ***		(0.057) ***		(0.054) *		(0.107) **
vet. med.	—	0.910	—	0.816	—	0.743	—	0.847
		(0.060)		(0.039) ***		(0.068) **		(0.057) *
health sciences	—	—	—	—	—	—	—	1.537
								(0.098) ***
agri-, forest-, nutrion studies	—	1.052	—	1.064	—	0.991	—	1.091
		(0.070)		(0.077)		(0.104)		(0.079)
engineering	—	1.226	—	1.204	—	1.175	—	1.290
		(0.062) ***		(0.067) ***		(0.067) **		(0.098) ***
arts	—	0.942	—	0.785	—	0.931	—	0.820
		(0.075)		(0.097) *		(0.095)		(0.059) **
law	—	1.213	—	1.193	—	1.278	—	1.441
		(0.074) **		(0.087) *		(0.090) ***		(0.113) ***
economics	—	0.966	—	0.906	—	0.756	—	0.947
		(0.097)		(0.072)		(0.070) **		(0.071)
final school grade (ref.: 1st quartile)								
2nd quartile	—	0.972	—	0.948	—	0.937	—	0.981
		(0.024)		(0.024) *		(0.029) *		(0.045)
3rd quartile	—	0.922	—	0.900	—	0.892	—	0.936
		(0.022) ***		(0.028) ***		(0.031) **		(0.042)
4th quartile	—	0.906	—	0.861	—	0.871	—	0.921
		(0.023) ***		(0.031) ***		(0.040) **		(0.039)

	1997		2001		2005		2009	
	a	b	a	b	a	b	a	b
missing	—	0.763 (0.041) ***	—	1.067 (0.105)	—	0.945 (0.058)	—	0.920 (0.126)
gender (ref.: male)								
female	—	0.911 (0.019) ***	—	0.870 (0.025) ***	—	0.913 (0.027) **	—	0.843 (0.034) ***
missing	—	0.942 (0.154)	—	—	—	—	—	—
parenthood (ref.: no)								
yes	—	1.049 (0.018) **	—	1.041 (0.023)	—	1.048 (0.031)	—	1.056 (0.034)
missing	—	0.943 (0.071)	—	—	—	1.148 (0.105)	—	1.050 (0.192)
parental education (ref.: low)								
medium	—	1.161 (0.212)	—	1.059 (0.058)	—	0.801 (0.093)	—	1.275 (0.126) *
high	—	1.159 (0.211)	—	1.102 (0.061)	—	0.809 (0.092)	—	1.315 (0.130) **
missing	—	1.289 (0.258)	—	1.228 (0.179)	—	0.726 (0.140)	—	1.258 (0.161)
eperience (years)	—	1.213 (0.081) **	—	1.128 (0.078)	—	1.101 (0.087)	—	1.153 (0.083) *
experience squared	—	0.993 (0.004)	—	0.997 (0.004)	—	0.999 (0.005)	—	0.996 (0.005)
N	1,736	1,736	1,227	1,227	823	823	567	567
adj. R^2	0.013	0.296	0.016	0.318	0.032	0.338	0.023	0.347

Source: DZHW graduate panel studies 1997, 2001, 2005, 2009.

Note: Own calculations. Weighted data. Exponentiated coefficients. Standard errors in parentheses. * p<0.05, ** p<0.01, *** p<0.001.

Table A4: OLS regression of log hourly wages (public sector)

	1997		2001		2005		2009	
	a	b	a	b	a	b	a	b
PhD	1.040	1.058	1.030	1.025	1.072	1.053	1.043	1.057
	(0.026)	(0.026)*	(0.023)	(0.025)	(0.028)**	(0.029)	(0.037)	(0.044)
field of study (ref.: linguistic/cultural studies)								
sport	—	1.016	—	1.046	—	1.087	—	1.146
		(0.049)		(0.096)		(0.108)		(0.112)
social sciences	—	1.001	—	1.048	—	1.066	—	1.059
		(0.043)		(0.030)		(0.039)		(0.056)
math./ sci-ences	—	0.988	—	1.024	—	1.000	—	1.027
		(0.020)		(0.027)		(0.035)		(0.042)
vet. med.	—	0.926	—	0.962	—	1.111	—	1.102
		(0.055)		(0.021)		(0.080)		(0.138)
health sci-ences	—	—	—	—	—	1.187	—	1.166
						(0.052)***		(0.132)
agri-, forest-, nutrion studies	—	0.913	—	1.080	—	0.923	—	1.138
		(0.039)*		(0.085)		(0.090)		(0.101)
engineering	—	1.105	—	1.117	—	1.058	—	1.177
		(0.043)*		(0.036)***		(0.044)		(0.125)
arts	—	0.978	—	1.088	—	0.880	—	1.015
		(0.043)		(0.052)		(0.066)		(0.078)
law	—	1.119	—	1.085	—	1.121	—	1.142
		(0.030)***		(0.036)*		(0.033)***		(0.057)**
economics	—	1.016	—	1.046	—	1.087	—	1.146
		(0.049)		(0.096)		(0.108)		(0.112)
final school grade (ref.: 1st quartile)								
2nd quartile	—	0.968	—	0.985	—	0.983	—	0.929*
		(0.022)		(0.025)		(0.030)		(0.033)
3rd quartile	—	0.967	—	0.959	—	0.984	—	0.935
		(0.024)		(0.023)		(0.033)		(0.034)
4th quartile	—	0.959	—	1.011	—	0.997	—	0.971
		(0.023)		(0.025)		(0.030)		(0.037)

	1997		2001		2005		2009	
	a	b	a	b	a	b	a	b
missing	—	0.864	—	0.843	—	1.080	—	0.878
		(0.042) **		(0.048) **		(0.060)		(0.124)
gender (ref.: male)								
female	—	0.970	—	0.967	—	0.985	—	0.961
		(0.017)		(0.018)		(0.022)		(0.030)
parenthood (ref.: no)								
yes	—	1.096	—	1.056	—	1.076	—	1.067
		(0.019) ***		(0.019) **		(0.025) **		(0.030) *
missing	—	0.808	—	2.290	—	2.271	—	1.229
		(0.024) ***		(0.061) ***		(1.229)		(0.164)
parental education (ref.: low)								
medium	—	0.929	—	1.093	—	1.027	—	0.889
		(0.081)		(0.159)		(0.041)		(0.062)
high	—	0.907	—	1.135	—	1.004	—	0.896
		(0.079)		(0.167)		(0.036)		(0.063)
missing	—	0.898	—	1.146	—	1.160	—	0.836
		(0.096)		(0.213)		(0.152)		(0.079)
experience (years)	—	1.074	—	1.060	—	1.048	—	1.078
		(0.049)		(0.055)		(0.043)		(0.067)
experience squared	—	0.999	—	0.999	—	0.999	—	0.997
		(0.003)		(0.003)		(0.002)		(0.004)
N	1,306	1,306	1,220	1,220	761	761	672	672
adj. R^2	0.002	0.130	0.001	0.089	0.008	0.075	0.001	0.071

Source: DZHW graduate panel studies 1997, 2001, 2005, 2009.

Note: Own calculations. Weighted data. Exponentiated coefficients. Standard errors in parentheses. * p<0.05, ** p<0.01, *** p<0.001.

Table A5: OLS regression of log hourly wages (pooled cohorts) with interaction term cohort and PhD status

	cross sector		private sector		public sector	
	a	b	a	b	a	b
cohort (ref: 1997)						
2001	0.958 (0.024)	0.990 (0.013)	0.940 (0.032)	0.977 (0.020)	1.002 (0.015)	1.011 (0.014)
2005	1.009 (0.024)	1.022 (0.015)	0.964 (0.032)	0.989 (0.021)	1.079 (0.019) ***	1.066 (0.017) ***
2009	1.112 (0.033) ***	1.190 (0.022) ***	1.120 (0.046) **	1.245 (0.034) ***	1.140 (0.023) ***	1.157 (0.022) ***
PhD	1.094 (0.024) ***	1.076 (0.019) ***	1.125 (0.032) ***	1.085 (0.027) ***	1.040 (0.026)	1.046 (0.024)
cohort & PhD (ref: 1997 & PhD)						
2001 & PhD	0.987 (0.032)	0.982 (0.024)	1.020 (0.048)	1.038 (0.037)	0.990 (0.034)	0.979 (0.030)
2005 & PhD	1.035 (0.035)	1.004 (0.028)	1.056 (0.053)	1.045 (0.043)	1.032 (0.037)	1.006 (0.035)
2009 & PhD	1.029 (0.042)	1.045 (0.037)	1.044 (0.064)	1.066 (0.048)	1.003 (0.044)	1.026 (0.043)
field of study (ref.: linguistic/cultural studies)						
sport	—	1.023 (0.037)	—	0.892 (0.047) *	—	1.068 (0.044)
social sciences	—	1.057 (0.020) **	—	1.092 (0.040) *	—	1.046 (0.023) *
math./sciences	—	1.132 (0.019) ***	—	1.214 (0.035) ***	—	1.010 (0.016)
health sciences	—	1.182 (0.034) ***	—	1.514 (0.050) ***	—	1.162 (0.061) **
vet. med.	—	0.903 (0.020) ***	—	0.832 (0.040) ***	—	1.012 (0.044)
agri-, forest-, nutrion studies	—	1.040 (0.031)	—	1.052 (0.044)	—	1.013 (0.041)
engineering	—	1.213 (0.026) ***	—	1.220 (0.036) ***	—	1.105 (0.028) ***
arts	—	0.944 (0.025) *	—	0.873 (0.048) *	—	0.988 (0.031)
law	—	1.178 (0.024) ***	—	1.275 (0.047) ***	—	1.116 (0.021) ***

	cross sector		private sector		public sector	
	a	b	a	b	a	b
economics	—	1.023 (0.037)	—	0.892 (0.047) *	—	1.068 (0.044)
final school grade (ref.: 1st quartile)						
2nd quartile	—	0.960 (0.011) ***	—	0.961 (0.016) *	—	0.965 (0.014) *
3rd quartile	—	0.936 (0.011) ***	—	0.915 (0.016) ***	—	0.960 (0.014) **
4th quartile	—	0.932 (0.011) ***	—	0.891 (0.016) ***	—	0.984 (0.015)
missing	—	0.855 (0.026) ***	—	0.828 (0.036) ***	—	0.895 (0.031) **
gender (ref.: male)						
female	—	0.909 (0.009) ***	—	0.882 (0.014) ***	—	0.967 (0.011) **
missing	—	1.045 (0.150)	—	0.958 (0.147)	—	—
parenthood (ref.: no)						
yes	—	1.057 (0.010) ***	—	1.049 (0.013) ***	—	1.074 (0.012) ***
missing	—	1.213 (0.129)	—	1.057 (0.094)	—	1.370 (0.232)
parental education (ref.: low)						
medium	—	1.005 (0.047)	—	1.095 (0.081)	—	0.948 (0.042)
high	—	1.018 (0.048)	—	1.116 (0.083)	—	0.948 (0.042)
missing	—	1.021 (0.060)	—	1.173 (0.110)	—	0.935 (0.062)
experience (years)	—	1.102 (0.025) ***	—	1.149 (0.042) ***	—	1.058 (0.028) *
experience squared	—	0.998 (0.001)	—	0.996 (0.002)	—	0.999 (0.002)
N	8,312	8,312	4,353	4,353	3,959	3,959
adj. R^2	0.035	0.254	0.046	0.336	0.040	0.122

Source: DZHW graduate panel studies 1997, 2001, 2005, 2009.

Note: Own calculations. Weighted data. Exponentiated coefficients. Standard errors in parentheses. * p<0.05, ** p<0.01, *** p<0.001.

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Are Employment Trajectories of STEM Doctoral Degree Holders Gender-Specific?

Evidence from a Large German Technical University[*****]

Abstract: Gender balance across different employment sectors is beneficial in order for society to make the best use of its talent pool. However, particularly in the STEM (science, technology, engineering and mathematics) fields, women are underrepresented as researchers and professors in universities and non-university research organizations in Germany. To better understand the career trajectories of doctoral degree holders, we investigate the critical phase of transition into the post-graduation employment context. Based on rich process-generated data for a large German technical university, we explore the relationship of employment sector and employment volume during and after doctoral training. Results of a sequence analysis indicate that the employment trajectories of men and women follow similar patterns, but that the prevalence of individual sequences differs substantially by gender. Our findings suggest substantial path dependence in employment biographies. Regression results show no overall gender-specific difference regarding the post-graduation employment sector when controlling for previous sector-specific work experience and STEM subfields. However, when distinguishing between men, women without children and women with children (mothers), we observe that mothers are more likely to remain in the university sector compared to men. In the years following doctorate completion, both women without children, and women with children are significantly less often full-time employed than are men.

Keywords: Doctoral degree holders; employment biographies; sector mobility; gender differences; motherhood.

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Sind die Erwerbsverläufe von Promovierten aus den MINT-Fächern geschlechtsspezifisch?

Empirische Analyse am Beispiel einer großen deutschen technischen Universität

Zusammenfassung: Um den vorhandenen Talentpool optimal zu nutzen, profitiert die Gesellschaft von einem ausgewogenen Geschlechterverhältnis in den verschiedenen Beschäftigungssektoren. Allerdings sind in Deutschland insbesondere in den MINT-Bereichen (Mathematik, Informatik, Naturwissenschaften, Technik) Frauen als Forscherinnen und Professorinnen an Universitäten sowie außeruniversitären Forschungseinrichtungen unterrepräsentiert. Um die Karrierewege von Promovierten besser zu verstehen, untersuchen wir die kritische Übergangsphase nach der Promotion. Auf der Grundlage umfangreicher prozessgenerierter Daten für eine große deutsche technische Universität untersuchen wir den Zusammenhang zwischen Beschäftigungssektor und Beschäftigungsvolumen während und nach der Promotion. Die Ergebnisse einer Sequenzanalyse deuten darauf hin, dass die Beschäftigungsverläufe von Männern und Frauen ähnlichen Mustern folgen, sich die Prävalenz einzelner Sequenzmuster allerdings deutlich nach Geschlecht unterscheidet. Unsere Ergebnisse deuten auf eine erhebliche Pfadabhängigkeit in den Erwerbsbiografien hin. Die Regressionsergebnisse zeigen keine geschlechtsspezifischen Unterschiede in Bezug auf die Sektorenwahl nach der Promotion, wenn man sektorspezifische Berufserfahrung und Fächerunterschiede berücksichtigt. Wenn wir jedoch zwischen Männern, Frauen ohne Kinder und Frauen mit Kindern (Müttern) unterscheiden, stellen wir fest, dass Frauen mit Kindern im Vergleich zu Männern eher im Hochschulsektor bleiben. Sowohl Frauen ohne Kinder als auch Frauen mit Kindern sind in den Jahren nach Abschluss der Promotion deutlich seltener vollzeitbeschäftigt als Männer.

Stichworte: Promovierte; Erwerbsbiografien; Sektorenmobilität; Geschlechtsunterschiede; Mutterschaft

1. Introduction

In order to make the best use of an economy's pool of talent, and to achieve gender equity as well as to secure innovative solutions for diverse societal problems (see e.g., Tannenbaum et al. 2019, Schiebinger et al. 2011–2021), gender balance in employment across different sectors is beneficial for society. However, STEM (science, technology, engineering, and mathematics) disciplines are often characterized by substantial gender imbalances, e.g., regarding the professorate at German universities (BuWiN 2021). To devise effective policies, it is vital to understand what mechanisms and circumstances can lead to gender-specific differences in observable labor market outcomes such as employment sector and employment volume.

One of the most critical junctures in the careers of doctoral degree holders (DDHs for short) is the phase of transition, after doctoral training, into post-graduation employment. On the one hand, doctoral training may be the initial step of pursuing an academic career. On the other hand, doctoral training can be put to a variety of uses in the labor market. In particular Germany has a long tradition of DDHs being employed in private-sector research and development (R&D), as well as in high-level managerial and administrative positions. Compared to education in the humanities and the social sciences, which primarily provide generic skills, education in STEM fields prepares graduates for entering occupation-specific segments of the labor market (e.g., van Klein 2011).

We use rich data for TU Berlin to explore potential gender-specific patterns in the career trajectories of more than 1,800 STEM DDHs covering a 10-year period starting five years before doctorate completion and running up to five years afterwards. Our dataset was built by refining record linkage techniques developed by Heinisch et al. (2020) while linking administrative information provided by TU Berlin with the Integrated Employment Biographies (IEB) dataset of the Institute for Employment Research (IAB). It covers more than 80 % of the respective TU Berlin graduation cohorts for whom we have detailed data on employment sectors —university, non-university research or other sectors—and also employment volume for the whole period. To control for potential effects of motherhood driving gender differences, we build on Müller/Strauch (2017) to trace women with children in the IEB. Our single-university setting allows us to avoid confounding heterogeneity stemming from variation in university and regional characteristics (as Lee et al. 2010; Jiang 2021).

In our empirical analysis we first employ sequence analyses (Abbott/Tsay 2000) separately for female and male DDHs to detect different clusters of career trajectories, and second we use multivariate regression analyses focusing on the relevance of employment sector (Bornmann/Enders 2004; Bloch et al. 2015) and employment volume during doctoral training for post-graduation employment, given sector-specific acquired work experience. We expect that the employment context during doctoral training shapes job-relevant knowledge acquisition, access to networks, and researcher identity formation processes, that are plausibly connected to career decisions. To investigate potential gender effects, we control for field-specific differences (Cheryan et al. 2017; Eren 2021; Schwerter/Ilg 2021)[1] and motherhood (e.g., van Anders 2004; Schubert/Engelage 2010; Koenig et al. 2021).

1 On the national level, in 2018 women accounted for 42 % of all doctoral students in science and mathematics, compared to 21 % in engineering (BuWiN 2021).

Results of the sequence analysis indicate that employment trajectories can be grouped in quite similar clusters for male and female DDHs. However, the prevalence of these clusters differs substantially by gender, in part reflecting an uneven representation of men and women in STEM subfields. Our findings are moreover suggestive of path dependence in employment biographies, as employment contexts during doctoral training predict post-graduation careers. Regression results indicate that both female DDHs with and without children are significantly less often full-time employed than men. Still, with more than 34 percentage points four years after graduation, the reduction in the full-time employment share of women with children is about four times as sizeable as the one estimated for women without children. Women with children, but not those without, are significantly more likely to remain in the university sector.

Our contribution to the literature is threefold. First, we trace similarities and differences between men and women in the evolution of employment sectors and employment volume over a 10-year period centered around the phase of doctorate completion, a critical juncture for (research) careers (Shauman 2017; Cañibano et al. 2019). To the best of our knowledge, we provide the first gender-specific sequence analyses for DDHs in the STEM fields. Second, we show how employment context during doctoral training relates to post-graduation employment outcomes. This apparent path dependence suggests that addressing gender differences might require balancing employment conditions as early as at the doctoral training stage. Third, we show that process-generated data can be employed to trace the employment trajectories of more than 80 % of the respective DDHs population. This corresponds to an improvement of about 30 percentage points over prior work using a similar approach (Heinisch et al. 2020), which is made feasible by access to university records.

2. Related literature

The transition phase from doctoral training into subsequent employment is decisive for DDHs' career pathways. In Germany, the majority of DDHs leave the university system directly after graduation or in the following few years (Koenig et al. 2021). Especially STEM DDHs have attractive career options in industry (Goldan et al. 2022), but opportunities vary between STEM subfields. While DDHs in engineering traditionally have favorable job prospects in manufacturing, in chemistry a doctorate is required as prerequisite for obtaining any adequate position at all—irrespective of the sector.

What factors shape the transition phase, i.e., continuation or changes in employment sector and/or employment volume after doctorate completion? An extensive body of literature shows that individual preferences (e.g., a "taste for science"; cf. Roach/Sauermann 2010; Noppeney et al. 2021), guidance from doctoral advisors and other mentors (e.g., Cidlinská 2019; Olson et al. 2021) and (perceived) career opportunities under current labor market conditions (e.g., Kinoshita et al. 2020) influence these individual career decisions. There is also some evidence that acquiring work experience in different sectoral employment contexts during doctoral training is associated with these transition patterns (e.g., Denton et al. 2019). Working experience allows DDHs to gain access to career-relevant knowledge and establish social contacts in the workplace (Weiss et al. 2014), and employment contexts during doctoral training also shape researcher identity formation processes.

In our study, we aim to examine the relationship between the employment context during doctoral training and post-graduation employment in STEM DDHs' careers. We focus on the roles of gender and motherhood for this transition phase. To frame our analysis and to conjecture upon potential underlying mechanisms at work, we point out related theories and elicit evidence from prior research, although we do not have detailed data on all potentially relevant factors in the empirical part of this paper. We highlight factors related to the employment context for DDHs' career decisions and illustrate the relevance of employers' hiring decisions to elicit both sides of the labor market. Furthermore, we consider the embeddedness of the overall labor market in the broader structural and cultural context of Germany with respect to parenthood among DDHs.

DDHs' decisions

Regarding employment sector, the university sector is the most common sector of employment during doctoral training, while significantly fewer doctoral students at this stage hold a position in non-university research organizations or in other sectors. Doctoral students obtain work experience, which enables them to acquire job-relevant knowledge, build social contacts and create networks opening new career opportunities. Employers and colleagues likewise may provide useful information on job vacancies for job search (Granovetter 1973; Lent et al. 1994; 2000; Weiss et al. 2014). Goldan et al. (2022) propose that doctoral students may benefit from sector-specific information and networks for their careers while employed at university, thereby enhancing the likelihood for subsequent employment in the same sector. The authors stress that doctoral students working in research organizations and other sectors may have similar advantages in their sectors. In addition, vicarious learning from role models, based on personal interactions with mentors, peers, and colleagues, as pointed out by social-cognitive theory (Bandura 1986), contributes to the emergence of vocational interests, goals, and career decisions. As these personal interactions are embedded in a sectoral context during the doctorate, they may reinforce sectoral persistence in post-graduation employment. Prior research confirms that integration into the respective scientific community via social contacts and network access is important for increasing DDHs' propensity for remaining employed in either the university or the non-university research sector following graduation (Jungbauer-Gans/Gross 2016; Jaksztat et al. 2017; Langfeldt/Mischau 2018).

Employment volume[2] differences within the same sector and discipline[3] may also impact knowledge acquisition and network access. Weiss/Klein (2011) and Robert/Saar (2012) highlight that the type of job might be important for the quality of acquired knowledge and contacts while working. If employment volume differences translate into different tasks e.g., within the academic sectors, or differences in teaching activities or embeddedness in administrative processes in the respective institution, this entails factual differences in the type of accumulated work experience. Despite substantial variation in idiosyncratic arrangements with advisors, prior evidence nonetheless indicates that tasks performed during doctoral training are shaped by employment volume. For Germany, full-time employed doctoral candidates within the National Academic Panel Study (Nacaps 2020) report having less time to work on their dissertation projects compared to their part-time employed peers.[4] Additional teaching tasks imply less time for research and may delay completion of the doctorate (Maher et al. 2004). At the same time, being employed full-time at the university is shown to be related to a stronger sense of belonging (Ryan et al. 2019) to the respective community, thus indicating more reliable contacts which may motivate DDHs to remain in the same sector.

Sense of belonging is a key factor in developing a solid self-conception as being a researcher (Caza et al. 2018; Eren 2021)—a researcher identity. Being a 'proper' STEM scientist is often associated with publications in prestigious journals, a strong h-index, international experience, high success rate in grant competitions (Cidlinská 2019), and accordingly requires extreme personal commitment. An individual's identity, as argued by identity theory, depends on the external roles the individual holds and on related expectations (Caza et al. 2018). Identities are internal, comprising internalized meanings, perceptions and expectations associated with the roles held by the individual (Gaunt/Scott 2017). In line with numerous studies proposing that identity is socially constructed (Castelló et al. 2021), we consider identity formation during doctoral training (Bentley et al. 2019) as an ongoing process embedded in organizational structures and shaped by personal experiences and social interactions with mentors, peers, and others. Regarding female DDHs, researcher identity formation processes can be hampered by masculine culture in the workplace and by gender stereotyping, as well as by role conflicts (most prominently related to parenthood; later in this section) (e.g., Cheryan et al. 2017; Master/Meltzoff 2020; Cidlinská et al. 2022).

2 In our sample for the analysis (see section 3), the percentage of female DDHs with a full-time (part-time) position one year before graduation is 31.5 (37.9) and remarkably lower compared to the corresponding share for their male peers with 55.1 (24.7).

3 Moreover, the recommendations of the *Deutsche Forschungsgemeinschaft* (DFG) regarding adequate payment of doctoral candidates varies among STEM subfields (https://www.dfg.de/formulare/55_02/55_02_de.pdf; last access 13 Oct 2022).

4 Own calculations based on the SUF (doi: 10.21249/DZHW:nac2018:1.0.0).

Employer decisions

Employers' preferences for job candidates of a certain gender might contribute to an increased likelihood that female and male STEM DDHs are concentrated in distinct labor market segments (employment sectors and types) following the achievement. The dominant economic approaches of taste-based discrimination (Becker 1957) and statistical discrimination (Arrow 1973; Phelps 1972) explain gender bias in recruiting with, respectively, subjective (dis)likings or the formation of expectations based on objective (e.g., sex, age, education, work-experience, parenthood) and subjective elements, to mitigate imperfect information about the relative productivity of the candidate. Employers' expectations regarding average gender differences thus translate into tendencies to discriminate. But according to critics of these approaches, this occurs regardless of time and social context (Keuschnigg/Wolbring 2016). Yet, recent literature stresses the role of the specific organizational context in which such discrimination evolves (e.g., Reskin 2003). Bertogg et al. (2020) show that discrimination is highly contextual on different levels (e.g., recruiter, firm, country) and depends on occupational characteristics, especially varying degrees of gender stereotyping associated with specific STEM occupations (Yavorsky 2019). In line with this, Kübler et al. (2018) find that discrimination against women is most pronounced in male-dominated STEM occupations.

From a sociological perspective, Ridgeway's (1997, 2011) theoretical work suggests that the assessment of an applicant's productivity is based on (implicit) gender status beliefs which often ascribe a higher social status to men such that they are believed to perform better and to deserve higher rewards (e.g., Rashotte/Webster 2005). Despite modern norms of gender equity, these beliefs have proven to be quite persistent. Unintentional recruiting bias, with men being perceived to have stronger competences, is corroborated by studies for STEM both in the private sector (e.g., Hill et al. 2010) and in the academic sector (e.g., Moss-Racusin et al. 2013). Recruiting practices of STEM faculty members were found to be implicitly biased when looking for new lab managers (Moss-Racusin et al. 2012), and scientific papers were shown to be evaluated as having higher quality when attributed to a male author (Knobloch-Westerwick et al. 2013).

Gender-specific parental roles in Germany

Overall, the individual career decisions of DDHs as well as employers' hiring practices are embedded in larger structural and cultural contexts (Nielsen 2017; Cañibano et al. 2019; McAlpine et al. 2021). External limiting factors such as insufficient childcare infrastructure, inflexible working hours and gender-specific parental roles (Schubert/Engelage 2011; Jaksztat et al. 2012) among others can contribute to gender-specific labor market outcomes among parents, especially regarding employment volume. Regarding sector choice, female DDHs with children, who seek part-time positions, may end up in different types of jobs than their male peers, as not all jobs are available for reduced employment volumes (Shauman 2017).

Not every woman has children before or directly after doctorate completion (Buenstorf et al. forthcoming), and both, mothers and fathers, need family-friendly environments. However, compared to their male peers, female DDHs are typically more challenged to integrate their roles of being both a researcher and a mother or being both a researcher and a woman in childbearing age with or without childbearing preferences (Schubert/Engelage 2010; Bentley et al. 2019; Cidlinská et al. 2022). Universities do not address parenthood in a gender-neutral way, but primarily consider supporting mothers via childcare provision (Bomert/Leinfellner 2017). This does not affect the academic working culture and/or induce any change to re-define the existing working culture in general (e.g., Nielsen 2017; Miner et al. 2018). An academic career is a prime example of a job with a culture of long hours, which also entails traveling and mobility requirements, putting stress on dual-career couples in general and even more so on parents (Grönlund 2020; Czerney et al. 2020). Even within STEM fields in academia, mothers are more likely to interrupt their employment and/or reduce working hours than are fathers (Langfeldt/Mischau 2018).

The considerations above guide our empirical analysis and help us form expectations regarding empirical patterns. We first expect a substantial degree of sectoral path dependence in DDHs' post-graduation choice of employment sectors due to prior access to sector-specific knowledge and networks as well as employers' attempts to reduce uncertainty regarding the fit of the potential new employee. Second, we expect that female researchers are less likely to remain in the academic sector if they were exposed to a male-dominated environment during doctoral training, hampering the development of a solid researcher identity. As female shares vary substantially across STEM subfields, e.g., electrical engineering versus bio-/food technology, we control for these discipline-specific effects. Third, we expect that female DDHs with children are more likely to be part-time employed. Role conflict is present regardless of the employment sector but given the highly competitive post-doctoral phase in pursuing an academic career, we would expect a shift towards the other sectors for many mothers in line with the 'leaky pipeline' phenomenon (e.g., Nielsen 2017). Those women remaining successfully in academia despite motherhood are more positively selected compared to their male peers (Kim/Moser 2022). We therefore differentiate between women with and without children (mothers). Neither fathers nor childless women who intend to become pregnant soon can be identified in our data.

3. Data and analytical strategy

3.1 Data and construction of the sample

For our analysis of STEM DDHs career trajectories, we employ the TU Berlin Panel of PhD graduates (TUBPP). TUBPP is an original dataset that links process-based information on doctoral holders from TU Berlin with the Integrated Employment Biographies (IEB) of the Institute for Employment Research (IAB). The linked dataset allows us to trace the entire employment biography of the respective individuals, including all spells available in German social security records before, during and after doctoral training. In this regard, TUBPP is similar to IIPED (IAB INCHER Panel of Earned Doctorates) which covers DDHs from all German universities (Heinisch et al. 2020). IIPED links the IEB with information about dissertations and their authors from the online catalog of the German National Library (Deutsche Nationalbibliothek). As it is based on richer administrative data, TUBPP is superior to IIPED in terms of the share of DDHs that could be matched to IEB entries.

With about 35,000 students in winter term 2020/21 (Destatis 2021) and about 400 PhD graduates in 2020 (Bartsch 2022), TU Berlin is one of the largest of Germany's technical universities, which traditionally have focused on STEM subjects and tend to be more open to university-industry collaboration than other research universities. TU Berlin is a member of TU9, a network of the nine leading technical universities in Germany. Presumably, potential doctoral students in STEM fields compare TU Berlin primarily with these other leading technical universities when choosing an adequate university. Since all TU9 are located in thick urban labor markets, STEM DDHs face rather similar conditions for their subsequent careers after completing their doctoral degrees. Hence, selection of doctoral students among TU Berlin and the other universities within the agglomeration of Berlin appears to be of less concern. However, from the perspective of our study, TU Berlin provides a particularly interesting empirical context as Berlin has the highest female share in STEM-related occupations of all German states (*Länder)*: 21.3 % compared to 15.7 % in Bavaria or 13.5 % in North Rhine-Westphalia, where comparable universities such as TU Munich, RWTH Aachen and TU Dortmund are located (Anger et al. 2021).

We obtained administrative data covering all 9,094 DDHs who obtained their doctoral degree from TU Berlin in the years 2000 to 2020. The data encompasses individual information (e.g., date of birth, gender, nationality) as well as information on doctoral training such as subject, date of certification, final grade, and duration of doctoral training.[5] We linked this dataset to the Integrated Employment Biographies (IEB) of the Institute for Employment Research (IAB), which is based

5 As information on the duration of the doctorate is only available for approx. 73 % of the DDHs of the TUB, we do not use this information in the analyses.

on employers' social insurance reports and process-generated data from the Federal Employment Agency.

The IEB data goes back to 1975 (1993 for Eastern Germany). They contain detailed information on the employment histories of all employed individuals subject to social insurance, as well as on the marginally employed (i.e., people with temporary and occasional part-time jobs with a limited number of working hours, which are subject to specific regulations in terms of taxation and social insurance payments), benefit recipients, jobseekers, unemployed individuals, and participants in active labor market policy programs. In the IEB, daily information is available on the start and end dates of the 'spells in employment' histories (e.g., employment/unemployment phases, participation in measures). The IEB data additionally comprise a set of individual characteristics (e.g., gender, nationality) for every worker, as well as job characteristics (e.g., type of employment, occupation, industry affiliation, region of workplace) (Antoni et al. 2019). The IEB cover about 80 % of the labor force in Germany (employment abroad is not captured). Self-employed individuals, civil servants, and doctoral students exclusively financed by scholarships (without compulsory social insurance) are not contained in the data. Self-employment is widespread among graduates in medicine, law, and business disciplines. In our STEM data, self-employment is of lesser relevance, except for smaller STEM subfields such as construction and planning. Note also that founders of research-oriented university spin-offs often remain in the social security system, in this case they are included in the IEB. One might be concerned regarding the exclusion of civil servants because most university professors in Germany are civil servants. However, as only a small share of DDHs holds (junior) professorships within the timeframe of our analysis (up to five years after completion of doctoral training) (GWK 2020), this data limitation appears of minor relevance for our study. The same applies to lectureships (*Akademische Räte*), which are (mostly permanent) positions with civil servant status. Moreover, no new positions of this type have been established at TU Berlin since 2000.

To combine the TU Berlin data with the IEB, we performed a systematic record linkage using a set of individual identifiers (e.g., first- and lastname, date of birth, sex, nationality).[6] These identifiers are available in both underlying datasets. Out of the 9,094 DDHs included in the TU Berlin data, 84.5 % could be successfully matched to the IEB. For graduates with multiple corresponding entries in the IEB, we additionally checked for university employment spells in Berlin prior to doctorate completion. While matching quotas of male and female DDHs are rather similar (85.4 % and 82.6 % respectively), the considerably lower percentage for DDHs

6 The Data and Information Management Department of the IAB conducted the record linkage ensuring social data protection. This department only keeps the confidential data used (e.g., name) for this linkage method. Researchers do not have any access. The TUBPP comprises an anonymized system-independent individual identifier for each DDH, which is only accessible on secured data machines at IAB.

with a foreign citizenship (68.5 %) probably indicates their greater propensity to exit the German labor market (due to return migration).

For our empirical analysis, we use data on STEM graduates who obtained their doctoral degrees from 2004 to 2013. The cohorts 2000–2003 are excluded due to missing birthdate information for a significant proportion of DDHs implying considerably lower matching quotas.[7] To achieve a more homogeneous sample, we imposed the following criteria: Inclusion of individuals older than 20 and younger than 40 years at graduation. Most DDHs who complete their doctoral training within this age range go on to subsequent early career stages (BuWiN 2021). Moreover, we exclude DDHs with fewer than two recorded spells in the IEB. The final sample includes 2,513 individuals, of whom 607 (24.2 %) are female and the remaining 1,906 (75.8 %) are male. More than two-thirds (69.8 %) of the included DDHs graduated in engineering (including computer sciences); DDHs from the sciences (including mathematics) account for 30.2 % of the sample. The share of female graduates varies noticeably across the individual engineering fields: from 9.5 % in electrical engineering to 48.8 % in bio- and food technology. For computer sciences, the female share is 14.6 %. The overall share of women in the sciences is 28.9 %, with food chemistry having the highest share (66 %) and physics the lowest share (17.5 %) of female DDHs. Overall, the shares of women are very similar to the shares for Germany in the same period (DZHW 2022; Table A-1).

3.2 Analytical strategy[8]

In the first part of our empirical analysis, we employ sequence analyses to detect typical career paths during and after doctoral training separately for male and female DDHs. A sequence analysis first performs a distance analysis across all sequences and then a cluster analysis of these distances. Technically, distance measurement employs an optimal matching procedure of the different sequences (Abbott/Tsay 2000; Lesnard 2014). The subsequent cluster analysis of these distance measures is based on Ward's algorithm minimizing the within-cluster variance (Ward 1963). Since there are no established reference values for clustering, the number of clusters in this study is determined by sufficient case numbers and the analytical power of the identified groups (Brzinsky-Fay 2007). We define ten possible employment states a DDH may have. In doing so, we differentiate between three sectors of employment: 'university' refers to jobs at regular universities and universities of applied sciences, 'research' encompasses employment in non-univer-

7 For earlier cohorts, the matching quota ranges from 68.6 % (2003) to 74.5 % (2001) while on average this share amounts to 85.6 % for the cohorts 2004 to 2013. These matching quotas refer to all DDHs at the TU Berlin.

8 The Stata do-file used for our analyses is available via the DZHW Research Data Centre: https://doi.org/10.21249/DZHW:bartsch2023:1.0.0

sity public and private research organizations[9], whereas 'other sectors' include the private sector[10] and the non-academic public sector. The first six states correspond to full- and part-time employment in one of these three sectors respectively. Three additional states are 'marginal' employment, vocational training, and unemployment/job search. Finally, an individual may not have been listed in the IEB at a given point in time, or no further spell information may be available for them. This indicates that the respective person is neither unemployed nor employed, thus being not subject to social insurance.

In the second part of our study, we apply regression analysis to investigate the effects of work experience obtained within a specific employment context during doctoral training on post-graduation employment patterns as well as potential gender-specific effects controlling for STEM subfields and motherhood. Here, we concentrate on DDHs' labor market outcomes two (t+2) and four (t+4) years after obtaining the doctorate. While we rely on the entire sample (N=2,513) in the sequence analysis, including missing information, we excluded DDHs with missing information regarding their employment states for the regression analysis. The IEB data do not comprise information on marital status and household composition. Müller/Strauch (2017) developed a workaround to deduce birth information for children based on social security notifications if women interrupt their employment for maternity leave. We follow their approach adjusting this procedure slightly to our specific dataset to calculate the expected date of birth if a woman (aged up to 37 years) leaves the labor market for at least 14 weeks (duration of German maternity protection period, Mutterschutzgesetz) before re-entering. We impose a one-year period between two births. Overall, the number of children is slightly underestimated as multiple births are counted as only one child and as births can only be detected during employment subject to social security contributions. To date it is not possible to reliably deduce fatherhood information based on the IEB data, as by far not all fathers take parental leave in Germany.

Using this procedure, we identify those female DDHs who have not had children by the fifth year after doctorate completion, which constitutes the end of our observation period. Likewise, we differentiate female DDHs who become mothers within two, and respectively four years of graduation (women with children in t+2; women with children in t+4). Of all 422 female DDHs in the sample used for the regression analysis on full-time employment, 22.0 % are women with children in (t+2) and 34.7 % are women with children in (t+4) indicating many birth events

9 We subsume in the employment sector 'research' all employers assigned to research activities in the NACE (Rev.2)-Classification of Economic Activities (codes 72.110, 72.190, 72.200). Non-university public research organizations comprise, for instance, research institutes of the Helmholtz Association and Max Planck Society, which conduct research activities including basic and applied research as well as support for industrial development. Private research organizations mainly provide research infrastructure and support to industrial development.

10 However, we cannot identify in-house research activities of private sector firms.

happening in the very first years after doctorate completion.[11] As our main contextual explanatory variables for employment context during doctoral training we include both prior work experience in the employment sectors 'university', 'research' and 'other sectors' as well as acquired work experience in full-/part-time or marginal employment positions. Work experience is operationalized by adding up the days of all respective employment episodes. While differentiating employment sectors, we cumulate all spells in full-/part-time or marginal employment in the respective sector. For work experience in full-time, part-time, and marginal employment positions we vice versa cumulate days in jobs with the respective employment volume across sectors. Furthermore, an indicator variable denotes all DDHs who completed vocational training before having completed their doctoral degree as this may be relevant for later employers, signaling earlier work experiences in a specific industry. In addition to these main explanatory variables, we incorporate age (at graduation date) which employers might use for anticipation-building regarding potential child-related employment interruptions or reductions, foreign citizenship as proxy for potential language issues if a DDH obtained the doctorate within a solely English-speaking work environment, and data-matching quality (an indicator variable denoting whether the IEB contained more than one potential entry to which the DDHs could have been merged) as further control variables (see Table A-4 for variable definitions).

4. Typical career patterns of female and male STEM DDHs

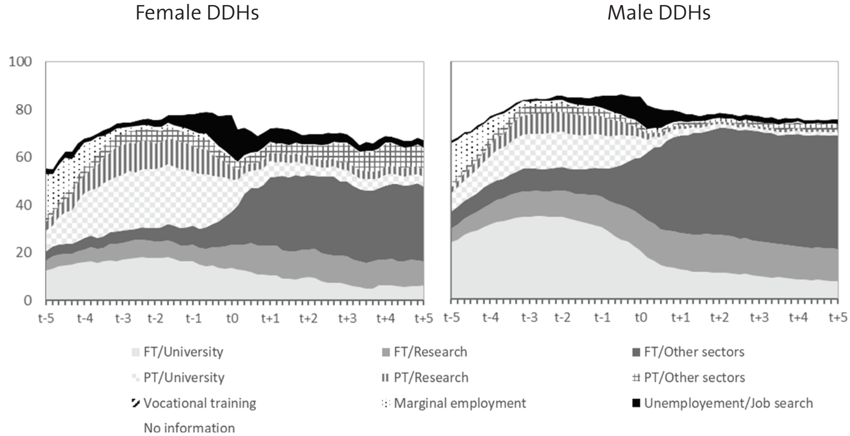
We use a sequence analysis (Abbott/Tsay 2000) to identify typical career trajectories of female and male STEM DDHs in the five-year periods during/after doctoral training. These five-year periods were mainly chosen due to an administrative regulation that TU Berlin adopted in 1992.[12] It states that doctoral and postdoctoral researchers paid from the university's own budget may only be employed full-time and for a period of five years. In 2008, the provision was adjusted to allow part-time and shorter contracts under certain conditions. As this regulation does not apply to third-party funded positions, we nonetheless observe part-time employment in our sample. We center the sequence analysis on the date of graduation, t0, and map employment states bimonthly. We identified eight typical career patterns (clusters) separately for male and female DDHs.

Figure 1 shows the overall distribution of female and male DDHs across the possible states in the five-year period before and after the date of graduation (observation point t0), and Figure 2 shows this by gender for the respective clusters. The average duration (in months) in one of the states is reported in Table A-2

11 The corresponding shares of mothers among female DDHs for the regression analyses on employment sector are 22.0 % in (t+2) and 35.3 % in (t+4).

12 Our choice of five-year periods before and after completing the doctorate implies that observed career trajectories are not directly affected by the time limits defined by the *Wissenschaftszeitvertragsgesetz*.

Figure 1: Overall distribution of STEM DDHs across ten potential labor market states, in percent



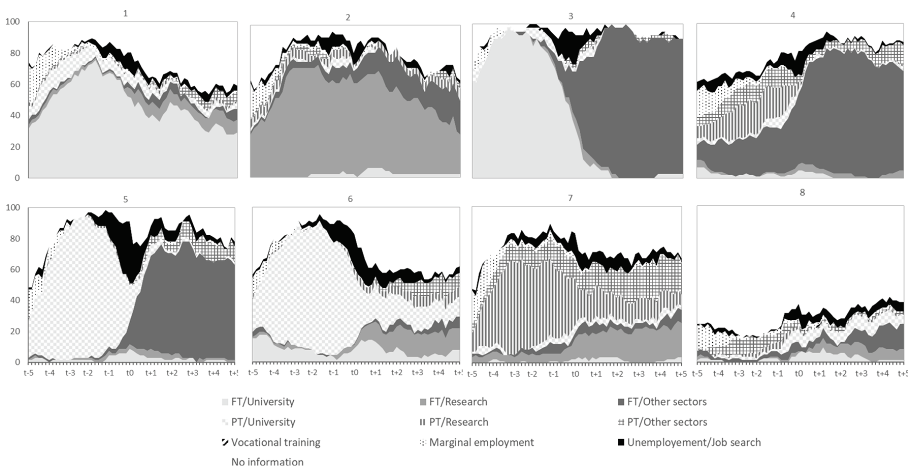
Note: FT denotes full-time employment; PT denotes part-time employment. t0: date of graduation. t-1/t+1: point of observation one year before/after graduation.
Source: TUBPP.

and the characteristics of the clusters in Table A-3. In line with extant evidence (Bloch et al. 2015; BuWiN 2021), unemployment is of minor importance for DDHs in our dataset. During the five years before (after) graduation, they are on average unemployed for 1.9 (2.1) months. Yet, the greatest average length with 16.0 months is full-time university employment during doctoral training, which can be explained by the aforementioned administrative regulation that TU Berlin adopted in 1992.

Before and after graduation, female DDHs are full-time-employed for less time than their male peers. This difference in employment volume is statistically significant for other sectors and also for university. During doctoral training, women work on average 9.5 months in full-time jobs at university, but men work considerably longer with 18.3 months. Conversely, female DDHs work significantly longer part-time at university than do men in this period (12.0 versus 7.5 months). This discrepancy is also true for the other two sectors before doctorate completion. Regarding employment sector, we do not find substantial differences between male and female DDHs, but a difference between pre- and post-graduation with a greater relevance of longer employment episodes in other (non-academic) sectors after graduation. For unemployment and marginal employment, we only observe a significant difference for the latter employment status after doctoral training.

Employing the sequence analysis separately for men and women allows us to identify both similarities and disparities in the career trajectories of men and women. The first four sequence patterns in Figure 2 are very similar for women and men. Cluster 1 depicts typical university careers with a high share of full-time employment at university before and after doctoral training. Cluster 2 mainly shows full-time careers in non-university research organizations. Cluster 3 includes career pathways that start from full-time university employment during doctoral training, followed by post-graduation employment in other sectors. Cluster 4 also illustrates similar career paths for both female and male DDHs. It shows predominant full-time employment outside university and research after graduation, but mixed employment patterns and a higher share of part-time employment during doctoral training. In this cluster, we find a particularly high share of graduates from bio- and food technology, the subject with the highest share of women in the sample (Table A-3).

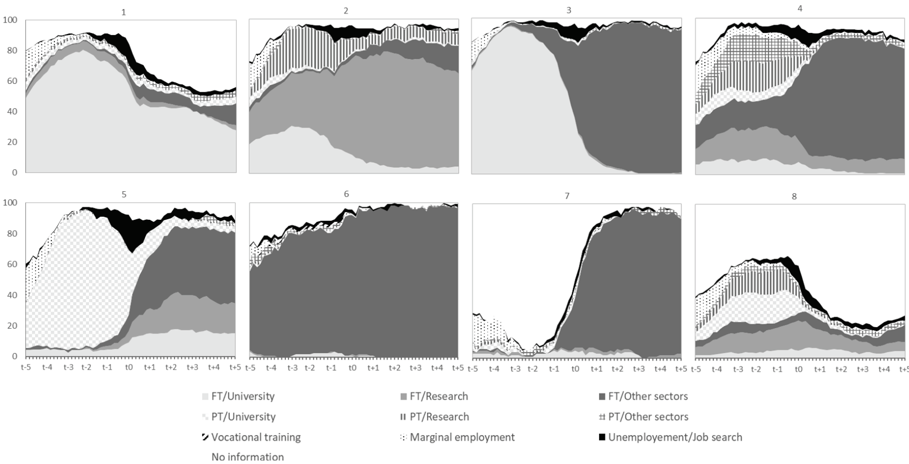
Figure 2: Typical career patterns of female STEM DDHs, distribution of all persons in the cluster across the possible states, in percent



Note: FT denotes full-time employment; PT denotes part-time employment. t0: date of graduation. t-1/t+1: point of observation one year before/after graduation.
Source: TUBPP.

Between them, Clusters 1–4 cover 46 % of the women and 61 % of the men in the sample. Cluster 3, with a change from university to other sectors after the doctorate is by far the 'biggest' cluster for men (and the 'smallest' for women). Cluster 4, which includes part-time and rather mixed employment during doctoral training as compared to the other three clusters, is the biggest cluster for female DDHs. In Clusters 1–3, full-time employment is predominant before and after graduation. Regarding subjects, we find average to high shares of engineers in all three clusters, with the highest share of them in Cluster 3 and especially high shares of computer scientists (Clusters 1 and 3), electrical engineering (Cluster 2), and mechanical

Figure 3: Typical career patterns of male STEM DDHs, distribution of all persons in the cluster across the possible states, in percent



Note: FT denotes full-time employment; PT denotes part-time employment. t0: date of graduation. t-1/t+1: point of observation one year before/after graduation.
Source: TUBPP.

engineering (Cluster 3). Considering that women are underrepresented in these subjects, it comes as no surprise that although these three clusters mark careers of both male and female DDHs, only 29 % of all women are concentrated within these three clusters, compared to 49 % of all men. Women in these male-dominated subjects appear to follow career patterns similar to those of their male colleagues.

In Cluster 5 most female and male DDHs originate from sciences and mathematics and work part-time at university during doctoral training. After graduation, the pattern looks different for men and women: While in the female cluster, full-time employment in other sectors is predominant, a substantial proportion of men remain at universities and in non-university research organizations. Cluster 5 is also the cluster with the lowest share of childless women and the highest share of women with children (t+4).

For women, Clusters 6–8 are characterized by mixed patterns regarding employment sector, part-/full-time employment and lacking information following doctorate completion. Cluster 6 is marked by a high share of science and mathematics DDHs as well as a high share of part-time university employment during doctoral training. In this cluster, we find the highest share of women with children at the time of doctorate completion. In Cluster 7, which is characterized by a high share of biotechnologists, most women are part-time employed at non-university research organizations during doctoral training. Cluster 8 encompasses many episodes for which information is lacking. Since the share of DDHs with foreign citizenship is highest in this cluster, the lack of information might be due to the funding of doctoral training through scholarships and subsequent employment abroad.

For men, Clusters 6–8 also show quite different patterns: Cluster 6 comprises mainly typical industrial DDHs whose careers take place outside university and public research, having already begun during their doctoral training. In Cluster 7, no information is available on employment status during doctoral training, making it likely that many scholarship-holders are concentrated in this cluster who later enter employment outside university and research institutions. Cluster 8, similar to those for female DDHs, comprises great swathes of sequences with no information indicating that many DDHs might be employed abroad, are self-employed or civil servants. The share of DDHs with foreign citizenship is also highest here.

Taken together, these patterns suggest a path-dependence regarding post-graduation employment at universities and research institutes (Clusters 1 and 2) in line with our conjecture that sector-specific work experiences during doctoral training influence post-graduation employment choices. This seems to be especially true for the academic sector, as there are no clusters that combine non-academic employment before graduation with subsequent employment at universities or public research institutes. As noted above, fewer women than men pursue academic careers after completing their doctorate. This may reflect subject choices but might also hint at a possible effect of women already having lower shares of employment at universities and research institutes during doctoral training. Our sequence analysis moreover finds that women with children concentrate on particular – relatively unstable – career paths, whereas women without children follow more diverse career trajectories that are more like those of men. These differences between women with and without children are plausibly related to role conflicts that mothers face.

5. Labor market outcomes of female and male STEM DDHs

In this section, we investigate potential gender differences in DDHs' labor market outcomes in the second and fourth year following doctorate completion. To isolate differences related to motherhood, we differentiate between three groups of DDHs: male DDHs, female DDHs with children below the age of 18 years (at the point in time when the labor market indicator is measured) and women without children (women for whom no children below the age of 18 are observed by the fifth year after graduation). We focus on the employment sector that DDHs enter after graduation and whether they take up a full-time position.[13] We first provide descriptive evidence on post-graduation employment sector and volume for male and female

13 We consider as other employment states here also 'No information', but only if there is still an entry for a given point in time in the IEB. In the sequence analysis, we also report no information for a given point in time when there is no entry in the IEB (see Section 3). Note that the sample for sector employment comprises DDHs with a part-/full-time employment spell two or four years after graduation.

DDHs (with and without children). Second, we employ regression analyses to identify which factors help explain gender-specific differences in labor market outcomes. Note that the sample for investigating employment sectors comprises only DDHs with part-/full-time employment spells after graduation, whereas the sample used to analyze employment volume includes all employment states reported in the TUBPP.

5.1 Descriptive analysis

Table 1 shows shares of male DDHs, female DDHs without children and female DDHs with children by employment sector and volume two (t+2) and four years (t+4) after graduation. Holding a position in the university sector after graduating is observed more often for childless female DDHs, 19.5 % in (t+2) and 16.2 % in (t+4), compared to male DDHs with 17.0 % in (t+2) and 13.0 % in (t+4). Notably, these shares are even higher among women with children. A comparable pattern is found for the non-university research sector; here men appear slightly more frequently than women without children, but again women with children show higher shares than both men and women without children. Accordingly, women with children are less often employed in other (non-academic) sectors (54.6 % in (t+4); compared to 65.5 % for women without children and 66.9 % for men).

Full-time post-graduation employment exhibits remarkably large gender differences. Whereas nine out of ten male DDHs hold a full-time position two and four years after graduating, the same holds true for only eight out of ten women without children. As expected, full-time employment is least often observed among women with children (51.4 % in t+4).

Table 1: Employment shares of DDHs in sectors two (t+2) and four (t+4) years after doctoral training, in percent

	Employment Sector	Men	All Women	Women without children	Women with children
t+2	Other Sectors	60.4	55.4	59.3	43.7
	University	17.0	21.5	19.5	29.9
	Research	22.7	23.0	21.2	26.4
t+4	Other Sectors	66.9	61.2	65.5	54.6
	University	13.0	17.0	16.2	20.6
	Research	20.1	21.8	18.3	24.8
t+2	Full-time employment	91.1	75.8	78.5	58.1
t+4	Full-time employment	90.6	69.4	78.6	51.4

Note: Employment: part-/full-time employment.
Source: TUBPP.

5.2 Regression analyses

Results of multinomial logit regressions regarding the likelihood of being employed in the university sector, at non-university research organizations or in other sectors (our reference group) are reported in Table 2. Table 3 summarizes the results of binary logit regressions on having a full-time position compared to all other employment volumes. Both tables include two models, where we differentiate between female and male DDHs in Models (1), and further differentiate the female DDHs into women with and without children in Models (2). We report average marginal effects in both tables. We found that results are very similar between the two points in time (t+2) and (t+4). Therefore, we concentrate our discussion on results for (t+4); results for (t+2) are found in Table A-5 und Table A-6 in the appendix.[14]

Employment sectors

Four years after graduation we find, compared to their male peers, no significantly higher likelihood for female DDHs to be employed at a university (Model (1) in Table 2). Estimation results for Model (2) show that the gender difference remains insignificant for female DDHs without children. In contrast, women with children are on average 7.3 percentage points (significant at the 5 % level) more likely to work at a university than men. For post-graduation employment in non-university research organizations, neither model yields significant gender differences.

We also find pronounced relationships between STEM subfields and subsequent employment sectors. DDHs in mechanical engineering are most likely to be employed outside academia. In electrical engineering and mechanics/flow research/transportation, DDHs are less likely to work in the university sector compared to other sectors.[15] In addition, our results indicate that the employment context during doctoral training is systematically related to subsequent employment sectors. Specifically, each additional 100 days of work experience in the university sector increases the probability of remaining in this sector (versus other sectors) by 0.4 percentage points (significant at the 5 % level). Work experience acquired in non-university research organizations during doctoral training is even more strongly associated with the likelihood of remaining in that sector (1.4 percentage points for each 100 days; significant at the 1 % level), whereas work experience in other sectors reduces the likelihood of post-graduation university employment by 1.0 percentage point for each 100 days (significant at the 1 % level). These patterns are in line with the career trajectories illustrated by the sequence analysis in section 4 and

14 Regressions for (t+1), (t+3) and (t+5) yielded very similar results. Results are available upon request.

15 If we add interaction terms between STEM subfields and the female dummy in Model (1), only one of them is significantly different from zero, and point estimates are not suggestive of a systematic relationship between female shares in STEM subfields (which might proxy for gender stereotyping) and individual career choices.

our expectations based on related research. They suggest that DDHs' careers are path-dependent in the sense that sector-specific work experience during doctoral training increases the likelihood of post-graduation employment in the same sector. Sector-specific work experiences acquired prior to doctoral training do not show significant effects. In an additional analysis[16], we integrated interaction-terms between gender and sector-specific work-experience to detect whether the employment context during doctoral training has different effects for men, women with and without children. Yet, the regression results are in most cases insignificant and therefore do not confirm this expectation.

Employment volume

Table 3 summarizes estimation results on factors associated with the likelihood of full-time employment four years after graduation. In Model (1) we find that female DDHs are 13.9 percentage points (significant at the 1 % level) less likely to hold a full-time position than their male peers. This gender difference in employment volume is even more pronounced when we differentiate between female DDHs with and without children in Model (2). Women with children are 34.4 percentage points (significant at the 1 % level) less likely than male DDHs to be full-time employed. With 8.4 percentage points (again significant at the 1 % level), this difference is considerably smaller but still appreciable for female DDHs without children. Associations between STEM subfields and employment volume after doctoral training are less pronounced than those obtained for employment sectors. A doctoral degree in mechanical engineering is associated with a higher probability of full-time employment relative to a degree in science, whereas fewer DDHs in civil engineering/geotechnology hold full-time positions after graduation.

Similar to post-graduation employment sectors, we moreover find some indication of path dependence with respect to employment volume during and after doctoral training. Extending full-time employment during doctoral training by 100 days increases the likelihood of holding a full-time position four years after graduation by 0.5 percentage points (significant at the 1 % level). In addition, Model (1) suggests that part-time work experience before doctoral training may be associated with a lower probability of subsequent full-time employment. The respective estimate is only marginally significant, however, and not robust to the differentiation between women with and without children in Model (2). We also ran additional analyses[17] with interaction-terms between gender and work experience in jobs with different employment volumes to detect whether effects vary among men, women with and without children. This was not the case.

Taken together, in line with our expectations from related research, we observe that employment contexts during doctoral training, with respect to employment

16 Results are available from the authors upon request.

17 Results are available from the authors upon request.

sector and employment volume, are related to post-graduation employment patterns. Contrary to our expectations, female DDHs with children are more likely to remain in the university sector compared to male DDHs, and female DDHs without children are also less likely to be full-time employed compared to their male peers.

Table 2: Multinominial logit regressions of sector employment four years after doctoral training (t+4), average marginal effects

	Model 1		Model 2	
Variables	t+4		t+4	
ref.: Other sectors	Uni	Research	Uni	Research
Gender (ref.: Men)				
Women	0.030	0.008		
	(0.019)	(0.023)		
Motherhood (ref.: Men)				
Women with children			0.073**	0.043
			(0.035)	(0.037)
Women without children			0.016	-0.025
			(0.025)	(0.027)
Nationality (ref.: German)				
Foreign	0.057***	-0.011	0.061***	-0.008
	(0.022)	(0.026)	(0.022)	(0.027)
Age, date of certification	0.009***	0.007*	0.009***	0.006*
	(0.003)	(0.004)	(0.003)	(0.004)
Data matching quality (ref.: No)				
Yes	0.034	-0.018	0.037	-0.017
	(0.041)	(0.056)	(0.041)	(0.055)
Subjects (ref.: Science)				
Energy/Process/Environ. engineering, Materials Sc.	-0.073**	0.026	-0.074**	0.022
	(0.029)	(0.030)	(0.029)	(0.030)
Bio-/Food technology	-0.067*	0.034	-0.069*	0.025
	(0.036)	(0.033)	(0.037)	(0.034)
Electrical engineering	-0.090***	-0.019	-0.093***	-0.021
	(0.034)	(0.035)	(0.034)	(0.035)
Computer Sc.	0.020	-0.096**	0.016	-0.096**
	(0.025)	(0.039)	(0.026)	(0.038)
Mechanics, Flow research, Transportation	-0.112***	0.007	-0.114***	0.005
	(0.032)	(0.033)	(0.032)	(0.033)

	Model 1		Model 2	
Variables	t+4		t+4	
Mechanical engineering	-0.135***	-0.112***	-0.137***	-0.113***
	(0.039)	(0.041)	(0.039)	(0.041)
Civil engineering, Geotech.	-0.001	-0.046	-0.006	-0.050
	(0.026)	(0.032)	(0.026)	(0.033)
Vocational training (ref.: No)				
Yes	-0.044	-0.000	-0.042	0.001
	(0.035)	(0.037)	(0.035)	(0.037)
Before doctoral training				
WE Uni in 100 days	0.002	-0.003	0.002	-0.003
	(0.002)	(0.002)	(0.002)	(0.002)
WE Research in 100 days	0.000	-0.001	0.000	-0.001
	(0.003)	(0.003)	(0.003)	(0.003)
WE Other Sectors in 100 days	-0.000	-0.002	-0.000	-0.002
	(0.002)	(0.002)	(0.002)	(0.002)
During doctoral training				
WE Uni in 100 days	0.004**	0.000	0.004**	0.000
	(0.002)	(0.002)	(0.002)	(0.002)
WE Research in 100 days	-0.002	0.014***	-0.002	0.014***
	(0.002)	(0.002)	(0.002)	(0.002)
WE Other Sectors in 100 days	-0.010***	-0.004	-0.010***	-0.004
	(0.003)	(0.003)	(0.003)	(0.003)
Years of graduation	YES	YES	YES	YES
Observations	1,819	1,819	1,794	1,794
Pseudo R^2	0.101	0.101	0.102	0.102

Note: Ref.= reference category. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. WE: Work experience in part-/full-time/marginal employment.
Source: TUBPP.

Table 3: Logit regressions of full-time employment four years after doctoral training (t+4), average marginal effects

Variables	Model 1 t+4	Model 2 t+4
Gender (ref.: Men)		
Women	-0.139***	
	(0.016)	
Motherhood (ref.: Men)		
Women with children		-0.344***
		(0.043)
Women without children		-0.084***
		(0.025)
Nationality (ref.: German)		
Foreign	0.024	0.007
	(0.023)	(0.022)
Age, date of certification	-0.010***	-0.012***
	(0.003)	(0.003)
Data matching quality (ref.: No)		
Yes	0.123*	0.111*
	(0.066)	(0.061)
Subjects (ref.: Science)		
Energy/Process/Environ. engineering, Materials Sc.	-0.013	-0.005
	(0.026)	(0.027)
Bio-/Food technology	-0.012	-0.009
	(0.025)	(0.024)
Electrical engineering	-0.016	-0.012
	(0.033)	(0.032)
Computer Sc.	0.019	0.015
	(0.036)	(0.034)
Mechanics, Flow research, Transportation	-0.028	-0.025
	(0.031)	(0.030)
Mechanical engineering	0.124***	0.124***
	(0.045)	(0.045)
Civil engineering, Geotech.	-0.074***	-0.065***
	(0.024)	(0.024)

Variables	Model 1 t+4	Model 2 t+4
Vocational training (ref.: No)		
Yes	0.045	0.038
	(0.034)	(0.034)
Before doctoral training		
Full-time WE in 100days	0.000	0.001
	(0.002)	(0.002)
Part-time WE in 100days	-0.004*	-0.003
	(0.002)	(0.002)
Marg. Empl. WE in 100days	0.001	0.001
	(0.001)	(0.001)
During doctoral training		
Full-time WE in 100days	0.005***	0.005***
	(0.002)	(0.002)
Part-time WE in 100days	0.001	0.001
	(0.002)	(0.002)
Marg. Emp. WE in 100days	-0.001	-0.003
	(0.005)	(0.004)
Years of graduation	YES	YES
Observations	1,887	1,861
Pseudo R^2	0.125	0.148

Note: Ref.= reference category. Robust standard errors in parentheses, *** $p<0.01$, ** $p<0.05$, * $p<0.1$. WE: Work experience in part-/full-time/marginal employment.
Source: TUBPP.

6. Discussion and conclusions

This study aimed to explore career trajectories of STEM DDHs and potential gender-specific differences focusing on the critical transition phase after doctorate completion investigating the impact of previous work experiences in specific employment contexts during doctoral training on post-graduation employment patterns. Based on related research from different disciplines, we expect that employment sector and employment volume during doctoral training shape knowledge acquisition, network access and researcher identity formation processes. We empirically analyzed career paths of a large sample of STEM DDHs from a leading German technical university, therefore a homogenous group in terms of city and university of graduation, based on a new, original dataset.

Results from our sequence analysis reveal typical career trajectory patterns, among others a cluster of 'full-time university careers' or a cluster of 'full-time university to other sectors careers' for both male and female DDHs. However, the share of male DDHs in the sample who have a continuous career pattern like this is higher compared to their female peers. We furthermore observe that female DDHs without children follow career trajectories comparable to their male peers, whereas female DDHs with children concentrate in more unstable career paths regarding employment sector and employment volume. The composition of STEM subfields varies across the respective clusters. For instance, we find many electrical engineers within the cluster 'full-time research organization careers', whereas DDHs from bio- and food technology are prominent within the cluster 'diverse employment patterns during doctoral training to full-time in other sectors'. These differences also relate to gender differences, as female shares in STEM subfields vary in our sample (e.g., 9.5 % in electrical engineering versus 48.1 % in bio- and food technology).

In a multivariate regression analysis, we thus controlled for STEM subfields. Again, our results suggest a substantial degree of path dependence between sector-specific work experience during doctoral training and post-graduation employment sectors. DDHs employed outside the academic sector during doctoral training rarely migrate to employment in academia after completing their doctorate, and a corresponding tendency to remain in the same employment sector is found for those employed both at universities and non-university research organizations during doctoral training. These findings confirm at least partly our expectations that sectoral employment context during the doctoral training appears to be associated with sector-specific access to career-relevant information and networks for subsequent employment. This stronger sectoral persistence in the academic sector is in line with previous evidence on DDHs' sectoral employment paths (e.g., Goldan et al. 2022; Langfeldt/Mischau 2018). This could reflect a biased focus on the part of supervisors who prepare their doctoral students primarily for academic careers (Roach/Sauermann 2010). In addition, our results point to the importance of addressing gender imbalances in academic careers (Findeisen 2011; Beaufaÿs/Engels 2012; Auspurg et al. 2017) early, during the doctoral training.

However, we also would like to emphasize that within all sectors of employment differentiated above, there may be relevant within-sector heterogeneity in the extent to which STEM-specific knowledge acquired during doctoral training is required either for day-to-day business, as a quality signal for gaining employment, for effective supervision of subordinates, or not at all. A further limitation of our study is that we cannot directly investigate whether gender stereotyping experienced during doctoral training affects later choices of employment sector. As women employed in strongly male-dominated fields tend to experience stronger explicit stereotypes (Smyth/Nosek 2015), we therefore used the variation of female shares in STEM subfields as proxy variable (e.g., 9.5 % in electrical engineering to 48.8 % in bio-/food technology for the DDHs in our sample). This variation is interwoven with employment opportunities outside academia also varying by STEM subfields, which might help to explain why we did not obtain strong evidence of associations between gender and post-graduation employment sectors.

Controlling for motherhood within our regressions, we observe a higher likelihood of part-time post-graduation employment for women with children. In addition, women with children are more likely to remain in the university sector after doctorate completion. A plausible interpretation is that universities may be more flexible than other employers regarding part-time employment and flexible work arrangements (work schedule, hours, and locations) for highly educated individuals such as DDHs. In addition, university employment is not necessarily employment in research. In the past decades, universities have expanded their numbers of managerial and administrative staff, which provided new employment opportunities for DDHs. At present, our data do not allow us to differentiate between employment in university research and other university employment. This is a relevant limitation. In future work, we plan to add publication information to the TUBPP to see how long individual DDHs remain active researchers after graduating. We will also extend the observation period, since after four years it is not yet possible to say whether the respective DDHs will remain in the university sector also in the long run (e.g., beyond the period of the *Wissenschaftszeitsvertragsgesetz*). Here, the fact that the transition from doctoral training coincides with the transition to motherhood could have an effect. Some women may prefer to stay in the familiar context of their universities, even if limited in time, and forego chances to establish career networks in industry or elsewhere.

More surprising than the result for female DDHs with children is, however, our finding that women without children also have a lower probability of working full-time compared to men. Consistent with our expectations based on related research and previous evidence, this finding might at least in part reflect gender bias in recruiting for positions in the academic sector and beyond, given that particularly implicit gender beliefs are quite persistent. Yet, the relevance of this factor might be questioned in light of strong shortages of skilled STEM workers in the German labor market. This raises the question of whether this outcome also reflects deliberate choices due to various reasons such as limited project funding in the academic sector, long commuting distances etc.

Prior research on German DDHs being parents does not differentiate between mothers and fathers (e.g., Koenig et al. 2021), neglecting gender-specific parental roles. We do not differentiate between male DDHs with and without children purely for data-driven reasons, as the IEB do not comprise detailed information on household composition, and we are to date not able to apply a workaround to also identify men with children in a reliable way (as not all fathers take parental leave which would be visible in the social security records). Given this, we cannot investigate whether men with children might behave differently to men without children, women with and without children, e.g., leaving the university sector more often to secure higher earnings for the family by being employed within the private sector.

We conclude by noting that while our use of a single-university dataset reduces problems that might emerge from heterogeneity in actual or perceived degree quality as well as regional labor market conditions, it should be acknowledged that the TU Berlin and its DDHs might be special and differ from other DDHs in other regions of Germany. This might particularly apply to those DDHs in our sample who deliberately stay after graduation in Berlin due to a capital-effect, the preference to remain in this attractive metropole. Compared to immobile DDHs from TU Munich, another member of the TU9 network, there are fewer local job opportunities in big industries available for immobile DDHs from TU Berlin, but a high number of universities and research institutions, which might lead to an 'academia'-bias in our sample.

Most research on employment outcomes of (doctoral) graduates is survey-based. In contrast, our analysis was based on process-generated administrative data. In labor market research, the use of process-generated data such as the IEB is well-established. However, they are not very informative regarding individual educational attainments. Our TUBPP dataset shows that information on education can be fruitfully linked to the IEB, and that a matching rate above 80 % can be attained with access to administrative records. We consider the use of process-generated data to study career paths of DDHs and other graduates from higher education as complementary to large-scale surveys. Many questions for which survey data have traditionally been used can be answered equally well or even better using process-generated data. At the same time, process-generated data do not include information about individual motives, attitudes etc. In our view, this type of information should be the focus of future surveys, whereas as little information as possible should be collected that can be readily obtained from process-generated data. Ideally, ways of systematically linking process-generated and survey data should be devised that minimize costs while safeguarding subjects' privacy.

Our analysis is nevertheless limited to career trajectories within the German social security system, and we have identified for both female and male DDHs one cluster of careers for which hardly any information on employment status is available in our data. We cannot trace likewise academic career paths which rely on long stays abroad or a transition into self-employment or a position as civil servant. In this respect, a linkage of process-generated and survey data in future research might provide valuable insights on career paths beyond the German social security system.

Another interesting avenue for future research is to link patent data to our TUBPP dataset. Like the underrepresentation of women in top positions in the academic sector, gender imbalances in innovation activities are as striking as they are persistent. Based on long-term trends in female inventor shares in U.S. patent data, it has been estimated that another 118 years will be required until 50 % of all inventors are women (Bell et al., 2019). Several studies find that female scientists and engineers are less likely to become innovators than their male counterparts (Murray/Graham 2007; Sugimoto et al. 2015; Jensen et al. 2018). Investigating the relationship between employment context during doctoral training and later innovative activities may help to accelerate expedient interventions to increase gender balance in this respect.

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Appendix

Table A-1: Share of female DDHs at TU Berlin by subject in % (graduation years 2004–2013)

Subject	%
Mathematics, Natural sciences	29.5
Energy/Process/Environmental Engineering, Materials Science	28.0
Bio-/Food Technology	48.1
Electrical engineering	9.5
Computer Science	14.6
Mechanics/Flow research	13.4
Transportation	11.1
Mechanical Engineering	15.4
Civil Engineering/Geotech.	34.2

Source: TUBPP.

Table A-2: Average duration of 10 labor market states in months

		Total	Men	Women	Significance-level	t-value	Degrees of freedom
Status: Average number of months/n=		2,513	1,906	607			
Five year-period before date of doctoral certificate	FT/University	16.0	18.3	9.5	***	3.340	1,043
	FT/Research	5.8	6.4	3.9		1.914	438
	FT/Other sectors	5.7	6.4	3.7	**	1.986	1,807
	PT/University	8.5	7.5	12.0	***	3.961	2,738
	PT/Research	4.2	3.8	5.6	***	2.433	513
	PT/Other sectors	1.9	1.8	2.5	***	6.887	8,058
	Vocational training	0.0	0.0	0.0	***	2.447	3,004
	Marginal employment	2.7	2.7	3.1		0.008	836
	Unemployment/Job search	1.9	1.7	2.7		1.592	1,281
	No information	13.3	11.5	16.9		-0.963	425
Five year-period after date of doctoral certificate	FT/University	6.1	6.5	5.0	**	2.943	2,258
	FT/Research	8.3	8.9	6.8	***	3.961	2,738
	FT/Other sectors	23.7	25.9	17.5	***	6.712	2,299
	PT/University	1.7	1.3	3.3	***	6.886	8,058
	PT/Research	1.1	0.8	2.0		-0.963	425
	PT/Other sectors	1.6	1.0	3.7		0.051	659
	Vocational training	0.0	0.0	0.0			
	Marginal employment	0.2	0.2	0.2	**	2.862	114
	Unemployment/Job search	2.1	1.9	3.0		0.787	1,740
	No information	15.1	13.5	18.4		0.023	195

Note: t-test, *** p<0.01, ** p<0.05, *p<0.1.
Source: TUBPP.

Table A-3: Descriptive characteristics of the clusters

Female DDHs		**Cluster**							
	Total	1	2	3	4	5	6	7	8
Percentages n=	607	86	50	42	101	68	92	82	86
Subjects									
Science	33.3	31.4	26.0	16.7	26.7	60.3	47.8	20.7	30.2
Engineering	66.7	68.6	74.0	83.3	73.3	39.7	52.2	79.3	69.8
Energy/Process/Environmental Engineering, Materials Science	13.0	11.6	10.0	21.4	13.9	14.7	13.0	11.0	11.6
Bio-/Food Technology	18.6	7.0	22.0	11.9	29.7	10.3	14.1	30.5	18.6
Mechanical engineering	4.3	3.5	4.0	16.7	5.0	0.0	4.3	3.7	2.3
Electrical engineering	3.0	3.5	10.0	2.4	1.0	1.5	1.1	3.7	3.5
Mechanics/Flow res.	1.8	4.7	4.0	0.0	1.0	0.0	1.1	2.4	1.2
Computer Science	5.8	14.0	10.0	16.7	5.0	0.0	3.3	0.0	3.5
Transportation	2.6	4.7	0.0	7.1	2.0	4.4	4.3	0.0	0.0
Civil engineering/ Geotechnology	17.6	19.8	14.0	7.1	15.8	8.8	10.9	28.0	29.1
Age at submission (mean)	32.8	32.8	32.3	32.3	32.0	31.2	32.6	32.4	32.1
Foreign	23.4	18.6	20.0	7.1	24.8	14.7	15.2	23.2	52.3
Women with children, t+2	24.4	23.3	24.0	19.0	20.8	25.0	35.9	29.3	15.1
Women with children, t+4	33.9	32.6	34.0	28.6	29.7	44.1	43.5	39.0	19.8
Women without children, t-5/t+5	62.1	65.1	58.0	64.3	65.3	52.9	54.3	58.5	75.6

Male DDHs	**Cluster**								
	Total	1	2	3	4	5	6	7	8
Percentages n=	1,906	305	259	325	265	217	113	102	320
Subjects									
Science	29.2	25.2	24.7	9.5	24.9	70.0	11.5	34.3	36.9
Engineering	70.8	74.8	75.3	90.5	75.1	30.0	88.5	65.7	63.1
Energy/Process/Environmental Engineering, Materials Science	11.4	10.8	13.1	12.3	12.5	5.1	14.2	9.8	12.5
Bio-/Food Technology	6.6	3.3	8.5	0.3	12.1	5.5	8.8	9.8	9.1
Mechanical engineering	10.3	6.6	5.8	23.7	13.2	2.8	15.0	8.8	5.3
Electrical engineering	10.4	10.8	16.2	13.5	10.9	2.3	5.3	11.8	8.4
Mechanics/Flow res.	3.6	3.9	4.6	6.2	3.4	2.3	5.3	2.9	0.3
Computer Science	11.4	23.0	10.8	14.2	8.3	0.9	7.1	7.8	10.6
Transportation	6.9	6.9	6.6	13.5	4.2	4.1	16.8	3.9	1.9
Civil engineering/ Geotechnology	10.3	9.5	9.7	6.8	10.6	6.9	15.9	10.8	15.0
Age at submission (mean)	32.8	33.4	33.3	33.4	33.3	32.3	33.8	31.3	32.9
Foreign	17.5	16.1	12.0	12.3	14.7	9.7	9.7	25.5	36.3

Source: TUBPP.

Table A-4: Definition of explanatory variables

Personal characteristics	
Female	1 if female, 0 if male
Women with children	1 if Women with children, 2 if Women without children, 0 if Men
Age	Age at time of graduation
Age²	Age (at time of graduation) squared
Foreign	1 if foreign graduate, 0 if German graduate
Data matching quality	1 if number of prs_ids in IEB data > 1, if number of prs_ids in IEB =1
Doctoral degree	
Year of graduation	Year of achieving the doctoral degree
STEM field	■ Science (including Mathematics) ■ Engineering ■ Energy/Process/Environmental Engineering, Materials Science ■ Bio-/Food Technology ■ Mechanical engineering ■ Electrical engineering ■ Mechanics/Flow research ■ Computer Science ■ Transportation ■ Civil engineering/Geotechnology
Work experience	
Vocational training	1 if graduate completed a vocational training before completion of doctoral training, 0 otherwise
Experience (in 100 days)	■ Marginal, part- and full-time employment work experience in employment sectors before doctoral training ■ Marginal, part- and full-time employment work experience in employment sectors during doctoral training ■ Marginal*/part-time*/full-time employment work experience before doctoral training ■ Marginal*/part-time*/full-time employment work experience during doctoral training

Table A-5: Multinominial logit regressions of sector employment two years after doctoral training (t+2), average marginal effects

Variables	Model 1 t+2		Model 2 t+2	
ref.: Other sectors	Uni	Research	Uni	Research
Gender (ref.: Men)				
Women	0.026	-0.014		
	(0.021)	(0.023)		
Motherhood (ref.: Men)				
Women with children			0.123**	0.027
			(0.048)	(0.040)
Women without children			0.003	-0.030
			(0.026)	(0.026)
Nationality (ref.: German)				
Foreign	0.075***	-0.009	0.094***	-0.009
	(0.023)	(0.026)	(0.023)	(0.027)
Age, date of certification	0.007*	0.007*	0.006*	0.008**
	(0.004)	(0.004)	(0.004)	(0.004)
Data matching quality (ref.: No)				
Yes	0.013	-0.033	0.021	-0.029
	(0.047)	(0.058)	(0.046)	(0.058)
Subjects (ref.: Science)				
Energy/Process/Environ. engineering, Materials Sc.	-0.064**	0.026	-0.068**	0.027
	(0.029)	(0.029)	(0.030)	(0.030)
Bio-/Food technology	-0.082**	0.026	-0.101**	0.034
	(0.039)	(0.035)	(0.042)	(0.036)
Electrical engineering	-0.119***	-0.009	-0.129***	-0.012
	(0.037)	(0.034)	(0.037)	(0.034)
Computer Sc.	0.017	-0.106***	0.009	-0.112***
	(0.029)	(0.039)	(0.030)	(0.040)
Mechanics, Flow research, Transportation	-0.116***	0.018	-0.123***	0.012
	(0.033)	(0.033)	(0.033)	(0.034)
Mechanical engineering	-0.138***	-0.117***	-0.153***	-0.116***
	(0.037)	(0.040)	(0.038)	(0.040)
Civil engineering, Geotech.	0.002	-0.029	-0.014	-0.033
	(0.029)	(0.032)	(0.030)	(0.033)

	Model 1		Model 2	
Variables	t+2		t+2	
Vocational training (ref.: No)				
Yes	-0.026	-0.019	-0.026	-0.021
	(0.037)	(0.038)	(0.039)	(0.039)
Before doctoral training				
WE Uni in 100 days	0.003	-0.003	0.003	-0.004*
	(0.002)	(0.002)	(0.002)	(0.002)
WE Research in 100 days	0.000	-0.003	-0.000	-0.003
	(0.003)	(0.003)	(0.003)	(0.003)
WE Other Sectors in 100 days	-0.001	-0.002	-0.000	-0.003
	(0.002)	(0.002)	(0.002)	(0.002)
During doctoral training				
WE Uni in 100 days	0.002	-0.001	0.003	-0.001
	(0.002)	(0.002)	(0.002)	(0.002)
WE Research in 100 days	-0.005**	0.017***	-0.004	0.017***
	(0.002)	(0.002)	(0.002)	(0.002)
WE Other Sectors in 100 days	-0.017***	-0.007**	-0.016***	-0.006*
	(0.004)	(0.003)	(0.004)	(0.003)
Years of graduation	YES	YES	YES	YES
Observations	1,846	1,846	1,770	1,770
Pseudo R^2	0.129	0.129	0.136	0.136

Note: Ref.= reference category. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. WE: Work experience in part-/full-time/marginal employment.
Source: TUBPP.

Table A-6: Logit regressions of full-time employment two years after doctoral training (t+2), average marginal effects

Variables	Model 1 t+2	Model 2 t+2
Gender (ref.: Men)		
Women	-0.099***	
	(0.015)	
Motherhood (ref.: Men)		
Women with children		-0.260***
		(0.049)
Women without children		-0.090***
		(0.024)
Nationality (ref.: German)		
Foreign	0.021	0.017
	(0.021)	(0.021)
Age, date of certification	-0.014***	-0.013***
	(0.003)	(0.003)
Data matching quality (ref.: No)		
Yes	0.067	0.059
	(0.050)	(0.048)
Subjects (ref.: Science)		
Energy/Process/Environ. Engineering, Materials Sc.	0.024	0.028
	(0.026)	(0.026)
Bio-/Food technology	-0.003	-0.002
	(0.025)	(0.025)
Electrical engineering	-0.030	-0.017
	(0.030)	(0.031)
Computer Sc.	-0.023	-0.022
	(0.033)	(0.032)
Mechanics, Flow research, Transportation	-0.032	-0.025
	(0.030)	(0.029)
Mechanical engineering	0.015	0.035
	(0.030)	(0.031)
Civil engineering, Geotech.	-0.047**	-0.035
	(0.024)	(0.025)
Vocational training (ref.: No)		

Variables	Model 1 t+2	Model 2 t+2
Yes	0.063*	0.056
	(0.037)	(0.037)
Before doctoral training		
Full-time WE in 100days	-0.000	0.000
	(0.002)	(0.002)
Part-time WE in 100days	-0.002	-0.001
	(0.002)	(0.002)
Marg. Empl. WE in 100days	-0.001	-0.001
	(0.001)	(0.001)
During doctoral training		
Full-time WE in 100days	0.009***	0.009***
	(0.002)	(0.002)
Part-time WE in 100days	0.000	0.000
	(0.002)	(0.002)
Marg. Emp. WE in 100days	0.004	0.004
	(0.004)	(0.004)
Years of graduation	YES	YES
Observations	1,932	1,855
Pseudo R^2	0.128	0.1411

Note: Ref.= reference category. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. WE: Work experience in part-/full-time/marginal employment.
Source: TUBPP.

Lea Goldan[*], Aaron Bohlen[**], and Christiane Gross[***]

Social inequalities in postdoctoral dropout from academia by gender, parental academic background, and migration background, and their intersections[****]

Abstract: Academic careers should be independent of social characteristics. However, empirical evidence on social inequalities in German academia is ambiguous, and research explicitly on intersectional inequalities in academic careers is scarce. To provide new insights into the empirically contested question of whether there are inequalities in academic careers, we examine whether postdoctoral dropout from academia is associated with any of gender, social origin, migration background, or the intersections of these social categories. Building on the intersectionality approach complemented by theories on minority and majority effects in the workplace, we assume that several minority groups have a higher risk of dropout from academia. We use panel data that are representative of the 2014 doctoral graduation cohort in Germany and their career trajectories up to five years after graduation and apply event history techniques. We find that many graduates drop out from academia in the initial years following graduation, but we find—against our hypotheses—no inequalities in dropout by any of the social categories under study.

Keywords: intersectionality; social inequalities; dropout; academia; doctoral graduates; Germany

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Code availability: We used Stata/SE 17 to complete our work. Our code is available upon request at the Research Data Centre for Higher Education Research and Science Studies (FDZ-DZHW) under DOI: 10.21249/DZHW:goldan2023b:1.0.0.

Zusammenfassung: Akademische Laufbahnen sollten unabhängig von sozialen Merkmalen sein, allerdings sind die empirischen Befunde zu sozialen Ungleichheiten in der Wissenschaft in Deutschland nicht eindeutig und es gibt bisher wenig Forschung explizit zu intersektionalen Ungleichheiten. Um neue Einblicke in die empirisch umstrittene Frage zu gewinnen, ob es Ungleichheiten in akademischen Laufbahnen gibt, untersucht dieser Beitrag, ob der Dropout aus der Wissenschaft nach Promotionsabschluss mit dem Geschlecht, der sozialen Herkunft, Migrationserfahrung oder ihren Intersektionen zusammenhängt. Auf dem Intersektionalitätsansatz aufbauend, ergänzt durch Theorien zu Minder- und Mehrheitseffekten am Arbeitsplatz, nehmen wir an, dass mehrere Minderheitsgruppen ein höheres Risiko haben, aus der Wissenschaft auszuscheiden. Wir nutzen Längsschnittdaten, die repräsentativ für die 2014er Promotionsabschlusskohorte in Deutschland und ihre Erwerbsverläufe bis fünf Jahre nach dem Abschluss sind und wenden ereignisdatenanalytische Verfahren an. Es zeigt sich, dass viele Promovierte in den ersten Jahren nach ihrem Abschluss aus der Wissenschaft ausscheiden, aber – entgegen den aufgestellten Hypothesen – entlang keiner der untersuchten sozialen Merkmale Ungleichheiten beim Dropout aus der Wissenschaft bestehen.

Stichwörter: Intersektionalität, soziale Ungleichheiten, Dropout, Wissenschaft, Promovierte, Deutschland

1 Introduction

Academic careers and career advancement should be based solely on scientific achievements in the production of knowledge and should be independent of researchers' social characteristics. This orientation towards meritocratic principles has already been described by Merton (1973) as a central imperative of scientific research and is incorporated in his concept of the ethos of science.

However, for German academia, there is some empirical evidence of inequality. On the one hand, a large body of research has shown that there are social inequalities by gender and parental academic background—which is one of the main dimensions of an individual's social origin—in the participation *in* and the completion *of* higher education (e.g., Becker 2009; Jaksztat 2014; Jaksztat et al. 2021; Lörz 2019; Lörz/Mühleck 2019; Lörz/Schindler 2016; Müller/Pollak 2016; Müller et al. 2011; Vogel 2017; Watermann et al. 2014); some studies also found inequalities by migration background (Lörz 2019, 2020). Yet individuals who have earned an advanced higher education degree seem to be such a preselected group (Mare 1980) that these inequalities no longer persist (Bornmann/Enders 2004; König et al. 2021; Lörz/Mühleck 2019; Lörz/Schindler 2016; Zimmer 2021). More precisely, from completion of the doctorate onward, academic careers seem to follow meritocratic principles.

On the other hand, some studies nevertheless find indications of social inequalities in academic careers in Germany by at least one of the above-mentioned social categories (Buche/Gottburgsen 2012; Flöther 2017; Goldan et al. 2023; Jungbauer-Gans/Gross 2013), while a few studies even detect intersectional inequalities (Löther 2012; Möller 2017; Shinozaki 2017). However, research explicitly on intersectional inequalities in academic careers is scarce. The term 'intersectional inequalities' stems from the intersectionality approach, which assumes that an individual's different social categories may be intertwined and cause specific and additional inequalities in certain contexts.

In this paper, we study inequalities in academic careers in terms of postdoctoral dropout from academia. Doctoral graduates fulfill the general requirements for an academic career but have not yet put them into practice and therefore could still opt for a career outside academia. The doctoral degree qualifies them for taking further steps toward an academic career, but it is also highly valued in the non-academic labor market so that a substantial number of doctoral graduates in fact leave academia with good career prospects outside academia. Please note that our research interest does not imply any evaluation of whether dropout is positive or negative. Quite the contrary, we do justice to the fact that doctoral graduates' dropout from academia is a structural necessity because the number of doctoral graduates largely exceeds the number of permanent positions inside academia. Yet outside academia doctoral graduates can be professionally as successful as if they had realized the ideal-typical academic career. Therefore, dropout itself is not an issue, but that chances to stay within academia depend on social characteristics, is. We investigate the main and intersectional "effects"[1] of gender, parental academic background, and migration background in dropout from academia. These categories reflect widespread inequality dimensions in both society and academia whose influence on academic careers has already been studied, and they refer to ascriptive social categories and not to those acquired in the life course. Our overall research question is: *are there inequalities by gender, parental academic background, and migration background, and their intersections in postdoctoral dropout from academia?*

Our contribution to the literature is threefold. *First*, we explicitly consider intersectional inequalities in academic careers, something which has hardly been done in previous research (exceptions: Buche/Gottburgsen 2012; Shinozaki 2017) but does justice to potential intersectional entanglements of social categories with specific advantages or disadvantages for an academic career. Thus, taking intersectional inequalities into account is more accurate than confining research to the main effects only. *Second*, we provide new insights into the empirically contested question of whether there are social inequalities in academic careers. Knowledge of such

1 We put the word in inverted commas to emphasize that we cannot guarantee causal relationships. See section 4.3 for a brief discussion on causality in our analyses. For the purpose of better readability, we do not use inverted commas for effects in the remainder of the paper.

inequalities is important to identify measures to redress them, which is required by law and in the interest of science itself, in order not to let the potentials of certain groups go untapped. *Third*, in contrast to previous research, we use a rich panel data set on the employment trajectories of doctoral graduates in Germany up to five years after their graduation, which enables us to use event history techniques on postdoctoral dropout from academia while controlling for discipline and academic performance. By considering both *if* and *when* the graduates experience such a dropout, we are able to account for the dynamics of postdoctoral careers.

2 Literature review

2.1 Previous research on social inequalities in academic careers

In the following, we present previous research on inequalities in different aspects related to academic careers by gender, parental academic background, migration background, and their intersections. For better comparability, we confine ourselves to studies from German-speaking countries in the following.

Regarding *inequalities in doctoral students' academic career intentions*, previous research is scarce. The few existing studies find no differences by gender (Briedis et al. 2014; Dubach 2014; Hauss et al. 2015) and parental academic background (Briedis et al. 2014). By contrast, with regard to migration background, Hauss et al. (2015) and Dubach (2014) suggest that doctoral students with a migration background have a higher academic career intention than doctoral students with no migration background. Differences in academic career intentions by intersections of these potential inequality dimensions have not yet been studied.

Regarding *inequalities in postdoctoral chances of realizing an academic career*, previous research has provided some insights for different postdoctoral groups inside academia. Among researchers with a 'habilitation' in economics, business administration, and related fields, Schulze et al. (2008) find no gender differences in the chances of being appointed to a chair. Among researchers with a 'habilitation' in mathematics or law (Jungbauer-Gans/Gross 2013) and among junior professors (Zimmer 2018), the chances of being appointed seem to differ by gender and by parental academic background with women and those from a lower educational background having lower chances of being appointed. By contrast, analyzing procedural data on actual appointment procedures from one German university, Auspurg et al. (2017) find that women and men have the same chances at all stages of the appointment procedure. However, given their academic qualifications, women tend to less often apply for a professorship than might be expected. Other studies even find that women have higher chances of being appointed in sociology (Jungbauer-Gans/Gross 2013; Lutter/Schröder 2016) and in political sciences (Schröder et al. 2021). There is also some evidence that men have slightly better chances of obtaining research funding (Allmendinger/Hinz 2002; Findeisen 2011), but that the frequency of application for research funding does not vary by parental academic background among doctoral graduates in Switzerland (Leemann et al. 2010).

With regard to migration background, Löther (2012) indicates that scientists with a migration background less often habilitate, less often hold permanent positions, and are less often professors than are scientists without a migration background. However, the findings rely on survey data that was collected in German language only, therefore people without German language skills are underrepresented in the data, which likely affects the generalizability of the findings. Nevertheless, the share of people without a German nationality is, for example, with seven percent indeed quite low among professors in Germany in 2020 (Federal Statistical Office 2021: 18, 24). Further studies suggest that professors with a migration background experience discrimination inside German academia (Neusel et al. 2014; Pichler/Prontera 2012). According to Leemann et al. (2010), educational migrants and locals differ in application frequency for some types of research funding but not for other types.

Intersectional inequalities in postdoctoral chances of realizing an academic career have hardly been studied to date. However, there are some descriptive findings that point in the direction of intersectional inequalities. *First*, gender and social origin seem to be intertwined insofar as female professors come on average from a higher social class than male professors (Möller 2017, 2018). *Second*, social origin and migration background seem to be intertwined insofar as scientists with a migration background more often come from a higher social class than scientists without a migration background, which holds in particular for professors (Löther 2012; Möller 2017, 2018). *Third*, migration background and gender seem to be intertwined insofar as the share of women is higher among scientists with a migration background than among scientists without a migration background (Bakshi-Hamm/Lind 2008; Löther 2012). However, female scientists with a migration background feel less integrated into academia, perceive their academic career prospects to be poorer, more frequently think about dropping out from academia, and less often hold a professorship than do male scientists with a migration background (Löther 2012). In addition, female international professors more often report having experienced discrimination due to their gender than do male international professors (Neusel et al. 2014).

Only two studies explicitly examine academic careers within the framework of intersectionality. The first study is from Shinozaki (2017). Shinozaki describes academic career advancement from doctoral training to professorship by gender, nationality, and their intersections at two German universities based on triangulated data. The author finds that most professors are male and German (68 percent) and least professors are female and non-German (3 percent). However, within their respective nationality group, the share of women is higher among non-German professors (32 percent) than among German professors (25 percent). These findings emphasize the importance of examining social inequalities through an intersectional lens. The second study is from Buche and Gottburgsen (2012) and is the most extensive study on intersectional inequalities in academic careers so far. Buche and Gottburgsen study the chances of holding a full-time position in the faculty of a German university by gender, parental academic background, the country where the university entrance qualification was gained, and the individuals' or their parents' birth country. They find main effects of all social categories under study with women, individuals from non-academic families, individuals who gained their university entrance qualification in Germany, and individuals who themselves or whose parents were born outside Germany less often holding full-time positions, whereas none of the interactions between the categories is statistically significant. However, their findings are not meant to show intersectional inequalities in dropout from academia as they examine faculty staff within a cross-sectional design.

Regarding *inequalities in doctoral graduates' occupational destinations* more general, female doctoral graduates seem to stay as frequently inside academia as male doctoral graduates (Bornmann/Enders 2004; Briedis et al. 2014; Enders/Bornmann 2001; Franken 2020; König et al. 2021: 64, 72; Leemann et al. 2010; Lörz/Mühleck 2019; Lörz/Schindler 2016) but to be less frequently employed in the private sector (BuWiN 2013: 256; Flöther 2017; Goldan et al. 2023; König et al. 2021: 99; Schubert/Engelage 2011). With respect to parental academic background, there seem to be no differences in postdoctoral occupational destinations (Bornmann/Enders 2004; Briedis et al. 2014; Enders/Bornmann 2001; Franken 2020; König et al. 2021; Leemann et al. 2010; Lörz/Mühleck 2019; Lörz/Schindler 2016). Only few studies consider doctoral graduates' migration background. Among doctoral graduates in Switzerland, Leemann et al. (2010) find that graduates who had migrated to Switzerland for taking up doctoral training are more likely to be employed inside academia than those graduates who had already completed their studies in Switzerland prior to doctoral training. For doctoral graduates in Germany, Flöther (2017) finds no differences in employment sectors between educational migrants and locals one to two years after their graduation. Intersectional inequalities in postdoctoral occupational destinations have not yet been studied.

2.2 Research gap and purpose of the paper

Overall, a large body of research in Germany has investigated social inequalities in academic careers, mostly by one single social category and sometimes only incidentally. However, few studies have examined inequalities by migration background in academic careers due to insufficient data bases, too few cases with a migration background in the data, and challenges in defining a migration background (Bakshi-Hamm et al. 2008; Baur 2016; Buche/Gottburgsen 2012; BuWiN 2013: 352f.; Löther 2012).

Research specifically on intersectional inequalities in academic careers is even more scarce. Shinozaki (2017) has only considered two social categories, conducted descriptive analyses, and used data from only two universities. Buche and Gottburgsen's (2012) study is the most extensive study so far but due to their survey design and research interest, the authors provide insights into other academic employment outcomes than dropout from academia.

Our paper contributes to the literature by studying intersectional inequalities in postdoctoral dropout from academia by means of event history techniques. Using panel data on the career trajectories of a recent doctoral graduation cohort from Germany, we are able to test the main effects of gender, parental academic background, and migration background, and their intersections while controlling for discipline and academic performance. By adopting an intersectional perspective, we are able to accurately depict the complex social situatedness of individuals striving for an academic career. Thereby we provide new insights into the question of whether there are social inequalities in academic careers.

3 Theoretical background & hypotheses

We use the intersectionality approach (section 3.1) as theoretical framework and combine it with theories that assume minority and majority effects in the workplace in order to derive hypotheses on social inequalities in dropout from academia (section 3.2).

3.1 Intersectionality approach

The intersectionality approach focuses on the intersections of different axes of inequality and on how these are intertwined and cause specific advantages and disadvantages for the individuals (Collins/Chepp 2013; Crenshaw 1989; Davis 2011; McCall 2005). From an intersectional perspective, single social categories are insufficient to explain inequalities. Instead of assuming that locations in different socially constructed groups are separate axes of inequality with independent effects on the respective group members' life chances, the intersectionality approach assumes that these axes of inequality are social systems of power that are intertwined and therefore simultaneously and mutually constitutively cause inequalities. The intersectionality approach claims that inequalities and discrimination cannot be understood in isolation from one another because they are always multidimensional along different axes of inequality. Intersectionality helps to detect how power works as it assumes that overlapping social categories and identities "are the ossified outcomes of the dynamic intersection of multiple hierarchies, not the dynamic that creates them. They are there, but they are not the reason they are there." (MacKinnon 2013: 1023). However, inequalities only emerge in certain social contexts, and they vary according to these. Not all social categories lead to inequality in every context; the activation of some categories requires a specific context, which in turn can affect the direction and strength of the influence of a particular social category. Individuals and groups can be privileged in one context and at the same time disadvantaged in another.

The general idea of intersectionality arose from debates within black feminism and gender studies in the 1970s and 1980s, but only in 1989 did the US legal scholar Crenshaw (1989) introduce "intersectionality" as a heuristic term. Crenshaw used the analogy of traffic at an intersection. The directions of that intersection represent axes of inequality, and discrimination or rather "accident[s] […] can be caused by cars traveling from any number of directions and, sometimes, from all of them" (1989: 149). Crenshaw's intersection analogy can be generalized into multidimensional or rather intersectional inequalities being greater than the sum of their underlying single discriminations.

McCall (2005) differentiates inter-, anti- and intra-categorical intersectionality research depending on their use of categories. We follow the inter-categorical approach, which systematically compares inequality between multiple intersectional groups: "Unlike single-group studies, which analyze the intersection of a subset of dimensions of multiple categories, however, multigroup studies analyze the intersection of the full set of dimensions of multiple categories and thus examine both advantage and disadvantage explicitly and simultaneously." (McCall 2005: 1787). The categorial approach is thus more holistic but necessarily also more complex than single-group approaches. While most of the empirical studies within the intersectional framework use qualitative methods, we use quantitative methods (see Gross et al. 2016 for a discussion of the strengths and weaknesses of the different methodological approaches regarding intersectionality).

The intersectionality approach is a rather vague and ambiguous theoretical concept as it does not specify which social categories cause which inequalities in which social context and how they affect these inequalities. However, this vagueness is often acknowledged as its particular strength. The approach is theoretically and empirically so open-ended that it "allows endless constellations of intersecting lines of difference to be explored" (Davis 2011: 51) in various contexts. Because of its openness, the intersectionality approach alone does not allow the deductive derivation of concrete hypotheses regarding what dimensions (and what constellation of them) lead to disadvantages in what social context. Therefore, in the following section, we combine the intersectionality approach with other theories that assume minority and majority effects in the workplace in order to fill this gap and to derive hypotheses on social inequalities in dropout from academia.

3.2 Minority & majority groups in the (academic) workplace

To derive testable hypotheses, we draw on theories that argue based on minority and majority effects in the workplace both from employers' and employees' perspectives and apply them to doctoral graduates inside academia. For the employers' perspective, we refer to discrimination approaches: tastes for discrimination (Becker 1957) and statistical discrimination (Arrow 1973; Phelps 1972). For the employees' perspective, we refer to Kanter's (1977) tokenism.

Becker (1957) suggests that employers tend to have a "*taste for discrimination*", i.e., they discriminate against particular social groups and are willing to pay a price for cooperating with people who are similar to themselves in terms of social characteristics. Against the background of their taste for discrimination, employers try to maximize their utility, usually in hiring and remuneration decisions. For example, a male employer would act as if associating with women entails non-pecuniary costs. As a result, this employer will hire a woman only for a lower wage than a man with the same qualification, to compensate for the higher non-pecuniary costs of employing the woman.

Following the *theory of statistical discrimination* (Arrow 1973; Phelps 1972), employers also try to maximize their utility and discriminate against minority groups, not because of tastes but because of estimations about the average productivity of the members of social groups. In hiring decisions, employers face incomplete information on the productivity of each applicant, so they use further information such as social characteristics to improve their estimation. If they have a priori beliefs about the available social characteristics (e.g., women taking on average more parental leave than men) an employer may estimate the costs of employing a woman as higher even if the female applicant under consideration never actually takes any parental leave at all. In addition, the productivity estimation for the minority group is by definition based on a smaller sample and therefore has a higher variance and is less reliable. An employer benefits from an exact estimation of the employee's productivity, since over- and underestimation of productivity are associated with higher costs (salary too high or too low and the employee quits). As a result, employers are more likely to hire members of the majority group than those of the minority group even if the average productivity does not vary by social category.

At their core, both rational choice-based discrimination theories are blind for gender or any other social category. However, people who have social attributes similar to the decision-makers or those in power (for taste-based discrimination) and/or are members of the statistical majority (for statistical discrimination) benefit from their attributes at least in this social context.

From an employee's perspective, Kanter's (1977) *theory of tokenism* provides insights into interaction dynamics between minority and majority groups in the workplace. According to Kanter (1977: 965), the "relative numbers of socially and culturally different people in a group" largely affect interaction dynamics within that group. Kanter refers to minorities in largely skewed groups as "tokens". These tokens only differ from the respective majority in terms of ascribed characteristics but not in terms of productivity or ability. The skewed numerical proportions of different social subgroups within a given group may cause dynamics in everyday interaction in the workplace that have many negative effects on the tokens. One such interaction dynamic is that tokens are particularly visible, which places them under high performance pressure while at the same time evoking efforts to limit both their visibility and their achievements. The presence of tokens also causes majority members to exaggerate their intragroup commonalities and the tokens' otherness, which reinforces the polarization and the isolation of tokens. Another interaction dynamic is role entrapment of the tokens, which occurs if they assimilate into their ascribed stereotypic roles for the sake of convenience or resignation because constantly 'fighting' their stereotypic role requires time and much self-assertion. Taken together, these dynamics diminish both career and promotion opportunities of minority groups in the workplace.

We assume that minority and majority or rather group-size effects also exist in the academic workplace and that the presented theories, together with intersectionality help to explain social inequalities in postdoctoral dropout from academia. Inside academia, there is no one employer, but rather many actors involved in hiring and appointment decisions: appointment committees, professors, but also universities and their managements. Both historically and empirically, the majority groups inside academia include men, people with academic parents, and those without a migration background, whereas women, people with non-academic parents, and those with a migration background are the respective minority groups. In addition, the intersections of these minority groups are even smaller minorities and therefore prone to face multiple disadvantages.

Following the presented theories, members of the minority groups may be discriminated against for different reasons. Doctoral graduates who are members of one (or several) minority groups could be disadvantaged in hiring decisions and contract extensions, which increases their risk of dropout from academia. Or they could be disadvantaged by group-size effects because they have no—or only a small number of—role models and face a particularly high performance pressure due to their high visibility inside academia, which could in turn lead to reduced well-being and a higher likelihood of opting out. We assume that the described mechanisms hold for all minority groups and increase their risk of dropout from academia.

To sum up, we assume that the social categories are directly associated with dropout from academia. We expect that female doctoral graduates, those with a non-academic background, and those with a migration background have a higher risk of dropout from academia than their respective majority groups; and as a result, also drop out from academia more quickly after graduation. Furthermore, we assume that these disadvantages reinforce each other and that the social categories are intersectionally intertwined, which gives specific and additional risks of dropout. The following Table 1 summarizes all expectations.

Table 1: Hypotheses on the main and intersectional effects on postdoctoral dropout from academia

Inequality dimensions – minority groups	Effect on risk of dropout
Main effects	
H1a: female gender	+
H1b: parental non-academic background	+
H1c: migration background	+
Intersectional effects	
H2a: female gender # parental non-academic background	+
H2b: parental non-academic background # migration background	+
H2c: migration background # female gender	+

4 Data & methods

4.1 Data & sample

We use data from the DZHW PhD Panel 2014 (Brandt/Briedis et al. 2020; Brandt/Vogel et al. 2020), which was conducted by the German Centre for Higher Education Research and Science Studies (DZHW). The target population of the survey were people who had earned doctoral degrees at a German university in the winter semester of 2013/14 or the summer semester of 2014. The data was collected in five annual waves from 2015 to 2019, i.e., approximately one to five years after the respondents' doctoral graduation, and includes information on their employment trajectories. The first wave was realized as a standardized postal survey, and the subsequent waves were realized as standardized online surveys. The full sample in wave 1 consists of 5,408 graduates.

We confine ourselves to those graduates who have completed their doctoral training inside academia and are thus at risk of dropping out from academia after graduation. Therefore, we exclude graduates with no or a non-academic institutional integration during doctoral training (–1,868 cases) and instead use a subsample of graduates who have completed their doctoral training as employees of a university or non-university research institution or within the framework of a structured doctoral program or doctoral scholarship (3,540 cases). Due to incomplete data, some cases needed to be excluded from the analysis sample: graduates who had not indicated their date of graduation (–3 cases), who had not given any information on their employment trajectories after graduation (–986 cases), and whose last job episode was academic, had no ending date, but was also no longer running at the last time of observation (–2 cases). Thus, the final analysis sample consists of 2,549 cases.

Little's (1988) test indicated that the (remaining) missing values were not missing completely at random (x^2: 4,057.79; 3,147 degrees of freedom; p: 0.00), which is a violation of the complete case analysis assumption. Therefore, we applied multiple imputation by chained equations with m = 25 imputations and 70 iterations and used various auxiliary variables to replace missing values in all relevant variables (see Table A1 in the appendix for details on the imputation model). Following the recommendation of White and Royston (2009), we additionally included the event indicator (i.e., dropout from academia) and the Nelson-Aalen estimate of the baseline cumulative hazard as auxiliary variables in the imputation model. Note that both variables did not have any missing values and therefore were not imputed but only used for estimating missing values in the other variables.

4.2 Variables

The dependent variable is duration in months from doctoral graduation until either a dropout from academia or the date of the last participation in the survey. The data includes information on the beginning, ending, and academic setting of graduates' job episodes after doctoral graduation. This information was used to identify whether and when graduates have dropped out from academia. Postdoctoral dropout from academia is defined as first indication of a non-academic job episode after doctoral graduation. Of the 2,549 graduates in the analysis sample, 1,710 dropped out from academia during the observation period and 839 stayed inside academia until their last participation in the survey and are thus right-censored. Thus, we do not know whether these graduates will ultimately drop out from academia or be able to obtain a permanent position inside academia.

The main predictors of interest are gender, parental academic background, and migration background. Because this paper focuses also on their intersectional effects, they are measured dichotomously with 1 indicating the respective minority groups. Thus, gender is coded 1 for female graduates and 0 for male graduates. The parental academic background is coded 1 if none of the graduates' parents has a university degree and 0 if at least one parent has a university degree. Following Buche and Gottburgsen (2012), we assume that graduates have a migration background if they were born outside Germany or if at least one parent has migrated to Germany. If both aspects do not apply, they have no migration background. To test the intersections of the three social categories, we generate pairwise interaction terms between them, which is the recommended analytical strategy for applying quantitative methods to an intersectionality framework (Gross et al. 2016). See Table A2 in the appendix for a description of all predictor variables.

To disentangle inequalities in dropout from academia, we control for discipline and for several academic performance indicators. Previous research has shown that these variables are associated with academic careers (Briedis et al. 2014; Enders/ Bornmann, 2001; Flöther 2017; Franken 2020; Goldan et al. 2023; Jungbauer-

Gans/Gross 2013; König et al. 2021; Leemann et al. 2010; Schulze et al. 2008; Vogel 2020: 312f.). More precisely, we control for the doctoral subject group in six categories, the final grade of the doctorate (summa cum laude vs. other), research productivity given by the numbers of publications and conference contributions during doctoral training, both standardized by subject group, and for age at graduation.

4.3 Event history analysis

We use event history techniques that allow for analysis of the time until event occurrence and of the influence that covariates have on the risk of experiencing that event, while accounting for right-censored data structure. The event is dropout from academia, the onset of risk is the month of doctoral graduation ($t = 0$), and analysis time (t) is the time in months between doctoral graduation and event occurrence or last participation in the survey, i.e., right-censoring.

We estimate semiparametric Cox proportional hazards models (Cox 1972), which model the occurrence of an event as linear function of covariates (Allison 2014: 33ff.; Cleves et al. 2016: 131ff.). The dependent variable is a hazard rate, which is the conditional probability that a particular graduate drops out from academia at a particular time, given that the graduate is still inside academia at that time. The Cox model assumes that the covariates multiplicatively vary the baseline hazard function. It defines the hazard rate for the jth individual as

$$h\left(t \middle| x_j\right) = h_0(t)exp\left(x_j\beta_x\right)$$

where $h_0(t)$ refers to the baseline hazard rate, x_j is a vector of covariates, and β_x is the corresponding vector of regression coefficients to be estimated from the data. Semiparametric means that Cox models are parametric insofar as the effects of the covariates are assumed to be constant over time—i.e., "for any two individuals at any point in time, the ratio of their hazards is a constant" (Allison 2014: 33) (*proportional hazards assumption*)—but that Cox models are nonparametric as far as time is concerned because they do not require any assumption about the distribution of events over time. The estimation method of Cox regression is partial likelihood and depends exclusively on the ordering of events rather than the exact times at which the events occur.

Regression diagnostics (Cleves et al. 2016: 205ff.) indicated no problems[2] except for a violation of the proportional hazards assumptions for the final grade of the

2 We have also tested whether our analyses are sensitive to violations of the additional *non-informative assumption*, which means that the censoring times of randomly censored subjects are not associated with the subject's hazard of dropout at that time (Allison 2014: 15ff.). To test how sensitive our analyses are to violations of that assumption, we have re-estimated an illustrative full model in two extreme ways with different alterations of the randomly censored graduates in the data. First, we have altered them so that they experience a dropout from

doctorate, i.e., that its effect on dropout varies over analysis time. Therefore, in the Cox models the grade is interacted with analysis time, which allows for its non-proportionality. As a result, its regression coefficient still indicates the effect on dropout, but the respective interaction term with analysis time indicates how the effect on dropout develops over time.

A limitation of our analytical strategy is that event history techniques on survey data do not allow us to identify causal effects but only correlative associations. Yet our research interest is on inter-individual differences by gender, parental academic background, and migration background, each of which cannot be experimentally manipulated. In addition, (a) these social categories are clearly exogenous and we do not have any endogeneity issues with them; (b) we are able to model the dynamics of dropout by using event history techniques (in contrast to cross-sectional analyses); and (c) our analyses have a high external validity as we use survey data with real behavior/dropout (compared to, e.g., measures of attitudes or preferences within a factorial survey approach). Thus, we consider our analytical strategy most suitable for our research interest.

5 Results

In the following, we *first* nonparametrically describe survival inside academia (section 5.1). Nonparametric estimation means that there is no assumption about the functional form of the survivor function and that the effects of covariates are not modeled. *Second*, estimating semiparametric Cox regression models, we investigate whether there are social inequalities in postdoctoral dropout from academia (section 5.2). *Third*, we discuss our findings (section 5.3).

5.1 Description of postdoctoral survival inside academia

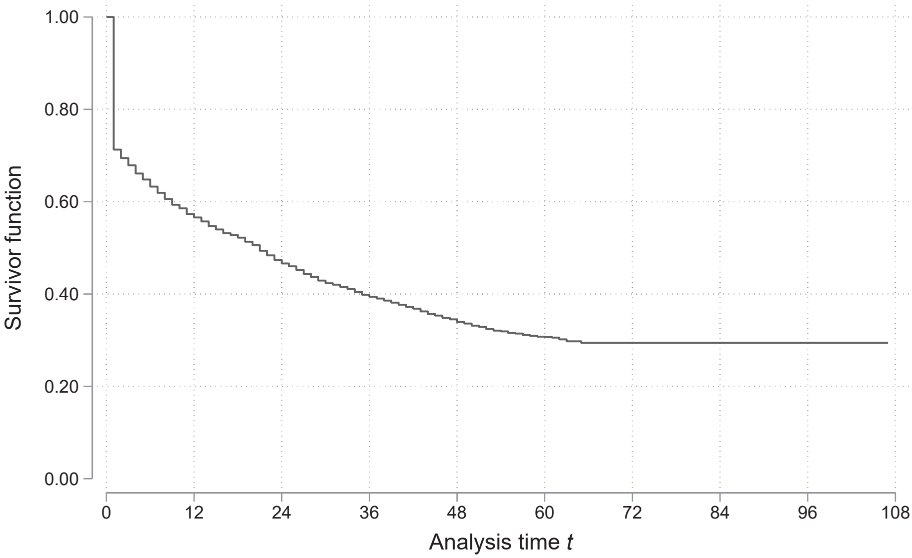
Figure 1 plots the estimator of Kaplan and Meier (1958), which is a nonparametric estimate of the survivor function. The survivor function is the conditional probability of survival beyond a certain point in analysis time, given survival up until that time, or rather the probability that there is no event prior to that time (Cleves et al. 2016: 93ff.). It is equal to 1 at $t = 0$ and decreases towards 0 as t approximates infinity. The x-axis shows analysis time in months, and the y-axis shows the survivor function.[3]

academia at the time of their censoring. Second, we have altered their censoring times to the largest possible observation time in the survey, i.e., the time of wave 5. In both cases, regression coefficients and their statistical significance were very similar to those from the original model (see Figure A2 in the appendix), which indicates that the models are not sensitive to violations of the non-informative assumption.

3 See Table A3 in the appendix for more detailed statistics on survival inside academia. See Figures A1a–c for the Kaplan-Meier survival estimates by each of the social categories. We find that female doctoral graduates, those with a non-academic background, and those with a

The survivor function drastically decreases in the first month after graduation (the probability of survival beyond t = 1 is 71.3 percent)[4] and continuously declines further in the subsequent months and years. However, note that the survivor function is only reliable until approximately t = 60. Thereafter, estimation is unreliable because of too few cases left in the data.[5] Overall, the survivor function is already relatively low in the first month following graduation, but until five years after graduation it further and substantially decreases to 30.7 percent. Therefore, survival inside academia after graduation appears to be the exception rather than the rule.

Figure 1: Kaplan-Meier survival estimates



Note: multiply imputed data, results reported for m = 1, N = 2,549.
Source: DZHW PhD Panel 2014 (4–0–0).

migration background drop out from academia after graduation as quickly as their respective reference groups.

4 Note that we are likely to overestimate dropout in the first month after graduation due to having defined the initial risk set based on the institutional integration during doctoral training. Thus, some of the dropouts in the first month may in fact not occur exactly at that time but rather (shortly) before the official date of doctoral graduation.

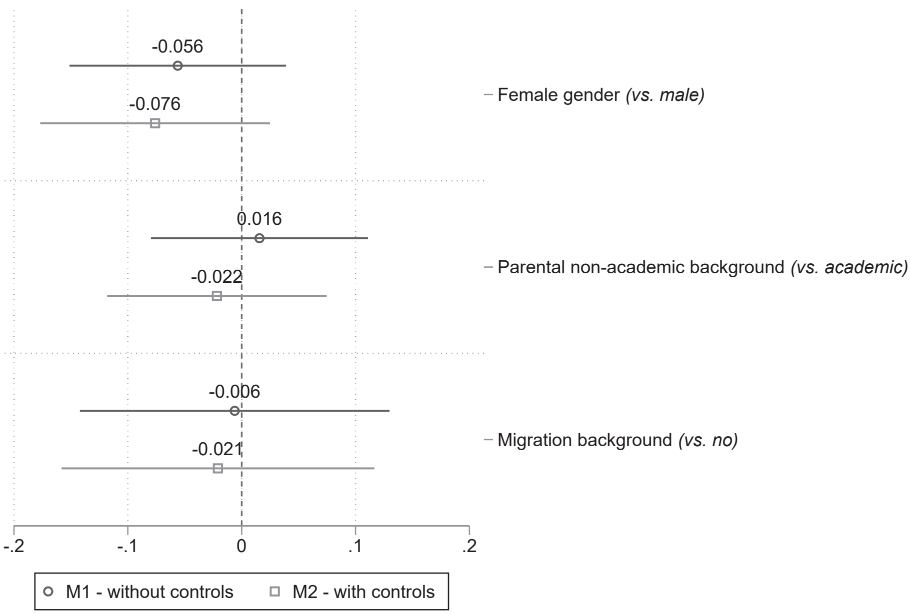
5 Note that the maximum analysis time is t = 107, which indicates that data collection did not work perfectly, because then the maximum time would have been approximately 60 months. However, beyond t = 60 (see Table A3 in the appendix), most graduates are censored anyway, which means that the main analysis time in this paper aligns with the overall observation period of the panel survey.

5.2 Inequalities in postdoctoral dropout from academia

We estimate Cox regression models to test our hypotheses on social inequalities in postdoctoral dropout from academia. In the following, we illustrate the effects of interest by plots of the according point estimators. See Table A4 in the appendix for the detailed regression models these plots refer to. The presented point estimators are reported in the coefficient metric and can be transformed into the hazard-ratio metric through exponentiation with the formula $exp(\beta\,\Delta\,x)$ (Cleves et al. 2016: 132ff., 176f.).

Figure 2 shows the point estimators for the main effects of all social categories both without and with controls. Against expectations, we find that gender, parental academic background, and migration background are not statistically significantly associated with dropout from academia. Thus, none of the expected main effects can be confirmed (H1a–c).

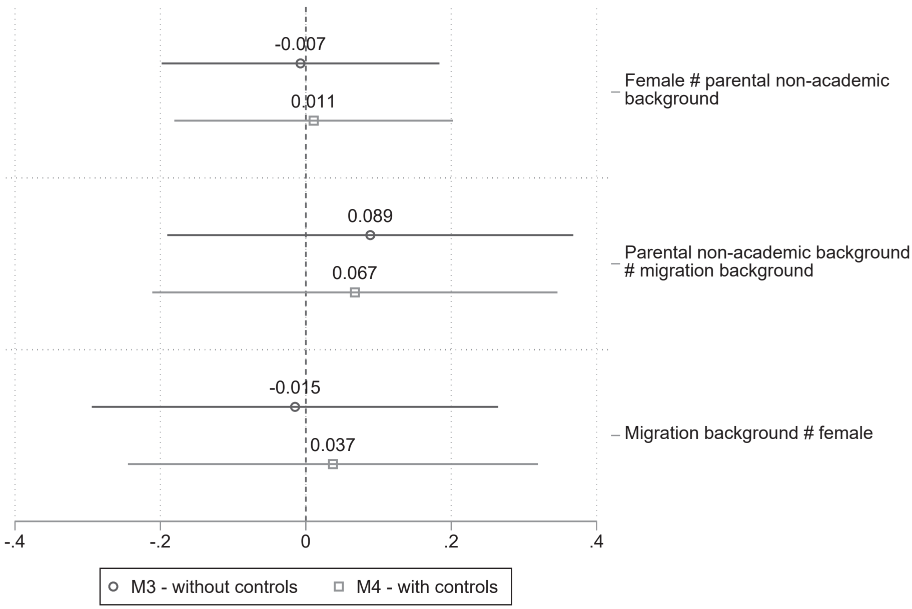
Figure 2: Cox regression on postdoctoral dropout from academia—main effects of all social categories



Note: point estimators and 95 percent confidence intervals presented, multiply imputed data, N = 2,549, M2 controls for doctoral subject group, final grade of the doctorate, numbers of publications and conference contributions, and age at graduation.
Source: DZHW PhD Panel 2014 (4–0–0).

We now turn to the expected interaction effects. Maybe the social categories are not associated directly with dropout from academia, but rather are associated only when their interrelations are taken into account. Figure 3 shows the point estimators for all twofold interaction terms between the social categories both with and without controls. Here again, we find no inequalities as none of the interaction terms is statistically significantly associated with dropout from academia, which opposes H2a–c. Taken together, we find that none of the hypotheses can be confirmed because there are no main or intersectional effects of gender, parental academic background, and migration background on postdoctoral dropout from academia.[6]

Figure 3: Cox regression on postdoctoral dropout from academia—interaction effects of all social categories



Note: point estimators and 95 percent confidence intervals presented, multiply imputed data, N = 2,549, M4 controls for doctoral subject group, final grade of the doctorate, numbers of publications and conference contributions, and age at graduation.
Source: DZHW PhD Panel 2014 (4–0–0).

6 With regard to the control variables (see Table A4 in the appendix), we find that they are all statistically significantly associated with dropout from academia. Doctoral graduates from engineering and computer sciences as well as those from social sciences, economics, and law have a higher risk of dropout from academia than graduates from natural sciences and mathematics. Graduates who have completed their doctorate with summa cum laude have a lower risk of dropout, and the higher the number of both publications and conference contributions, the lower the risk of dropout. Age at graduation is negatively associated with the risk of dropout from academia.

5.3 Discussion

The surprising finding of no inequalities in postdoctoral dropout from academia raises the question of whether there are no inequalities or whether we are simply not able to detect them. For example, in line with Mare (1980), it could be that inequalities tend to exist prior to doctoral graduation, so that doctoral graduates are such a preselected and high performing group that their chances of realizing an academic career are truly based on meritocratic factors and are independent of social categories.

To check the statistical power of our analyses, we have carried out a power analysis and found that with the available sample size, we have a statistical power of 80 percent to detect statistically significant effects with a coefficient size from ±.1203. Because the effects are very small for the social categories under study, these are not statistically significant. Yet overall, the statistical power of our analyses is sufficient, which is also reflected in the fact that we do find statistically significant effects for the controls. Therefore, the data is sufficient for event history analyses on dropout from academia.

We also carried out two robustness checks. *First*, it could be that disciplines are an important sub context and inequalities only show when differentiating between subject groups. To check whether the potential main and intersectional effects on postdoctoral dropout differ by discipline, we have rerun the presented regressions separately by doctoral subject group (see robustness check I in the appendix). However, these subject-specific analyses emphasized the finding of no inequalities in dropout from academia, with one exception. In engineering and computer sciences, female doctoral graduates, as well as those with both non-academic parents and a migration background had a statistically significantly lower risk of dropout from academia. Yet overall, the risk of postdoctoral dropout from academia does not seem to vary by subject group.

Second, it could be that the expected inequalities do not exist with regard to dropout from academia but rather with regard to the reasons for dropout and with regard to the transition to the non-academic labor market after dropout. For example, it could be that the members of a minority group are forced to drop out from academia because their contracts expire without renewal, while members of the respective majority group drop out from academia because of more attractive career options outside academia. In that case, transition to non-academic employment should be smooth and continuous for members of the majority group and difficult for members of the minority group. To exclude the possibility that we have only found no inequalities because they do not exist in dropout from academia but in transition to the non-academic labor market after dropout, we have repeated our regression analyses on these transitions among the subsample of graduates who have dropped out from academia (see robustness check II in the appendix). However, we also found no differences in these transitions by the main and intersectional categories.

Taken together, the expected inequalities are reasonable from a theoretical point of view, in previous research there was some evidence for their existence, and the data and statistical power are sufficient. Nevertheless, empirically we do not find any inequalities, which suggests that there are no inequalities in postdoctoral dropout from academia. However, there are still reasons why we may not be able to detect existing inequalities.

First, minority groups may be more selective with regard to unobserved predictors that decrease the risk of dropout from academia (e.g., better social skills, being more ruthless) and neutralize their ascribed disadvantaged position associated with being member of a minority group. This line of argumentation is, for example, supported by Zimmer (2021) who found that the chances of being appointed to a full professorship do not differ between junior professors from privileged and underprivileged educational families because the latter lack bourgeois serenity and are therefore particularly zealous and take shorter periods of parental leave.

Second, in the case of gender, it could be that discrimination against women and gender mainstreaming to promote women's academic career advancement result in opposite effects that neutralize each other so that overall, there is no main effect of gender. However, with the data at hand we cannot check this presumption.

Third, in the case of migration background, it could be that the effects differ by home country and as long as we do not account for that, we cannot detect the possibly existing associations. Unfortunately, because there are only a few graduates with a migration background in the data, we cannot further differentiate these groups in analyses.

Finally, a more general reason could also be that inequalities in postdoctoral dropout from academia only show in longer-term data, i.e., data that covers more than five years after graduation, because obtaining a permanent position inside academia—which is the only way to avoid dropout from academia in the long term—usually takes more than five years.[7]

6 Conclusions

Building on the intersectionality approach and ambiguous empirical evidence of inequalities in academic careers, this paper aimed to provide new insights into the empirically contested question of whether there are social inequalities in academic

7 The German law on academic employment ("Wissenschaftszeitvertragsgesetz") provides that researchers can be employed on temporary contracts in academia for up to six years before doctoral graduation and up to another six years after graduation (nine for medicine), unless the positions are funded by third parties. This period can be extended for parents by two years for each child born within this period.

careers. Inequalities in access *to* and chances *of* realizing an academic career are problematic because they restrict the career opportunities of certain groups and let their scientific potentials go unused. In addition, they are forbidden by law. Knowledge of inequalities is important to identify measures to address them. Therefore, we have examined whether there are main and intersectional effects of gender, parental academic background, and migration background in postdoctoral dropout from academia. We would like to emphasize that we do not assume that dropout per se is negative and that the ideal-typical realization of an academic career is preferable. Quite the contrary, doctoral graduates can be professionally successful both inside and outside academia. The focus of the problem is not dropout from academia itself but rather when the chances of staying within academia depend on social characteristics.

We have derived our hypotheses against the background of the intersectionality approach complemented by theories on minority and majority groups in the workplace. We expected that female doctoral graduates, those with non-academic parents, and those with a migration background are more likely to dropout from academia than their respective reference groups. In addition, we expected that these social categories are intersectionally intertwined and cause specific and additional inequalities in dropout. We referred to doctoral graduates because they fulfill the general requirements for an academic career but have not yet realized one and could still opt for a non-academic career. To test our expectations, we used panel data on the employment trajectories of doctoral graduates in Germany over a period of five years following their graduation and event history techniques on postdoctoral dropout from academia.

The results indicated that survival inside academia after doctoral graduation appears to be the exception rather than the rule, but that there are no inequalities by gender, parental academic background, or migration background, or their intersections in postdoctoral dropout from academia. Our study contributes to the literature by explicitly examining intersectional inequalities in academic careers, which has hardly been done in previous research and is a more accurate depiction of reality than confining research to the main effects of the social categories only. Thereby, we were able to provide new insights into social inequalities in academic careers for which previous empirical findings were ambiguous. Having used panel data, we were also able to control for discipline and academic performance and to use time-related analysis methods.

Our study is a first step in studying inequalities in dropout from academia. Nevertheless, in the future, more research is needed to challenge our finding that there are no inequalities after doctoral graduation, which we would like to actively encourage. Future research could study postdoctoral dropout from academia over a longer period and inequalities in the chances of eventually being appointed to a chair, an undertaking which will be possible upon the publication of subsequent survey waves of the DZHW PhD Panel 2014. In addition, future research could also examine other social categories, e.g., parenthood and health.

We would like to point out this paper's limitations. *First*, the dichotomous measurement of the social categories is a severe simplification and does not correspond to the complexity of these categories. However, a more differentiated measurement was hardly possible with the data. From a methodological point of view, the dichotomous measurement also helped us to reduce the complexity that is inherent to the categorical intersectionality approach (McCall 2005), and a more extensive measurement would have been detrimental to the generation and interpretation of the interactions. In addition, our measurements correspond to those from previous research. Nevertheless, we see our study only as a first and non-conclusive step in the investigation of intersectional inequalities in academic careers.

Second, the identification of dropout from academia may not be entirely accurate and comparable between graduates because of the way the data was collected. In each survey wave, the graduates were asked to indicate whether their job episodes were academic or not; however, what an academic job is, is not always straightforward and sometimes lies in the eye of the beholder. The definition may depend on criteria such as working tasks and labor market sector, and the criteria used may differ between graduates.

Third, we have controlled for academic performance to disentangle inequalities in dropout. However, it may be that differences in academic performance in fact result from discrimination and that they are thus rather proxies for discrimination that mediate inequalities in dropout from academia than meritocratic controls.

Fourth, our observation period is somewhat limited. With five years after graduation, we have only studied mid-term dropout from academia. Against the background of the German law on academic employment, a longer observation period would have been desirable. Accordingly, our analyses do not allow any statement about whether graduates who were still inside academia when last observed will eventually be able to realize an academic career and to obtain a permanent position inside academia.

Finally, event history techniques do not allow us to identify causal effects but only correlative associations. Since our research interest is on inter-individual differences in postdoctoral dropout from academia between members of different ascriptive social categories, and event history techniques at least account for dynamics, our analytical strategy is the best available approximation of the causal effect.

The fact that we found no inequalities in postdoctoral dropout from academia raises the question of whether there are no such inequalities or whether we were simply not able to detect them. Especially against the background of the repeatedly confirmed phenomenon of the leaky pipeline, this finding is surprising and worthy of discussion. We have suggested several reasons for the finding—inter alia, the opposite effects of gender mainstreaming and discrimination against women having a neutralizing effect on each other, effects of having a migration background differing by home country, inequalities in dropout from academia only showing in the long term. However, with the data at hand we were unable to check these presumptions. Yet we have carried out robustness checks and tested whether inequalities only show in some disciplines and whether our expected risk groups have more difficulties in taking up new jobs after dropout. However, we found no differences by subject group and also no social inequalities in transition to the non-academic labor market.

Further explanations could be related to the aforementioned limitations of our study but also to selections prior to doctoral graduation. Previous research has repeatedly shown that there are social inequalities in participation in, and completion of, higher education. Therefore, doctoral graduates may be such a preselected and high-performing group that characteristics other than social determine their chances of realizing an academic career. In addition, it could also be that minority groups are more selective with regard to unobserved predictors that decrease the risk of dropout from academia (e.g., better social skills, being more ruthless) and again neutralize their ascribed disadvantaged position associated with being a member of a minority group. As long as other studies do not come to different conclusions, our findings allow for cautious optimism regarding inequalities in academic careers.

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Appendix

Table A1: Imputation model

Variables	% missing	# complete	# imputed	Estimator
Dropout from academia[a]	.00	2,549	0	Logit[b]
Nelson-Aalen estimate of the baseline cumulative hazard function[a]	.00	2,549	0	Propensity mean matching[c]
Gender	.27	2,542	7	Logit[b]
Parental academic background	.90	2,526	23	Logit[b]
Migration background	21.30	2,006	543	Logit[b]
Doctoral subject group	.35	2,540	9	Multinomial logit[b]
Final grade of the doctorate	.04	2,548	1	Logit[b]
Number of publications	1.29	2,516	33	Propensity mean matching[c]
Number of conference contributions	6.04	2,395	154	Propensity mean matching[c]
Age at graduation	.12	2,546	3	Propensity mean matching[c]
Educational trajectory[a]	2.86	2,476	73	Logit[b]
Formal type of doctoral training[a]	.00	2,549	0	Multinomial logit[b]
Size of professional network[a]	1.06	2,522	27	Logit[b]
Subjective career prospects inside academia[a]	3.33	2,464	85	Ordered logit
Subjective career prospects outside academia[a]	3.30	2,465	84	Ordered logit
Life goal: having good opportunities for career advancement[a]	.59	2,534	15	Ordered logit
Life goal: working in a managerial position[a]	.63	2,533	16	Ordered logit
Life goal: managing and leading other people[a]	.55	2,535	14	Ordered logit
Life goal: earning a lot of money[a]	.51	2,536	13	Ordered logit
Life goal: expanding my mental horizon[a]	.55	2,535	14	Ordered logit
Life goal: further developing my abilities[a]	.55	2,535	14	Ordered logit
Life goal: developing my personality[a]	.67	2,532	17	Ordered logit

Variables	**% missing**	**# complete**	**# imputed**	**Estimator**
Support: someone who helped with questions about the content of my doctorate[a]	1.22	2,518	31	Ordered logit
Support: someone who helped with methodological/technical questions about my doctorate[a]	1.22	2,518	31	Ordered logit
Support: someone who supported me with their expertise[a]	1.26	2,517	32	Ordered logit
Support: someone who motivated me to work on my doctorate[a]	1.22	2,518	31	Ordered logit
Support: someone who gave me joy in research[a]	1.26	2,517	32	Ordered logit
Support: someone who considered my research project as important[a]	1.29	2,516	33	Ordered logit
Support: someone who supported me emotionally[a]	1.29	2,516	33	Ordered logit
Support: someone who would listen to my worries and problems[a]	1.29	2,516	33	Ordered logit
Support: someone who encouraged me in difficult times[a]	1.49	2,511	38	Ordered logit
Support: someone who put me in touch with researchers at other universities and research institutions[a]	1.29	2,516	33	Ordered logit
Support: someone who put me in touch with people who were particularly relevant for my research topic[a]	1.22	2,518	31	Ordered logit
Support: someone who supported me in expanding my scientific contacts and networks[a]	1.22	2,518	31	Ordered logit
Self-efficacy: in difficult situations I can rely on my abilities[a]	.94	2,525	24	Ordered logit
Self-efficacy: I can handle most problems well on my own[a]	.98	2,524	25	Ordered logit
Self-efficacy: I can usually solve well even strenuous and complicated tasks[a]	1.02	2,523	26	Ordered logit
Academic career intention[a]	2.20	2,493	56	Ordered logit

Note: [a] auxiliary variables, [b] augmented, [c] propensity mean matching with five nearest neighbours.
Source: DZHW PhD Panel 2014 (4–0–0).

Table A2: Description of variables

Variables	Description	Categories	Per cent/ mean	SD
Gender	Graduates' gender	Female	.48	.50
		Male	.52	
Parental academic background	None of the graduates' parents has a university degree	Yes: non-academic	.49	.50
		No: academic	.51	
Migration background	Graduates were born outside Germany or at least one parent has migrated to Germany	Yes: migration background	.17	.37
		No: no migration background	.83	
Doctoral subject group	Subject group of the doctorate	Natural sciences, mathematics	.39	1.55
		Engineering, computer sciences	.17	
		Social sciences, economics, law	.20	
		Humanities, art	.10	
		Medicine	.07	
		Other	.06	
Final grade of the doctorate	Respondents' doctoral graduation grade	Summa cum laude	.27	.45
		Other	.73	
Number of publications	Number of scientific publications that have been published during doctoral training, standardized by subject group		.17	1.20
Number of conference contributions	Number of presented posters and given talks at scientific conferences during doctoral training, standardized by subject group		.17	1.14
Age at graduation	Age in the year of doctoral graduation		31.73	3.63

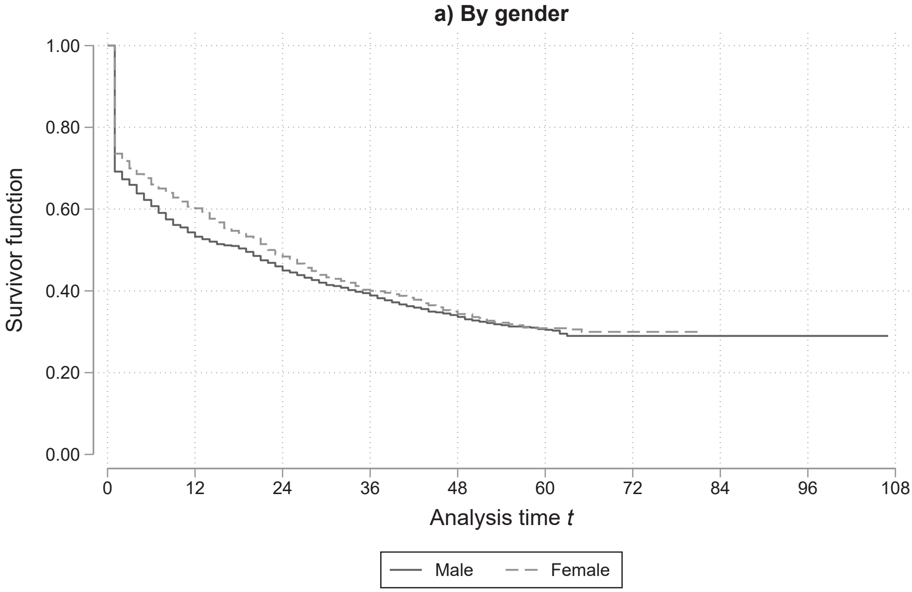
Note: multiply imputed data, results reported for m = 1, N = 2,549.
Source: DZHW PhD Panel 2014 (4–0–0).

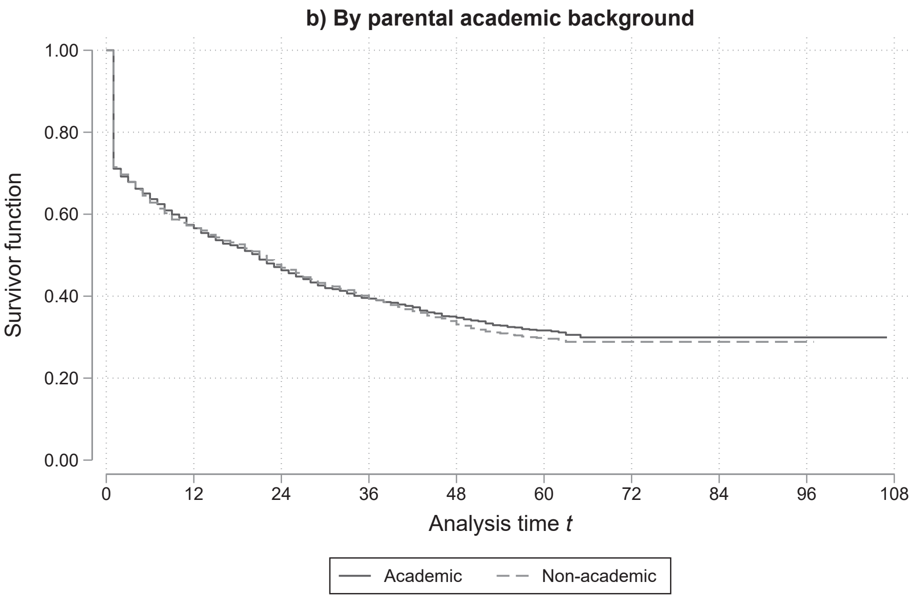
Table A3: Survival statistics over analysis time

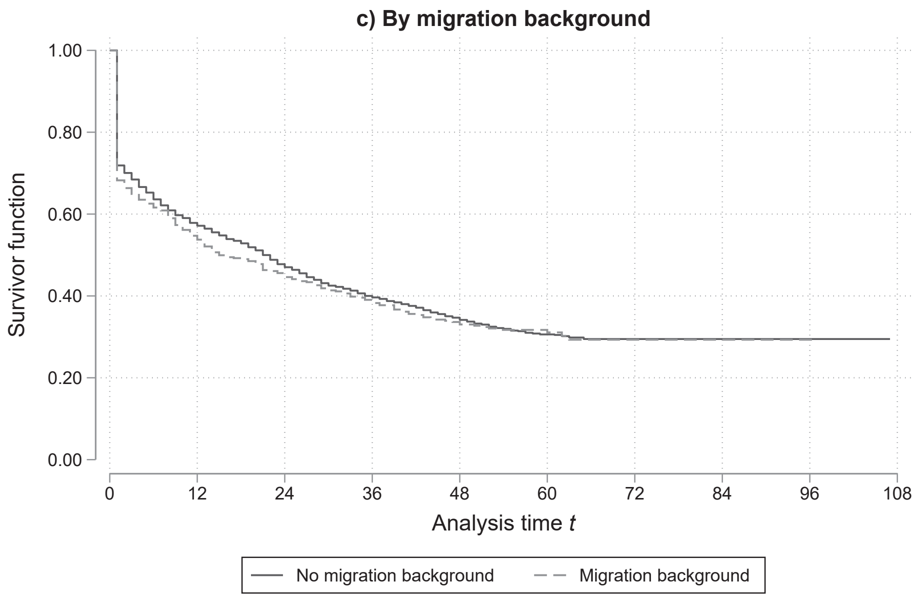
t	# at risk	# dropouts	# censored	Survivor function	Standard error	[95 % conf. int.]	
1	2,549	732	1	.713	.009	.695	.730
2	1,816	47	1	.694	.009	.676	.712
3	1,768	40	0	.679	.009	.660	.696
4	1,728	45	2	.661	.009	.642	.679
5	1,681	33	0	.648	.010	.629	.666
6	1,648	39	0	.633	.010	.614	.651
7	1,609	34	0	.619	.010	.600	.638
8	1,575	34	0	.606	.010	.587	.625
9	1,541	32	0	.593	.010	.574	.612
10	1,509	20	0	.586	.010	.566	.604
11	1,489	31	0	.573	.010	.554	.592
12	1,458	250	50	.566	.010	.546	.585
24	1,158	180	63	.466	.010	.447	.486
36	915	117	104	.394	.010	.375	.413
48	694	67	311	.340	.010	.321	.359
60	316	9	297	.307	.010	.288	.326
72	10	0	10	.295	.010	.274	.315

Note: multiply imputed data, results reported for $m = 1$, N = 2,549.
Source: DZHW PhD Panel 2014 (4–0–0).

Figure A1a–c: Kaplan-Meier survival estimates by social categories

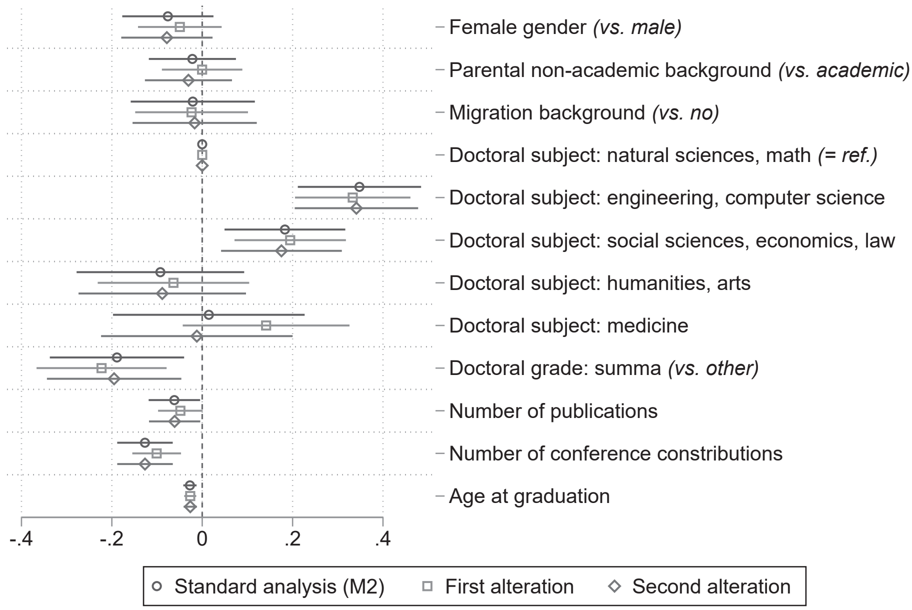






Note: multiply imputed data, results reported for m = 1, N = 2,549.
Source: DZHW PhD Panel 2014 (4–0–0).

Figure A2: Cox proportional hazards models on dropout from academia—illustration of whether analyses are sensitive to violations of the non-informative assumption



Note: point estimators and 95 percent confidence intervals presented, multiply imputed data, N = 2,549.
Source: DZHW PhD Panel 2014 (4–0–0).

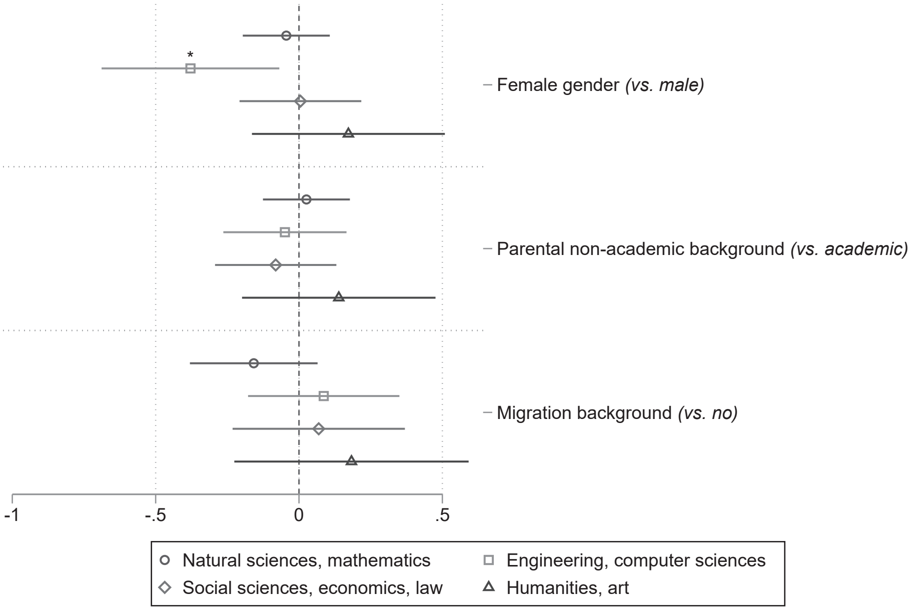
Table A4: Cox proportional hazards models on dropout from academia

Variables	Bivariate	M1	M2	M3	M4
Gender: female (*ref.*: male)	–.056 (.049)	–.056 (.049)	–.076 (.051)	–.049 (.072)	–.087 (.074)
Parental academic background: non-academic *(ref.: academic)*	.016 (.049)	.016 (.049)	–.022 (.049)	.005 (.071)	–.037 (.072)
Migration background: yes *(ref.: no)*	–.005 (.069)	–.006 (.069)	–.021 (.070)	–.042 (.124)	–.069 (.124)
Female gender # non-academic parental background				–.007 (.097)	.011 (.098)
Non-academic parental back-ground # migration background				.089 (.142)	.067 (.142)
Migration background # female gender				–.015 (.143)	.037 (.144)
Doctoral subject group *(ref.: natural sciences, mathematics)*					
Engineering, comp. sciences			.348*** (.070)		.346*** (.070)
Social sciences, economics, law			.183** (.068)		.182** (.068)
Humanities, art			–.093 (.095)		–.093 (.095)
Medicine			.015 (.108)		.015 (.108)
Other			.210* (.103)		.212* (.103)
Final grade of the doctorate: summa *(ref.: else)*			–.189*** (.076)		–.189* (.076)
Number of publications			–.062* (.029)		–.061* (.029)
Number of conference contributions			–.127*** (.031)		–.127*** (.031)
Age at graduation			–.027*** (.007)		–.027*** (.008)
Interactions with analysis time *t*					
# Final grade of the doctorate: summa			–.013** (.004)		–.013** (.004)
Likelihood-ratio χ^2		1.68	160.32***	2.55	160.70***
N		2,549	2,549	2,549	2,549

Note: point estimators in coefficient metric presented, standard errors in parentheses, multiply imputed data; significance: * p <.05, ** p <.01, *** p <.001.
Source: DZHW PhD Panel 2014 (4–0–0).

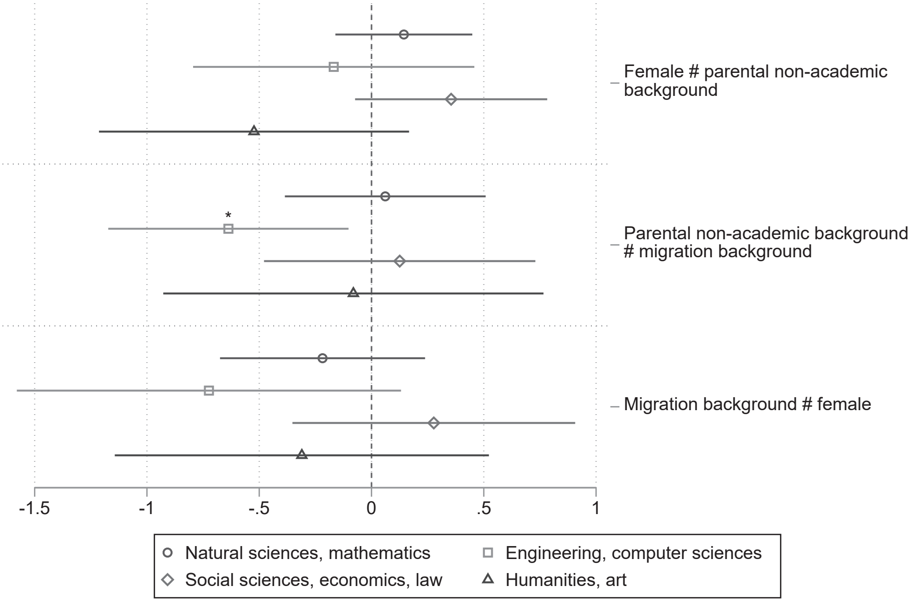
Robustness check I: Postdoctoral dropout from academia by doctoral subject group

Figure A3: Cox regression on postdoctoral dropout from academia—main effects of all social categories by doctoral subject group



Note: point estimators and 95 percent confidence intervals presented, multiply imputed data, N = 2,549.
Source: DZHW PhD Panel 2014 (4–0–0).

Figure A4: Cox regression on postdoctoral dropout from academia—interaction effects of all social categories by doctoral subject group



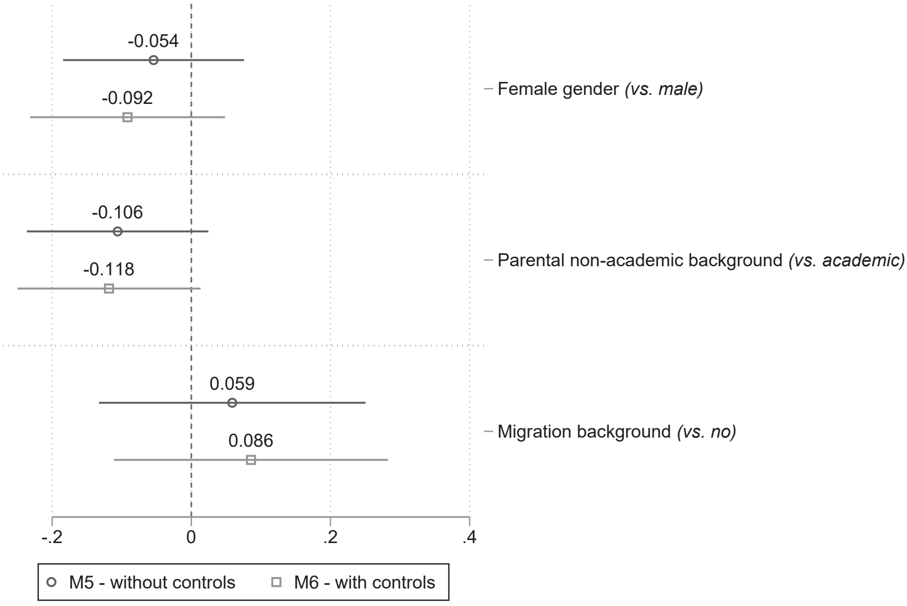
Note: point estimators and 95 percent confidence intervals presented, multiply imputed data, N = 2,549.
Source: DZHW PhD Panel 2014 (4–0–0).

Robustness check II: Transition to the non-academic labor market

To exclude the possibility that we have found no inequalities because they do not exist in dropout from academia but only in transition to the non-academic labor market following dropout, we have repeated our regression analyses on a different outcome variable among the subsample of graduates who had dropped out from academia and who were not self-employed in the first job episode following dropout (N = 1,500). The new outcome variable differentiates between smooth and difficult transitions with the latter being the event under study. Transition to the non-academic labor market is smooth if the next job begins no later than two months following dropout and is permanent and/or in a high position (n = 580). High positions are defined as jobs with management responsibilities and those in the upper or higher grade of the civil service. By contrast, transition to the non-academic labor market is difficult if graduates are temporarily unemployed (i.e., the next job begins three or more months following dropout), their next job is temporary, or not in a high position (n = 920).

See the following Figures A5 and A6 for the key results of Cox regression and Table A5 for the detailed regression models these plots refer to. We again find no social inequalities in transition to the non-academic labor market.[8]

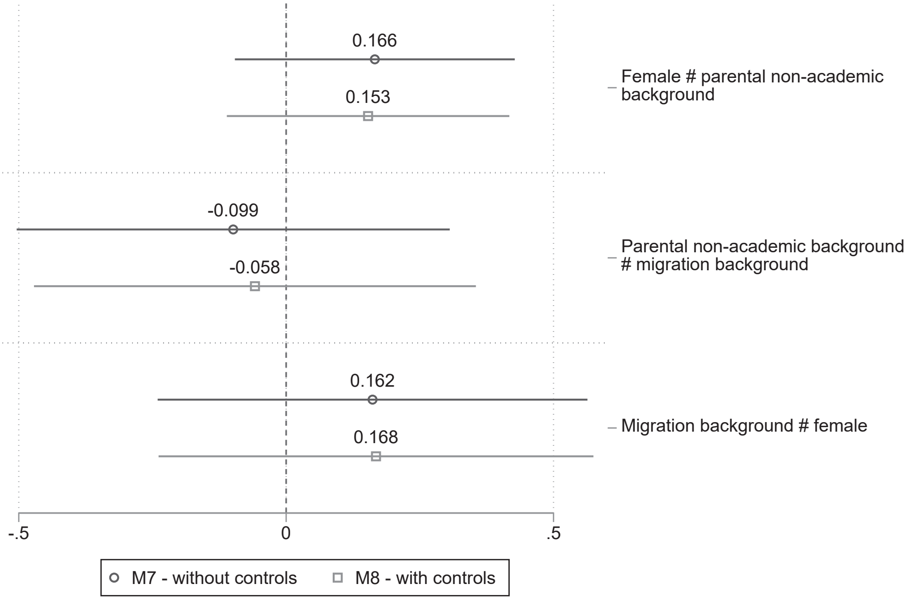
Figure A5: Cox regression on difficult transition to the non-academic labor market—main effects of all social categories



Note: point estimators and 95 percent confidence intervals presented, multiply imputed data, N = 1,500, M6 controls for doctoral subject group, final grade of the doctorate, numbers of publications and conference contributions, and age at graduation.
Source: DZHW PhD Panel 2014 (4–0–0).

8 To ensure that this finding is not biased due to sample restrictions, we have also repeated these analyses with the same analysis sample but additionally including graduates with no or a non-academic institutional integration during doctoral training (3,844 cases of whom 1,278 experienced a difficult transition). However, the result that there are no social inequalities in transition to the non-academic labour market was robust.

Figure A6: Cox regression on difficult transition to the non-academic labor market—interaction effects of all social categories



Note: point estimators and 95 percent confidence intervals presented, multiply imputed data, N = 1,500, M8 controls for doctoral subject group, final grade of the doctorate, numbers of publications and conference contributions, and age at graduation.
Source: DZHW PhD Panel 2014 (4–0–0).

Table A5: Cox proportional hazards model on difficult transition to the non-academic labor market

Variables	Bivariate	M5	M6	M7	M8
Gender: female *(ref.: male)*	–.052 (.066)	–.054 (.066)	–.092 (.071)	–.162 (.099)	–.191 (.102)
Parental academic background: non-academic *(ref.: academic)*	–.104 (.066)	–.106 (.067)	–.118 (.067)	–.167 (.099)	–.179 (.099)
Migration background: yes *(ref.: no)*	.064 (.097)	.059 (.098)	.086 (.100)	.039 (.173)	.043 (.176)
Female gender # non-academic parental background				.166 (.134)	.153 (.135)
Non-academic parental background # migration background				–.099 (.206)	–.058 (.210)
Migration background # female gender				.162 (.205)	.168 (.207)
Doctoral subject group *(ref.: natural sciences, mathematics)*					
Engineering, computer sciences			.025 (.098)		.030 (.098)
Social sciences, economics, law			.220* (.094)		.205* (.095)
Humanities, art			–.005 (.125)		–.008 (.125)
Medicine			.209 (.159)		.205 (.161)
Other			.129 (.149)		.126 (.149)
Final grade of the doctorate: summa cum laude *(ref.: other)*			.182 (.115)		.185 (.115)
Number of publications			–.028 (.037)		–.028 (.037)
Number of conference contributions			–.033 (.033)		–.033 (.033)
Age at graduation			–.035** (.011)		–.036** (.012)
Interactions with analysis time *t*					
# Final grade of the doctorate: summa			.000 (.005)		.001 (.005)
Likelihood-ratio x^2		5.81	782.85**	9.88	842.24***
N		1,500	1,500	1,500	1,500

Note: point estimators in coefficient metric presented, standard errors in parentheses, multiply imputed data; significance: * p <.05, ** p <.01, *** p <.001.
Source: DZHW PhD Panel 2014 (4–0–0).

Ester Höhle*

Fixed-term employment and leaving intention

An analysis of junior academics across Europe**

Abstract: The academic career systems in Europe differ significantly. While in tenure systems, permanent positions can be obtained shortly after the doctorate, in up-or-out systems, most researchers remain in fixed-term employment until they become professors. Therefore, the article focuses on how the type of contract affects the intention of post-doctoral researchers to leave academia in different countries, using theoretical labor market concepts as well as the social-cognitive approach. Findings based on EUROAC data from ten European countries show that more researchers in up-or-down systems intend to leave academia than in tenure systems. This applies to both temporary and permanent researchers. Still, the duration of work contract – especially temporary employment without prospects of permanent employment – is a significant predictor for leaving academia even after controlling for other factors. In contrast, job satisfaction plays an important role in both groups for the remain. In addition, the number of publications only has a significant influence in tenure systems and does not play a role in the up-or-out systems. It is also only in tenure systems that women with children show a lower leaving intention – whereas in Germany for example, the compatibility of an academic career with a family is discussed as a problem area.

Keywords: Employment system; fixed-term employment; early career researchers; intention to leave; international comparison

Befristung und Ausstiegsintention

Der wissenschaftliche Nachwuchs in Europa

Zusammenfassung: Die akademischen Karrierestrukturen in Europa sind sehr unterschiedlich. In Tenure-Systemen können Wissenschaftler/innen nach der Promotion unbefristete Stellen erhalten, in Rauf-oder-raus-Systemen verbleiben die meisten Wissenschaftler/innen bis zur Professur in befristeten Arbeitsverhältnissen. Daher konzentriert sich dieser Beitrag auf die Frage, wie sich die Vertragsart auf

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die Absicht promovierter Wissenschaftler/innen in verschiedenen Ländern auswirkt, die Wissenschaft zu verlassen. Dazu werden arbeitsmarkttheoretische Überlegungen sowie der sozial-kognitive Ansatz zugrunde gelegt. Die Ergebnisse, die auf den EUROAC-Daten aus zehn europäischen Ländern basieren, zeigen, dass Wissenschaftler/innen in Rauf-oder-raus-Systemen häufiger beabsichtigen, die Wissenschaft zu verlassen als diejenigen in Tenure-Systemen. Dies gilt sowohl für befristet als auch für dauerhaft beschäftigte Wissenschaftler/innen. Die Vertragsdauer – insbesondere die befristete Beschäftigung ohne Verstetigungsperspektiven im Vergleich zur Dauerbeschäftigung – ist auch nach Kontrolle durch weitere Faktoren ein signifikanter Prädiktor für das Verlassen von Universitäten. Im Gegensatz dazu trägt in beiden Gruppen Arbeitszufriedenheit zum Verbleib in der Wissenschaft bei. Die Publikationsstärke hat nur in den Tenure-Systemen einen signifikanten Einfluss und spielt in den Rauf-oder-raus-Systemen interessanterweise keine Rolle. Ebenfalls nur in den Tenure-Systemen zeigen Frauen mit Kindern eine geringere Ausstiegsintention – dabei wird grade in Deutschland die Vereinbarkeit einer wissenschaftlichen Karriere mit Familie als ein Problemfeld diskutiert.

Stichworte: Karrieresystem; Befristung; wissenschaftlicher Nachwuchs; Ausstiegsintention; internationaler Vergleich

1 Introduction

The decline in career prospects for early career researchers (ECR) is a general phenomenon that all higher education systems in Europe have been confronted with over the last two decades (Jones/Finkelstein 2019; Shin et al. 2014). Increasing numbers of PhD holders and falling rates of permanent employment predestine that many ECRs leave academia, be it voluntarily or through lack of opportunity (McAlpine/Emmioğlu 2014). In the first few years after obtaining a doctorate, between 15 percent (Portugal) and 79 percent (Austria) of ECRs leave academia (Auriol 2013; Höhle 2016: 177) and in Germany, only one in ten doctorate holders becomes a professor (Konsortium 2013). Therefore, research into the reasons for leaving academia and the role of contracts is of high interest for higher education policy, university governance and the quality of academic research.

When examining academic careers, it should be noted how tremendously the academic career systems within Europe differ from country to country (Finkelstein/Jones 2019; Teichler/Höhle 2013). On the one hand, tenure systems offer a permanent position shortly after completion of the doctorate; with a permanent position, staying in academia is guaranteed for the ECRs. Up-or-out systems, on the other hand, keep researchers in temporary contracts right up to the level of professorship (Kreckel 2008). There, the ECRs, who are often into their forties, remain unsure whether they will manage to secure one of the few permanent positions. According to Metz-Göckel et al. (2016), temporary ECRs in Germany have very little chance of ever finding a permanent position in academia. For them, employment insecurity is a key reason for leaving academia (Zhou/Volkwein 2004; McAlpine/Emmioğlu 2014).

As most studies about intention to leave academia are based on only one employment system, the existing research leaves a gap regarding the interplay between different employment systems. Since it is generally assumed that the intention to leave academia depends on the employment system, the question becomes: Does it vary across different systems? Therefore, the paper focuses on how the type of contract affects the intention of young researchers in different career systems to leave academia. Does the type of contract have the same effect on intention to leave academia in systems with early employment stability as it does in up-or-out systems? Bluedorn (1982) and Flöther (2017) have shown that intention to leave is a reliable indicator of actual exit.

In addition to uncertain prospects, several additional factors for leaving academia are highlighted in the literature on academic careers. The most frequently-discussed drivers include the lack of integration into the scientific community and lack of job satisfaction (e.g., Metz-Göckel et al. 2016; Padilla-González/Galaz-Fontes 2015; Jaksztat et al. 2017; Schröder et al. 2021; Jungbauer-Gans/Gross 2013; Kahlert 2013). According to Broadbent et al. (2013), temporary positions in academia often differ from permanent in terms of institutional resources, influence in the department, and social integration. Therefore, the employment contract is modeled as mediated by the predictors of integration into the institution and the scientific community, and job satisfaction. The study focuses on the questions:

- **Does the intention to leave academia differ depending on the career system?**
- **Does the intention to leave academia depend on the early career researchers' employment contracts?**
- **Can other reasons, namely integration into the institution and the scientific community, along with job satisfaction, explain the effect of the type of contract on the intention to leave academia?**

Hypotheses are developed with the help of different theoretical perspectives from e.g., labor market theory, social-cognitive theory, and organizational psychology. Since the division into tenure and up-and-out systems does not well describe all ten chosen career systems, I introduce the categorization into early and late permanent employment systems that serves as a framework for the empirical investigation. Subsequently, the role of employment contract for the intention to leave academia is analyzed in multivariate analyses.

2 Theoretical frame and literature review

Although the intention to leave academia is very personal and is influenced by individual factors, it occurs in a context of career structures *within* academia and career opportunities *outside* of academia. The individual employment situation, integration into the institution and the scientific community, job satisfaction, belonging to a discipline and the family situation can all influence the intention to leave. In this section, theoretical perspectives for each aspect are presented together with the corresponding literature review. Four hypotheses are derived from this. Although studies on intention to leave academia go back several decades, they are still limited in number. Those available focus on different countries with different career systems; they take different researcher groups into account, and each pursues their own specific question and approach. Therefore, the possibility for a comparison between European countries, and especially regarding the group that falls between PhD and professorship, is limited. Also, not all studies observe the effect of employment contract in their model; however, a few studies do systematically consider the employment contract and some, but not all of these confirm its importance for the decision to leave academia (Metz-Göckel et al. 2016; Padilla-González/Galaz-Fontes 2015; Aarnikoivu et al. 2019).

2.1 Employment system and opportunity structures

The decision for or against continuing an academic career takes place in the context of academic career structures and of extramural labor market opportunities. Labor market theory describes the interplay between higher education expansion, which leads to an increase in doctorates, and the demand for knowledge-intensive workers in all sectors (Schubert/Engelage 2006; Hadjar/Becker 2006). In the countries where the number of doctorate holders is growing, it exceeds the demand in academia, and the doctorate holders are striving for the extramural labor market. There, they increase the supply of highly qualified workers. The tertiary labor market incorporates them, reacts with increasing knowledge-intensity in all sectors and with an increase in the number of entrance qualifications. This leads to a higher demand for academics on the non-academic labor market. According to Schubert/Engelage (2006) and Hadjar/Becker (2006), the dynamics between the educational structures and the labor market exert both pull and push factors on academics.

Pull factors motivate ECRs to enter the non-university labor market and can be described as opportunity structures for finding adequate employment outside of academia. On labor markets with a developed knowledge economy, more private firms conduct research or apply academic knowledge than in less developed economies. Therefore, knowledge economies offer better opportunities for graduates than can be found in less-developed markets (Stehr 2001; Drucker 1968; Bell 1973). Also, by shaping it, high numbers of graduates and doctorate holders contribute to the knowledge intensity of the non-university labor market over time. Therefore, national contexts can be categorized according to the knowledge intensity of the labor market.

Push factors motivate ECRs to withdraw from academia. The national university employment systems provide more- or less-selective environments for ECRs and thus, determine the chances of permanent employment at university. A certain number of researchers compete for a certain number of permanent positions. In less selective systems, the chance of permanent employment is higher because the ratio between PhD holders and permanent positions is more balanced than in more selective systems. In more selective systems, however, a greater number of PhD holders compete for fewer permanent positions. This leads to the expectation that the intention to leave academia differs between systems with long periods of temporary employment and systems with early permanent employment.[1]

Tracer studies about PhD holders show that both PhD rates and the proportion of PhD holders working outside of academia vary widely across countries (Auriol et al. 2013). Konsortium (2013: 291) analyzes postdoctoral researchers in Germany shortly after completion of their doctorates and shows that not all of them naturally aspire to an academic career, but that over 30 percent aspire to a career outside of the university and 43 percent are open to both sectors. The motivation to leave research depends heavily on the alternative offers on the non-university labor market and on the academic discipline (see also Vogel/Hinz 2004). Waajer (2017) states that for PhD graduates in the Netherlands, the perception of job prospects is relevant to the sector of their job search. Overall, they assess the prospects in academia to be significantly worse than those outside academia. Reasons that still motivate them to stay in academia include are the intellectual challenge, the independence, the opportunity for personal development and the opportunity to contribute to society. However, not every highly developed economy offers attractive positions for postdocs, especially for those interested in research. In Germany, only some of those PhD holders who work outside university conduct research and development (Flöther 2017; Konsortium 2017: 186f) or can apply scientific methods (Konsortium 2013). According to a qualitative study from the UK and Switzerland, half of the PhD graduates interviewed find it difficult to make a start in the non-academic labor market, they have problems understanding the organizational culture and their own function inside the organizational structure (Sakni et al. 2022). An international study examining whether there is a correlation between the PhD rate, temporary employment contracts at universities, economic status in a country and the proportion of PhD holders outside of academia (Höhle 2016; 2019) tentatively confirms a correlation; the research intensity, the proportion of PhD holders and the percentage of PhD holders working outside of academia increases with a higher economic status, but the percentage of permanently-employed academics decreases.

1 Long temporary employment is found e.g., in habilitation systems in the Humboldtian model (e.g., Germany, Austria, Switzerland), early permanent employment is found in tenure systems of the Newmanian model (e.g., UK, Ireland, Netherlands).

***Hypothesis 1*: ECRs in systems with late employment stability ("LatePECs", see next paragraph) show a significantly higher rate of intention to leave academia than ECRs in systems with earlier employment stability ("EarlyPECs").**

2.2 Fixed-term Employment and Intention to Leave

According to the tournament theory of Lazear/Rosen (1981), a tournament is a reward system in which reward differences between employees are not based on their individual outcomes, but only on relative differences between individuals. In academia, this situation occurs when a certain number of positions (or, e.g., journal articles, funded projects, etc.) are distributed among a random number of competitors, where even good applicants are likely to miss out (Burk et al. 2016). According to Lent et al., career decisions are made based on a set of beliefs: "Social-cognitive theory suggests that people act both on their assessment of what they can do and on their beliefs about the likely effects of different actions" (Lent et al. 1994, pg. 84). According to this, the interests of the individuals and their career goals are moderated on the one hand by their expectations of self-efficacy ("can I do this"?) and on the other hand by their expectations of results ("if I do this, what will happen?"). In the academic environment, where there is limited access to permanent positions, ECRs attempt to assess their chances of staying in the system (or pursuing a career in the system that suits their goals). Since they know the academic field, they can assess their own strengths and weaknesses relatively well and compare them with those of other ECRs. They are also likely to be able to estimate what further investment is needed to reach their goals and find working conditions with which they are comfortable (e.g., a permanent contract). With this in mind, ECRs can reasonably assess their chances of winning the tournament. The end of a temporary contract represents a critical moment when ECRs can again choose either to compete in the tournament or potentially leave academia. Each transition from one contract to the next can involve a smaller or larger effort (e.g., applying for a job, writing a project application) and can be accompanied by changes (e.g., of university, department, team, or research topic). Especially in a situation of precarious employment, the transition can provoke a fundamental reappraisal of the academic career as a goal (Lent et al. 1994). Considering the prospects for remaining in the system or possible other alternatives, the decision to be an academic may be reconsidered. Therefore, a contractual transition can act as a recalibration of career goals. It can lead to self-selection by those ECRs who consider their own ability to be too poor to achieve the desired position, those who are (or have become) generally dissatisfied in their academic work, and those who expect a different professional situation, e.g., regarding employment stability, investments, and opportunities for self-realization (Best et al. 2016). On the other hand, for researchers with permanent employment, leaving a secure position at the university is a major loss of security and thus a decision that requires a higher motivation to change than is the case with their colleagues in temporary positions. This motivation would be either to want to leave the existing status (push-effect) or to want to take an alternative option (pull-effect). With either type of contract, opting for a position outside academia carries some risk, as most ECRs have no work experience outside academia and are therefore unable to assess whether their academic competencies match the requirements.

In empirical studies, the correlation between contract and leaving intention is rarely analyzed in a systematic way, although temporary employment is an often-discussed topic in the (German) literature on academic careers. Metz-Göckel et al. (2016: 75ff) show the important role that the contract plays when leaving academia. They examine mid-level faculty in Germany after they have left academic work at universities. When asked about their reasons for leaving, two-thirds of the formerly temporary academics reported they left because their employment contract was expiring, and 13 percent cited the "Wissenschaftszeitvertragsgesetz", a national law that limits the possible employment time for ECRs. Another quarter dropped out due to dismissal. The authors also note that women drop out earlier than men but are more likely to stay in higher education, e.g., in higher education management. Aarnikoivu et al. (2019), who studied temporary ECR academics at Finnish universities, found that their intention to leave was most often due to stress related to job-insecurity, dissatisfaction, and a desire for a higher salary. Padilla-González/Galaz-Fontes (2015), on the other hand, conduct a country comparison. They compare 15 countries from four continents from the Changing Academic Profession (CAP) dataset (6 countries from Europe, 3 from North America, 3 from Asia, 1 from South America). In the CAP study, the same questionnaire was used as in the EUROAC study; however, the sample of respondents analyzed includes all academic ranks (including those without doctorates as well as professors) plus lecturers from universities of applied sciences and those without research or teaching activities. They conclude that the employment contract has a significant effect on the leaving intention in only four countries (Finland, Japan, Canada, and the Netherlands).

***Hypothesis 2*: ECRs with fixed-term contracts intend to leave academia more often than permanently-employed ECRs.**

2.3 Intention to leave and contract duration: integration into the scientific community

According to Schein (1971), the organization is structured along boundaries that divide into center and periphery; functional boundaries as well as boundaries of inclusion and exclusion. Employees within an organization can occupy either a more peripheral or a more central position. With the latter, they belong to the inner circle, have access to internal information, and can influence organizational decisions (Schein 1971). The distinction between central and peripheral positions brings with it differences in access to internal information, participation in decision-making, networking, and the assignment of worthwhile tasks. It is assumed that in highly structured organizations, fixed-term employees are more affected by marginalization than permanent employees. This concept is to be combined with Goffman's (1952) concept of 'cooling out'. The term 'cooling out' describes a gradual loss of professional interest throughout the academic career, followed by disintegration, which can ultimately lead to dropout. Cooling out among researchers is attributed in particular to the disappointment at expectations of recognition not being met, at the lack of integration into social networks and at the lack of support from gatekeepers or supervisors (e.g., Kahlert 2012; Metz-Göckel et al. 2010); it gradually leads to a withdrawal from academic life. Being pushed out of jobs and (institutional and non-institutional) networks can go hand-in-hand with a gradual loss of interest and loss of identification as a researcher. Here I assume that temporarily-employed researchers have a higher risk of falling into peripheral roles and—due to poor integration—of getting into a cooling out process that leads to their exit. Since, according to Laudel/Gläser (2008: 390) academic integration takes place both in the scientific community (especially for research-related activities) and at one's own institution (especially for teaching-related activities), both fields are considered here.

Most empirical studies do not refer directly to the concept of integration, but to various measurable aspects of it. Broadbent/Strachan (2016) and Broadbent et al. (2013) found in their study of ECRs in Australia that fixed-term employees, compared to permanent employees, are clearly disadvantaged in several aspects, e.g., in the development of their own research profile, the formation of networks and cooperation, and in their publication opportunities. Because of the negative impact of precarious employment on academic careers themselves, they argue that temporary workers are part of a 'secondary' university workforce. Höhle (2015b: 1434) examines academics at all career levels in Germany, the Netherlands and Norway and finds that, among other factors, the contractual conditions (permanent contract, full-time employment, and a research-intensive position) correlate significantly with achieving a leading role in research. Jaksztat et al. (2017) examine young academics in Germany before and immediately following completion of their doctorates. They find that perceived support, involvement in scientific networks and involvement in activities in third-party-funded projects strengthen motivation to stay in academic research. For doctoral students who work outside universities, on the other hand, starting an academic career is rather unlikely. However, Schröder et al. (2021) and Jungbauer-Gans/Gross (2013) show that recognized publications increase the chance of a tenured professorship in Germany. Both note that more women are leaving universities, but those who remain have a higher chance of becoming professors than do men. Parasız et al. (2017) found in their study of academics in Turkey that organizational commitment, with its core element, emotional commitment, is a significant determinant for exit intentions. Gender and marital status have no influence in their multivariate model.

***Hypothesis 3*: The relationship between contract duration and intention to leave academia is fully mediated by the integration into the institution and the scientific community.**

2.4 Intention to leave and contract duration: job satisfaction

Various types of academic resources (or: academic rewards)—both social and financial—can increase job satisfaction and thus motivate people to stay in academia. Bandura posits that "Some of the most valued rewards of activities are in the satisfaction derived from fulfilling personal standards, rather than in tangible payoffs" (Bandura 1986: 231). Since intrinsic drive plays a special role for the academic profession (Beaufaÿs 2003), satisfaction can arise from academic content, but also, for example, from autonomy within the institution or interaction with students and colleagues, and so forth (Lent et al. 1994: 90). According to Schein's approach, employees on the periphery of the organization have less easy access to the rewards that can contribute to job satisfaction. They may also have less employee participation, less power within the organization and less access to resources that can be used to increase status (e.g., financial, and personal resources). Furthermore, employees on the periphery may also have less access to the intangible academic rewards such as visibility, interesting assignments, publishing opportunities, networks, and attractive topics. All of this can result in fixed-term employees achieving lower levels of job satisfaction than permanent employees. Therefore, assumedly, fixed-term contracts can lead to low levels of job satisfaction which in turn reduces staying in academia.

In a study on academic job satisfaction in Poland, the authors find that job satisfaction depends, among other factors, on the social significance of the research contents carried out (Szromek/Wolniak 2020). In a study from the Netherlands, the authors examine the effect of fixed-term contracts on the job satisfaction for ECRs (Waajer et al. 2017). They find that fixed-term contracts have a negative effect on job satisfaction, and on job content and work-life satisfaction, especially for employees without prospects for permanence. Goldan et al. (2022) use panel data to confirm the correlation between fixed-term contracts and job satisfaction for doctorate holders in Germany. According to their analysis, the correlation in the academic sector is significantly higher than in the private sector. Castellacci & Viñas-Bardolet (2021) support the result for European countries with data from the MORE2 study. They emphasize that in the multivariate model, the contract type has the largest impact on job satisfaction, especially mid-career. An additional significant factor that contributes to job satisfaction is the perception of good job prospects. In the continental and Scandinavian countries, both the type of contract and the employee's age have greater impact on job satisfaction than in Anglo Saxon countries or in southern and eastern Europe. In a Dutch study on the dropout of doctoral students, the authors find that respondents value the experience of openness, integrity, trust and freedom, but report being dissatisfied when they experience unhealthy research practices, such as lack of time for research, insufficient support, insufficient supervision and unethical practices. Those who are dissatisfied with unhealthy research practices are significantly more likely to consider leaving academia (Kis et al. 2022). Most studies on leaving intention focus on a single national system and therefore have limited comparability between countries. The study by Padilla-González/Galaz-Fontes (2015), however, compares 15 countries and concludes that the factors that lead to the intention to leave academia vary so much from country to country that no common pattern can be discerned. In fact, job satisfaction is the only significant common factor that determines leaving intention across all countries.

***Hypothesis 4*: The relationship between contract duration and intention to leave academia is fully mediated by job satisfaction.**

The causal direction of the hypotheses presented is based on an assumption. The opposite direction would also be conceivable, e.g., where an academic is planning to leave academia and therefore neither searches for a permanent contract nor tries to integrate in the scientific community and is satisfied despite having little access to academic rewards. However, it seems most probable that academics planning to leave university would already have done so after completing their doctorates, so they are therefore no longer included in the sample. It is therefore also assumed here that those in the sample intended to remain in academia following completion of their doctorates and that their intention to leave only arose due to the work itself.

3 Data Base, Country Categorization, Measures

3.1 Data Base

The data used for the analysis of the intention to leave were collected in the international study EUROAC "The Academic Profession in Europe: Responses to Societal Challenges", which was funded by the German Research Foundation.[2] It was headed by Prof. Dr. Dr. h.c. Ulrich Teichler at the International Center for Higher Education Research (INCHER) in Kassel. In the survey, academics employed at higher education institutions were asked about their careers, their academic activities and views, and also about institutional governance. The EUROAC project, whose results from 10 European countries are analyzed here, was carried out in 2010–2012 as an international collaborative project. The same questionnaire was used in each country. Valid answers were given by 13,828 academics working at universities. The information used here is limited to the responses of ECRs holding a PhD but not yet a professorship and who are active in teaching and/or research; that is, 4,742 valid cases, of which 4,554 also answered the independent variable leaving intention. Case numbers vary from 161 in the Netherlands to 1,575 in

2 For reasons of data protection, the international team decided to share the data only among project members and not publish them as a scientific use file. The Syntax that is written for this text can be downloaded here: https://doi.org/10.7802/2526.

Poland (case numbers in the other countries are: Switzerland: 426, Austria: 672, Germany: 500, Portugal: 162, Ireland: 276, United Kingdom: 371, Norway: 299 and Finland: 300). The results are considered to be representative (for detailed methodical information see Teichler/Höhle 2013). Doctoral students are excluded from this analysis, first, because their status varies from student to faculty member by country. Second, the PhD has a dual function: the selection between those who aspire to a career in academia and those who aspire to a position outside of academia usually occurs with the transition to post-doc (Jones/Finkelstein 2019; Kreckel 2008). In an international comparison, the career phase between doctorate and professorship seems to be well suited to studying whether or not to remain in an academic career, since the decision for or against staying is usually made in this phase (cf. IDEA consult 2013). All academics not active in research or teaching are also excluded. As a secondary analysis, the selection of countries and the operationalization of the indicators are based on the availability of data. The selected countries are similar in their characteristic of belonging to first-world OECD counties within the European Research Area, but they show a wide variety of career structures. Therefore, this composition seems suitable for a cross-country analysis of academic careers. When selecting the country cases, only those with a satisfactory number of cases, data quality and number of valid answers in the key questions were selected.

3.2 Categorization of Countries

The career systems differ in their structure. The central-European systems (Germany, Switzerland, Austria) go back to a long tradition of chair systems in which research-intensity, a post-doctoral qualification (habilitation, or: "second book") and the dependence on a professor go together with long phases of fixed-term employment (up-or-out systems). The United Kingdom, Ireland, and the Netherlands, on the other hand, belong to the classic department systems.

There, the intensity of teaching and a higher degree of independence in early career phases go hand-in-hand with early permanent employment (tenure systems). However, the systems in Portugal, Poland, Finland, and Norway, differ in a few features from the British and the German systems. Although the Polish system traditionally follows a chair structure, it is more teaching-oriented and ECRs can achieve permanent employment relatively early in their careers. Portugal, Finland, and Norway formerly used chair systems but later adopted the department structure, which has led in part to a hybridization of both. Nevertheless, research intensity and long employment instability persist (Teichler et al. 2022; Höhle 2015a). Therefore, here I categorize the systems into two groups according to the duration of employment instability. The contract variable in the questionnaire is well suited for this. This variable is measured in five categories (see Table 1).

Table 1: Employment contract by country (percentage)

	Germany	Norway	Austria	Finland	Switzerland	Netherlands	Portugal	Poland	Ireland	United Kingdom	Means, range	Means, range
Tenure	8	12	26	29	16	52	36	17	58	46	18 8–29	42 17–58
Continuous without guarantee	22	4	10	11	13	6	2	42	18	18	12 4–22	17 2–42
Tenure-Track	5	5	8	7	4	14	30	37	19	32	6 4–8	26 14–37
Fixed-term without Prospects	63	75	49	40	66	28	29	4	5	4	59 40–75	14 4–29
Other	2	3	7	14	1	1	3				5 1–14	2 1–3
Total	494	298	650	297	421	161	155	1557	269	361	2160	2503

Source: EUROAC-survey; Question: What is the duration of your current employment contract at your higher education institution?

For a categorization, the five items are summarized into a binary variable with the characteristics permanent employment (tenure & continuous without guarantee) and temporary employment (tenure-track & fixed-term without prospects & other) in a first step. Second, the ECRs are split into two career tiers. A classification according to academic positions is not suitable, since the positions between doctorate and professorship are too heterogeneous from country to country and therefore not comparable (OECD 2013:139–145; Kreckel 2008)[3]; therefore, the academic positions are not suitable for a cross-national categorization into career levels. For these reasons, the career levels for the ECRs are categorized into postdocs (0 to 6 years after graduation) and upper juniors (6 or more years after graduation), according to the scheme proposed in the Frascati Manual (OECD, 2002), which is reconstructed based on the survey data. Since in most countries, the postdoctoral phase is intended as a probation and selection phase as well as for further qualification for a professorship, fixed-term employment is a legitimized standard. On the other hand, especially in countries with tenure systems, ECRs in the upper junior phase are considered as mature academics and are accepted as peers, and therefore can expect to be continuously employed. In countries in which the qualification and selection processes are continued up to a professorship—especially in countries with chair systems in which the habilitation (or similar assignments) is a further qualification—temporary employment continues into late career phases. Since the differences between the career systems are particularly evident in the stage of the upper junior,

3 The positions in each national system differ and are not comparable.

this career stage serves as the main reference point for distinguishing between systems with early and late permanent employment. Countries where fewer than half (<50 percent) of upper juniors are permanently employed are categorized as Late Permanent Employment Countries (LatePECs), and countries where more than half (>50 percent) of upper juniors are permanent are categorized as Early Permanent Employment Countries (EarlyPECs) (Höhle 2015a; 2019). Table 2 shows that Norway, Switzerland, Austria, Germany, and Finland are categorized as LatePECs and Portugal, the United Kingdom, Poland, Ireland, and the Netherlands are categorized as EarlyPECs. The two columns on the right present the group mean and the rage of values for each group of countries. This measure is supplemented by further contextual indicators that support the differentiation of the systems: The PhD rate can be an indicator for selectivity and competition. If the number of doctorates is higher than can be absorbed by universities, there will be an 'overproduction' of doctoral degrees, which can lead to competition at universities and result in a push mechanism. High PhD rates means more postdocs need to leave the university than when there are low PhD rates. The combination of permanent employment and the PhD rate (with and without international PhDs) is used here as a measure of selectivity and competition.

The table shows that in LatePECs, higher PhD rates are associated with long periods of temporary employment. High PhD rates mean that the staff pyramid at universities has a broad base, where more potential researchers compete for academic positions, i.e., high selectivity prevails. In EarlyPECs, lower PhD rates are associated with early permanent employment. There, the PhD degree is more geared towards the academic labor market.

The wealth of the Western European economies is based (at least to a large extent) on knowledge-based industry for which large numbers of researchers (e.g., PhDs) are trained. They work in academia and also find good employment opportunities on the non-academic labor market. Because research is expensive to conduct, only wealthier economies can afford to invest in the training of large numbers of researchers—they are trained for industry. In contrast, in less knowledge-intensive economies, researchers are mainly trained for academia. The gross domestic product ('Purchase Power Parity': PPP) and the national share of researchers (across academic and non-academic markets) are indicators of the knowledge intensity of the economy (shown in Table 2). Here, LatePECs shows higher proportions of researchers and a higher PPP, with lower proportions of researchers and a lower PPP showing in EarlyPECs. The bivariate correlation between permanent employment of upper juniors and the PPP is significant ($r = -.654$; $p = .04$; 10 cases), implying longer periods of fixed-term employment in wealthier countries. This suggests a loose connection between better non-academic employment structures for academics in LatePECs—which might facilitate exits from academia—and, in contrast, less favorable extramural opportunities in EarlyPECs (particularly in Poland and Portugal), making dropout more difficult. Of course, within each group of countries, there is a wide range of different values. While Switzerland and Norway have the highest PPP and Poland the lowest PhD ratios, PPP and number of researchers, the boundaries between 'high' and 'low' PhD and PPP are fluid, and in some cases may overlap (e.g., Ireland and Netherlands (both EarlyPECs) have a relatively high PPP despite belonging to EarlyPECs; Ireland and Austria, belonging to EarlyPECs and LatePECs, have the same PhD rate (excluding internationals). However, a trend can clearly be observed that in LatePECs, there are knowledge economies with high numbers of researchers, high PPP, and PhD rates. In contrast, EarlyPECs are characterized by lower PhD rates, fewer researchers, and lower PPP. One study with a similar concept but with 20 countries also confirms this finding (Höhle 2019).

Table 2: Contextual descriptions for LatePECs and EarlyPECs

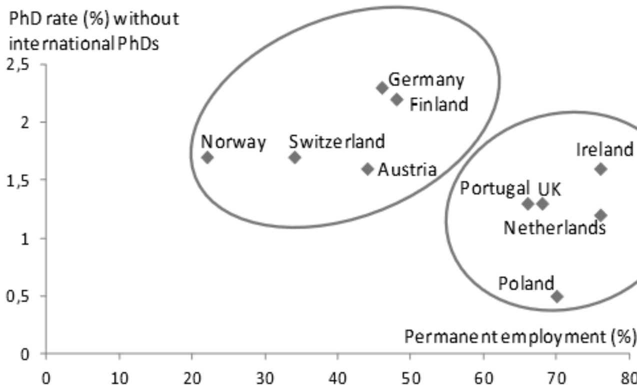
	LatePECs					EarlyPECs					LatePECs (mean§; range)	EarlyPECs (mean§; range)
	Norway	Switzerland	Austria	Germany	Finland	Portugal	UK	Poland	Ireland	Netherlands		
Permanent empl. postdocs* (%)	10	17	9	5	31	17	62	34	76	25	14; 5–31	43; 17–76
Permanent empl. upper juniors* (%)	**22**	**34**	**44**	**46**	**48**	**66**	**68**	**70**	**76**	**76**	39; 22–48	72; 68–76
PhD rate including int.** (%)	1.9	3.2	2.1	2.7	2.5	1.4	2.4	0.5	1.9	1.8	2.5; 1.9 – 3.2	2; 0.5 – 2.4
PhD rate excluding int.** (%)	1.7	1.7	1.6	2.3	2.2	1.3	1.3	0.5	1.6	1.2	1.9; 1.6 – 2.3	1; 0.5 – 1.6
Researchers per Million#	5,576	4,481	4,704	4,472	7,188	4,142	4,055	1,851	3,370	4,303	5,284; 4,472 – 7,188	3,544; 1,851 – 4,303
PPP***	54,947	46,430	42,597	40,007	35,617	23,068	37,307	21,214	39,547	41,711	43,920; 35,617 – 54,947	32,569; 21,214 – 41,711

Sources: *EUROAC survey, exact question see paragraph 3.3
**OECD 2014
***International Monetary Fund
#OECD 2016 online data source
§ constructed as mean of country means.
Note: contract was recoded into two categories.[4]

4 Contract categories are summarized:
permanent = tenure + continuous;
temporary = tenure-track + fixed-term + other.

Goastellec/Pekari (2013: 235) demonstrate that most international students leave the European countries following their PhD graduation[5], and are no longer available on the academic labor market. Thus, Figure 1 demonstrates the combination of permanent employment of upper juniors and PhD rate (excluding international students). The two groups of countries can be identified: LatePECs with lower rates of permanent employment and higher PhD rates, and EarlyPECs with high rates of permanent employment and lower PhD rates.

Figure 1: PhD rate and permanent employment of upper juniors in Europe



Source: EUROAC survey, permanent employment of upper juniors; OECD 2014
Note: contract was recoded into two categories.

In the following, the sample is divided into two groups. Although the sample size is insufficient to conduct a multilevel analysis[6], its main idea shall still direct the analysis. The theory of multilevel analysis postulates that not only individual characteristics, but also environmental conditions may influence individual decisions (Langer 2009; Pötschke 2014: 1105). Individuals decide based on their perception of opportunities (Lent et al. 1994). Here, career structures (described by contract conditions and competitiveness) and chances on the extramural labor market (Burk et al. 2016) constitute opportunity structures as well as professional boundaries that are assumed to moderate individual career decisions. These form the context in which academics make their decisions about whether or not to remain to remain in academia.

5 On the contrary, the rate of foreign PhD graduates who stay for 5–10 years or longer in the USA is much higher (Finn/Pennington 2018).

6 Maas and Hox (2004) give a minimum of 30 to 50 cases on level 2 for statistical multilevel analysis. In the case of country comparisons, such high numbers are difficult to reach.

3.3 Dependent Variable Intention to Leave Academia

The question "Within the last five years, have you considered a major change in your job?" is a multiple response question with five possible categories that was binary coded (Yes=1, No=0). The dependent variable of interest here is the answer "To work outside higher education/research institutes".[7] Table 3 shows the answers, case numbers, mean values and ranges of the country groups. The proportion of ECRs who considered leaving academia in the last five years varies substantially across systems, from about a quarter (Netherlands) to more than half (Switzerland and United Kingdom).

Analyzing the shares of intention to leave according to the LatePECs and EarlyPECs country classification proposed above, ECRs in EarlyPECs show on average a lower level of intention to leave academia than those in LatePECs (on average 48 percent vs. 34 percent; range of 40–61 percent vs. 27–52 percent), as expected. The results vary within country groups, but only the value for the United Kingdom overlaps with the values for LatePECs. In LatePECs, the 'risk' of intending to leave academia is 1.66 times greater than in EarlyPECs (p =.000).

Therefore, *hypothesis 1 is supported, which states that ECRs in LatePECs have a significantly higher intention of leaving academia than ECRs EarlyPECs*. Although this is not a proof of causality, this can be read as a description of how contextual factors influence individual behavior. The intention to leave academia is more prominent in an environment of intense competition and uncertainty, surrounded by greater availability of knowledge-intensive extramural job options.

7 The other answering options are (EarlyPECs and LatePECs):
"To a managerial position in your higher education/research institution", with 12 percent and 18 percent agreement,
"To an academic position in another higher education/research institute within the country", with 27 percent and 40 percent agreement,
"To an academic position in another country", with 24 percent and 43 percent agreement,
"No, I have not considered making any major changes in my job", with 41 percent and 24 percent agreement.

Table 3: Intention to leave academia

	LatePECs					EarlyPECs					LatePECs	EarlyPECs
	Germany	Norway	Austria	Finland	Switzerland	Netherlands	Portugal	Poland	Ireland	UK	Means[8]; range	Means; range
Yes %	40	47.7	43.8	48.1	61.3	27.2	28.4	33.3	33.1	51.8	48 % 40–61 %	34 % 27–52 %
No %	60	52.3	56.2	51.9	38.7	72.8	71.6	66.7	66.9	48.2	52 % 39–60 %	66 % 48–73 %
Total	490	284	612	290	399	157	151	1565	245	361	2075	2479

Source: EUROAC survey
Note: contract was recoded into two categories.

3.4 Independent Variables

Table 4 describes the predicted variable as well as the variables entered in the regression models. The independent variables are contract conditions, two mediation blocks (first, integration into the institution and the scientific community; and second, job satisfaction), as well as two blocks of control variables (institutional and individual demographics). In addition, the significance levels for the correlation with the employment contract and with intention to leave are also shown. Integration into the institution and scientific community is measured with different variables in one block. Affiliation to university and influence in department describe the integration into the institution. Managerial research roles and publications are indices that describe involvement in research activities with peers and structures outside the institution. The application of knowledge to society describes the transfer of research, which is also part of the integration into the scientific community.

The frequencies show that intention to leave academia is higher in LatePECs and the proportion of permanently employed academics is lower. They show that the two items that describe an institutional bond (affiliation and influence) are slightly higher in EarlyPECs than in LatePECs. On the other hand, the two research-oriented items, research management (which describes responsible positions in the scientific community with gatekeeping functions), and number of publications, are somewhat lower. In the EarlyPECs group, the overall satisfaction is slightly lower but the proportion of parenthood is slightly higher than in the LatePECs group.

8 Since case numbers vary by country, means of country groups are calculated as the means of country means. This applies for all means of country groups in this paper.

Table 4: Independent variables

	Frequencies		Correlation with			
			contract		leaving intention	
	LP$	EP$	LP	EP	LP	EP
Intention to Leave Academia (0=No, 1=Yes,)						
"Within the last 5 years, have you considered a major change in your job?" – "To work outside higher education"	48%	34%	***	***		
Contract (0=No, 1=Yes,)*						
Permanently employed (tenured)	18%	42%			***	***
Continuously employed (no guarantee of permanence)	12%	17%			*	n.s.
Fixed-term empl., permanent prospects (tenure-track)	6%	26%			n.s.	***
Fixed-term empl. without permanent employment prospects	59%	14%			***	***
Other	5%	2%			*	n.s.
Part-time employment	24%	12%			***	**
Integration into the Institution and Scientific Community						
Affiliation to univ. (1=Not at all important, 5=Very important)	52%§	55%§	***	n.s.	***	***
Influence in department (1=Not influential, 4=Very influential)	34%§§	39%§§	***	***	***	***
Managerial research roles (index[9]; 0=None, 5=All five) (means)	2.15#	1.95#	***	***	n.s.	n.s.
No. of publications (Score[10], log transformed)	2.45#	2.30#	***	**	n.s.	n.s.
Apply knowledge to problems in society (1=Disagree, 5=Agree)	53%§	56%§	***	n.s.	n.s.	*
Job Satisfaction						
"How would you rate your overall satisfaction with your job?"	62%§	56%§	***	*	***	***
"If I had it to do over again, I would not become an academic."	64%§	64%§	***	**	***	***
Institutional Demographics						
Career Stage (0=No, 1=Yes)						
Postdoc: PhD no longer than 6 years	35%	36%	***	***	*	***
Upper Junior: PhD longer than 6 years, not yet professor	65%	64%	***	***	*	***
Discipline (0=No, 1=Yes)						
Engineering	10%	18%	n.s.	***	**	n.s.
Humanities	23%	21%	*	*	***	**
Social Sciences	14%	16%	n.s.	*	n.s.	n.s.
Sciences	28%	32%	**	*	n.s.	n.s.
Medicine	26%	13%	***	n.s.	n.s.	n.s.

9 The 5 items are: Serving as a peer reviewer e.g., for journals or institutional evaluations; Editing journals or book series; Supervising researchers and team leadership; Writing for grants; Managing research budgets.

10 Score from: Number of … "Scholarly books you authored or co-authored"; "Scholarly books you edited or co-edited"; "Article published in an academic book or journal"; "Research report/monograph written for a funded project"; "Paper presented at a scholarly conference"; "Professional article written for a newspaper or magazine"

	Frequencies		Correlation with			
			contract		leaving intention	
	LP$	EP$	LP	EP	LP	EP
Individual Demographics						
Age in years	40.3	40.6	***	***	***	***
Gender and child/ren (0=No, 1=Yes)						
Male, with child/ren	29%	30%	***	*	n.s.	*
Male, no child	31%	22%	n.s.	**	***	*
Female, with child/ren	17%	28%	n.s.	*	n.s.	**
Female, no child	23%	20%	***	**	n.s.	*
Parental education (0=No, 1=Yes)						
Father higher education degree	48%	47%	n.s.	n.s.	n.s.	n.s.
Mother higher education degree	36%	38%	***	*	n.s.	n.s.

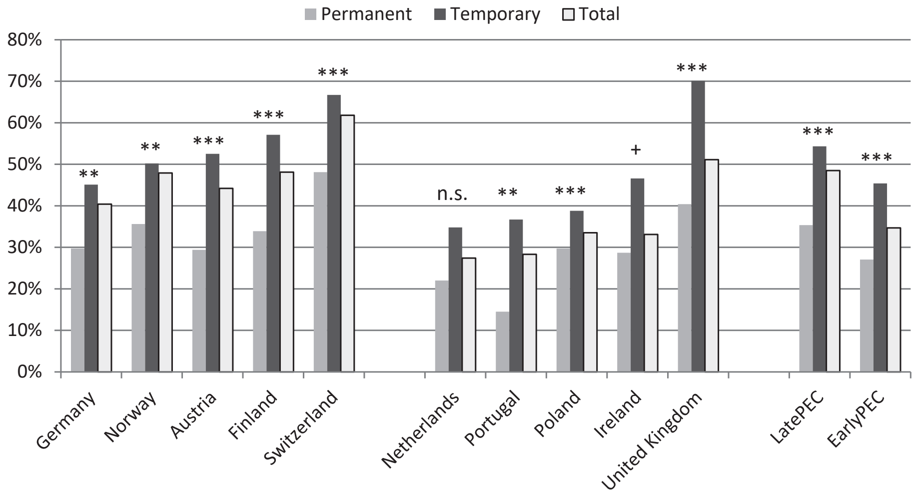
Note: $EP= EarlyPECs, LP=LatePECs; #means; §categories 4+5 added; §§categories 3+4 added; one-sided significance
Source: EUROAC-survey

4 Results

4.1 Intention to leave academia and employment contract

Figure 2 displays the intention to leave academia by type of employment contract and the level of significance between the categories temporary and permanent (based on Chi² tests), both for each country and aggregated by group of countries. As expected, temporarily employed academics in all countries surveyed intend to leave academia significantly more often than permanently employed ones. Therefore, *hypothesis 2 is supported.* The type of employment contract correlates with exit intentions both at the level of each individual country and at the level of country groups. The mean difference between the two types of contracts is similar in both country groups (18 and 19 percentage points). In addition, Figure 2 shows that the higher rates of intention to leave in LatePECs are not only due to there being a higher proportion of ERCs in temporary employment, but also to the fact that permanent ECRs in LatePECs show higher levels of intention to leave than those in EarlyPECs.

Figure 2: Intention to leave academia and contract duration in 10 European countries



Source: EUROAC survey;

contract was recoded into two categories.
Note: + p <= 0.10, * p <= 0.05, ** p <= 0.01, *** p <= 0.001.

The results show that the intention to leave academia is more pronounced in an insecure environment; that means in countries with high selectivity and long-term employment instability. While this is not surprising for academics on temporary positions, this finding also applies to permanently-employed academics. The fact that permanently-employed academics in LatePECs intend to leave academia more often than permanently employed ones in EarlyPECs is an interesting finding but needs some explanation. The literature offers conflicting approaches for this.

According to Shin et al. (2014) and Höhle (2016), the career systems that later offer stable employment are at the same time systems with a stronger focus on research, while tenure systems are generally more teaching-oriented. Zhou/Volkwein (2004) find that faculty who are intensively involved in teaching have a lower tendency to leave the department. Therefore, high levels of teaching-orientation within the system could explain the higher remain of both permanent and non-permanent faculty in systems with early employment stability than in systems with later employment stability, which are more research-oriented.

Another possible explanation is a higher exit intention in the latter group of countries, because of a general competitive climate and an acceleration of research (Broadbent/Strachan 2016). Research is increasingly being financed through third-party funding—especially in research-oriented systems—and studies show that both the workload researchers are facing when submitting proposals and the number of publications required are increasing; many researchers experience this development as a burden (Böhmer et al. 2010). Therefore, the general competitive climate in LatePECs can exert a push effect out of the system even for permanently employed academics (Hadjar/Becker, 2006).

Another possible explanation is that three of the LatePECs are organized as chair systems with a personnel structure characterized by a very narrow top layer, while four of the countries with early permanent employment are organized as department systems with a broader top layer. Therefore, the chance of reaching a leadership position as a professor is much greater in most EarlyPECs countries (Froese 2013). In LatePECs, however, those permanently employed academics aspiring to a professorship face a glass ceiling and may therefore intend to leave academia. On the other hand, higher levels of intention to leave academia in LatePECs countries can also be interpreted as an indication that high academic research qualifications are becoming increasingly attractive on the non-university labor market and have thus increasingly been given a dual function, aiming both at academia as well as at knowledge-intensive occupations outside academia (Konsortium 2013). Since LatePECs are also highly-developed knowledge economies with more knowledge-intensive employment opportunities outside of academia, non-university career prospects can exert a pull-effect to enter private industry or administration (Burk et al. 2016; Hadjar/Becker 2006). Table 1 shows that the labor market in the EarlyPECs group is less knowledge-intensive than that of the LatePECs and thus assumedly induces a weaker pull-effect than the labor market in LatePEC.

4.2 Regression Models

To find out whether the association between the formal contract and ECRs' intention to leave is mediated by integration in the institution and the scientific community, overall job satisfaction, and control variables, hierarchical binary logistic regression analyses are conducted in five consecutive models. To be able to compare the models, the average marginal effects are shown in Table 5 (Behnke 2015; Mood 2009). The question in focus is how the correlates of formal contract change with the stepwise integration of further factors (Baron/Kenny 1986).

As preparation, each model was run including all country cases and the country group dummy (not shown here). Belonging to country groups has been found to have a significant effect in each model, showing that the groups differ.[11] For this reason, it seems reasonable to run the models separated by country groups. Since the information presented above (Table 3, Figure 2, Table 4) shows in-group variance, a null model (M0), restricted to country dummies maps the country effect within each country group. Country dummies are also included in each of the following models. In the first model (M1), the criterion variable intention to leave academia is regressed on the predictor contract. In M2 and M3, the two mediator

11 *Hence, hypothesis 1 can be supported,* as shown in paragraph 4.1.

blocks are then included separately in the equation. In M4, the control variables institutional and individual demographics are added to the predictor, and in M5 the full model is run. The goodness-of-fit of the model is expressed as pseudo-R^2, which, unlike the R^2 in OLS regressions, cannot be interpreted directly as explained variance, but describes the relative increment of the effect between the models (Behnke 2015). All models are significant (p=.000).

M0: In-group variation by country

M0 shows a certain degree of ingroup heterogeneity for both country groups. In each group, one or two cases deviate significantly from the reference category: Switzerland for LatePECs and the UK and Portugal for EarlyPECs. Figure 2 shows higher levels of leaving intention in LatePECs.

M1: Employment contract

In both groups of countries, almost all contract types differ significantly from the reference category having a tenured contract. Although 'continuous' employment is usually permanent, it is associated with lower academic ranks than those of tenured academics, which may explain the difference in leaving intention. Working part-time is not significantly associated with the intention to leave academia. Based on these results, *hypothesis 2 can be supported.* Overall, the influence of the formal contract on the intention to leave of the ECRs, under control by country variation, is stronger in the LatePECs group than in EarlyPECs group.

M2: Integration into the institutional and scientific community

Integration into the institution and the scientific community explains part of the impact of the contract on intention to leave, since most values for the employment contract decrease from M1 in both country groups. Since it does not explain the effect of contract fully*, hypothesis 3 must be rejected, even if there is a partially mediating effect.* Still, the effect of contract is stronger than this of institutional and scientific integration in both country groups.

M3: Overall job satisfaction

Overall job satisfaction also reduces the effect of contract on the criterion variable. In addition, there is a mediating effect on contract, but it does not explain contract fully, *so that hypothesis 4 must also be rejected, even if there is a partially mediating effect.* Anyhow, it is an important finding that the influence of job satisfaction on intention to leave is quite strong. In the EarlyPECs group, satisfaction determines intention to leave academia even more strongly than in the LatePECs group.

Since job satisfaction is closely related to the contract conditions (cf. Table 4), Model 3 was also run with one interaction term (fixed-term contract*job satisfaction) and with two interaction terms (fixed-term contract*job satisfaction and fixed-term contract*not become an academic again). Both terms were not significant in the models of either group and had almost no impact on pseudo-R^2. Therefore, the models that include the interaction term(s) are not presented.

M4: Institutional and individual demographics

The two blocks of control variables, institutional and individual demographics, also have a mediating effect on the contract variable. The effect of most items in the contract block also decreases with the inclusion of the control variables. Although the control variables have a mediating effect in both country groups, they are somewhat stronger in the LatePECs group. Academics in the humanities in particular show a significantly lower level of leaving intention compared to those from engineering. Higher age also significantly reduces the probability of intending to leave academia. In both country groups, family status has a significant impact, but in different directions; in EarlyPECs, mothers have a significantly lower level of leaving intention than fathers—in LatePECs, on the other hand, men without children have lower levels of leaving intentions than men with children. While the values in EarlyPECs indicate family friendliness, the values for LatePECs can be read as a contrast to family friendliness.

M5: Full model

The values for the contract variables are greatly decreased in both country groups, suggesting that the effects measured in M1 are partly explained by the additional factors included. Since none of the single factors added in models M2-M4 decreased the coefficients for contract as much as in M5, the stronger effect must be explained by the combination of all three variable blocks. However, the contract variable still has an own effect on intention to leave academia that cannot be explained by the other factors. Therefore, *hypothesis 1 can still be supported* even after controlling for further factors.

Table 5: Hierarchic Binary Logistic Regression: Intention to Leave Academia in EarlyPECs and LatePECs (Average Marginal Effects)*

	M0		M1		M2		M3		M4		M5	
	Early PEC	Late PEC	Early PEC	Late PEC	Early PEC	Late PEC	Early PEC	Late PEC	Early PEC	Late PEC	Early PEC	Late PEC
Contract (reference: tenure)												
Continuous			0.13 ***	0.21 ***	0.12 ***	0.12 ***	0.11 ***	0.17 ***	0.09 **	0.14 **	0.06 *	0.11 *
Tenure-track			0.14 ***	0.17 **	0.12 ***	0.16 **	0.13 ***	0.16 **	0.09 **	0.05	0.06 *	0.04
Fixed-term			0.31 ***	0.30 ***	0.27 ***	0.27 ***	0.26 ***	0.24 ***	0.26 ***	0.19 ***	0.17 ***	0.13 **
Other			0.35	0.36 ***	0.30	0.32 ***	0.22	0.31 ***	0.36	0.27 ***	0.23	0.20 **
Part-time (ref.: full-time)			0.00	0.04	0.00	0.03	0.01	0.03	0.07	0.06	0.08	0.05
Integration												
Affiliation to university					-0.06 ***	-0.04 **					-0.02 **	-0.01
Influence in department					-0.07 ***	-0.06 ***					-0.04 **	-0.03 *
Managerial research roles					0.02 **	0.03 *					0.01	0.02 *
No. of publications					-0.02 *	-0.01					-0.01 *	0.01
Apply knowledge to society					0.01	0.02					0.02 *	0.03 *
Satisfaction												
Job satisfaction							-0.10 ***	-0.08 ***			-0.09 ***	-0.07 ***
Become academic again							-0.07 ***	-0.07 ***			-0.07 ***	-0.06 ***
Institutional Demographics												
Stage (ref.: upper junior)												
Postdoc									0.00	-0.06 *	0.02	-0.04
Discipline (ref.: Engineering)												
Humanities									-0.13 ***	-0.17 **	-0.11 ***	-0.17 **
Social Sciences									-0.05	-0.10	-0.04	-0.11 *

	M0		M1		M2		M3		M4		M5	
	Early PEC	Late PEC	Early PEC	Late PEC	Early PEC	Late PEC	Early PEC	Late PEC	Early PEC	Late PEC	Early PEC	Late PEC
Sciences									-0.03	-0.05	-0.05 *	-0.07
Medicine									-0.06	-0.02	-0.09 *	-0.07
Individual Demographics												
Age									-0.03 ***	-0.06 ***	-0.04 ***	-0.05 ***
Family Type (ref. male/child)												
Male / no child									-0.05	-0.07 *	-0.03	-0.05
Female / child									-0.10 ***	0.04	-0.10 ***	0.02
Female / no child									-0.04	-0.01	0.00	-0.01
Father tert. ed. (ref.: no ed.)									0.00	-0.03	0.00	-0.01
Mother tert. ed. (ref.: no ed.)									0.02	0.01	0.03	0.01
Country Dummies (ref.: PL, AT)	UK *** PT **	CH ***	UK *** PT *	CH ** DE *	UK *** PT *	CH ** FI *	UK ** PT *	CH *** DE *	UK *** NL * PT *	CH * DE *	UK * PT **	CH *** FI *
Pseudo R^2	.016	.018	.037	.064	.071	.079	.147	.125	.059	.093	.189	.158

*Coding of Intention to leave: 1 = Yes, 0 = No; All variables are coded in the way that positive coefficients are associated with intention to leave, while negative values are associated with staying in academia.
Note: N is kept stable for all models: EarlyPECs=2213; LatePECs=1343.
Significance levels: ***p<.001 **p<.01 *p<.05.
Source: EUROAC survey.

Both country groups represent different types of employment that offer a different set of opportunities for their employees, resulting in higher or lower levels of intention to leave academia. Although the results partly show similar motives for intention to leave, they also reveal differences between LatePECs and EarlyPECs. Having a contract other than a tenured contract is associated in both country groups with leaving academia, especially when it is a fixed-term contract with no permanent prospects. The effect that the contract shows in M1-M4 can be partly explained by the other factors, but it has an important effect itself, when all other variables are equal (Question 3). Further results are:

- Personal influence in the department significantly supports staying in academia in both country groups. On the contrary, the application of knowledge to society strengthens the intention to leave academia in both groups. The transfer of knowledge may have a bridge-building function to enterprises.
- In the EarlyPECs group, affiliation with the university (which indicates institutional integration), and a higher publication output (which signals integration into the scientific community, but also academic success), both contribute to staying in academia. This is not the case with LatePECs—there academics leave irrespective of their institutional affiliation and their academic success.
- Gatekeeping functions (managerial research roles) as a sign for integration into the institution and the scientific community was expected to motivate remaining in academia. Here, on the other hand, surprisingly, it significantly supports the intention to leave academia in the LatePECs group. A possible explanation could be that these activities may support academics in developing contacts outside academia that facilitate the transition in countries with a knowledge-based economy.

Hypothesis 3 claims that the relationship between contract duration and leaving intention is fully mediated by integration into the institution and the scientific community. While integration does affect leaving intention, it does not fully mediate contract and must therefore be rejected.

- In both groups of countries, overall job satisfaction has a strong effect of retaining academics at university. In EarlyPECs the effect is even stronger than in LatePECs. Possibly, in an environment of potentially secure employment (EarlyPECs) a stronger motive to leave academia, which may be provided by job dissatisfaction, is necessary.

Hypothesis 4 claims that the relationship between contract length and leaving intention is fully mediated by satisfaction. Although satisfaction has an even stronger effect on leaving intention than integration does, it does not fully mediate the contract and is therefore rejected.

- The results show that the academic disciplines also play an important role, although differently in each group. While, compared to engineering, belonging to humanities reduces the intention to leave in both groups—even more so in LatePECs than in EarlyPECs—there are still differences according to discipline by country group. In LatePECs, it is obvious that the 'soft' disciplines show a greater tendency to stay in academia than the 'hard' (STEM) disciplines, even if they conduct basic research (e.g., natural sciences) (Hamann 2015; Becher/Trowler 2001).

This finding supports Xu's (2008) analyses regarding turnover differences across disciplines. In EarlyPECs, ECRs who belong to the academic disciplines conducting basic research (humanities, sciences), have a higher tendency to remain in academia, while those in the applied disciplines (engineering and social sciences) have a tendency to leave. The stronger application focus in the EarlyPECs group can be read as an indication of a less research-based industry. (Medicine as applied discipline does not fit into this scheme.)

Overall, belonging to a discipline in the LatePECs has a stronger effect than in the EarlyPECs, possibly because the non-university labor market in knowledge societies with high PPP is more favorable for STEM disciplines than for the humanities and social sciences (Zhou/Volkwein 2004). In LatePECs, the natural sciences as a disciplinary group with basic research emphasize the knowledge-based research character on the extramural labor market.

- In both country groups, young ECRs are significantly more willing to leave academia, as Padilla-González/Galaz-Fontes (2015) have already pointed out for various groups of academics. Young academics may be the ones who are not (yet) established, who are more open to life decisions and can find attractive jobs outside of academia. Older academics on the other hand, may be the ones who have become more established.
- Being a researcher in EarlyPECs seems to support family life for women; being a mother reduces the intention to leave academia compared to the results for fathers.[12] This contrasts with discussions focusing on the difficult reconciliation of family and academic career in countries with late permanent employment as it is painted in Germany (Metz-Göckel et al. 2009). In LatePECs, there are no differences between different family types.
- The groups are not homogeneous: Portugal differs significantly from the other countries in the group of early permanent employment, while Switzerland and Finland differ in the group of late permanent employment. Further research would be needed to explain these differences.

12 McAlpine/Emmioğlu (2014: 1783), on the other hand, are likely to interpret this finding rather as a limitation of the horizon of action that young mothers have to face.

5 Discussion

The international increase of PhD rates, combined with unpredictable employment opportunities at universities, makes it necessary to study the transition from academia and the non-academic labor market (Best et al. 2016). The study confirms the great importance of the type of contract for the intention to exit. The approach pursued here was that individual career decisions take place within a context of career structure and labor market opportunities and can accordingly vary internationally (Cummings 2008). Firstly, the career systems in 10 European countries were divided into two groups and secondly, it was analyzed as to whether the academics differed in their intention to leave academia according to country groups. The proposed characterization into career systems with late permanent employment (Austria, Germany, Switzerland, Norway, and Finland) and systems with early permanent employment (United Kingdom, Portugal, Poland, Netherlands and Ireland) can be used both for further research and for practical measures: Countries with similar characteristics can be compared with each other, or one group of countries can learn from best practice in the other group of countries.

Different theoretical approaches were used to explain the mechanisms of action of career systems, contracts and the mediation through integration and job satisfaction. The analysis yielded empirical evidence for each of the approaches.

The labor market theory allows for a comparison at the system level. It predicts differences in the intention to leave between the two country groups based on the characteristics of the university employment system and of the labor market (Schubert/Engelage 2006; Hadjar/Becker 2006). The results show that early career researchers in four out of five countries with early permanent employment have a lower level of leaving intention than those in countries with late permanent employment. According to the labor market approach, this can be explained by the fact that in these countries, fewer doctorate holders are distributed among relatively more research positions, in particular more permanent positions. As a result, there are better chances of a permanent job in these countries and less selectivity (Höhle 2019), and therefore a lower push effect than in the other group of countries. In addition, the non-university job market offers less knowledge-intensive opportunities for highly qualified people than a knowledge-intensive job market does (pull effect).[13] The results thus confirm that the combination of push and pull effects contributes to exit intention: Hypothesis 1 can be accepted.

According to social-cognitive theory (Lent et al. 1994), ECRs with fixed-term positions rate their chances of securing an attractive (possibly permanent) position as low or requiring too much effort and therefore decide to leave academia. It is assumed that ECRs in temporary positions intend to leave academia more fre-

13 This argument is supported by a stronger influence of the variable “Apply Knowledge to Society” in LatePECs.

quently than their colleagues in permanent positions. In fact, in every country in the sample, temporary researchers have a higher level of exit intention than do permanent researchers. The multivariate analyses also show that the employment situation has an effect that is not fully explained by the other factors. Furthermore, it is interesting that both approaches work in combination: The differences according to the type of contract have a greater impact in systems with late employment stability and high doctorate rates than in countries with early employment stability. The result also confirms the earlier study by Metz-Göckel et al. (2016). The employment contract seems to be a better predictor for intention to leave in the group between doctorate and professorship, which is the focus here, than for researchers at all career levels examined by Padilla-González/Galaz-Fontes (2015). Hence H2 can be assumed.

According to Schein (1971), researchers who are employed in a peripheral (temporary) position in the organizational structure have a higher probability of not being well integrated into the institution or the scientific community, experience 'cooling out' (Goffman 1952) and develop leaving intentions. The same applies to job satisfaction (Bandura 1986), which is also assumed to be a mediator here. The results show that the items of the two factors job satisfaction and integration into the institution and scientific community are (at least partially) related in the bivariate analysis to both the employment contract and the intention to leave (cf. Table 4). In the multivariate analysis also, both factor blocks affect the intention to leave. However, the relationship between contract type and intention to leave academia is only partially explained by the two factors. Since it is not entirely mediated by either factor block, both (H3) and (H4) are rejected. Studies that find a connection between the employment contract and integration (Broadbent/Strachan 2016; Broadbent et al. 2013; Höhle 2015b) can be partially confirmed (cf. Tables 4 and 5). Studies in which the authors emphasize the importance of integration on the intention to leave (e.g., Jaksztat et al. 2017; Schröder et al. 2021; Jungbauer-Gans/Gross 2013; Kahlert 2013) are partially confirmed also. Although the items become significant, they have a much smaller effect than might be expected. Study results according to which the employment contract influences job satisfaction (e.g., Waajer et al. 2017; Goldan et al. 2022; Castellacci & Viñas-Bardolet 2021), or those according to which job satisfaction is associated with the intention to leave (Padilla-González /Galaz-Fontes 2015) are also confirmed.

In both country groups, the control variables—both institutional demographics and the socio-demographic variables—also explain to a small extent the effect of the contract on leaving intention. Surprisingly, the effect of integration is moderately pronounced. Academic discipline and age are also important indicators: Academics in the humanities in particular have a significantly lower level of intention to leave than those in engineering, which can be explained by a greater focus on the common good (Hamann 2015; Becher/Trowler 2001) and by lower numbers of market opportunities, the finding of which thus confirms earlier studies (e.g., Vogel/Hinz 2004; Flöther 2017). In addition, older researchers show less intention to leave compared to younger researchers—as those who have managed to stay in the system may be more established in their careers than recent PhDs.

However, some factors differ between the two country groups. While job satisfaction was identified as the most important predictor in the group of countries with early permanent employment, the effect of job satisfaction is only as strong as that of the other three main factors in the group of countries with late employment stability. There, the effects of the predictors of employment contract, academic discipline and age seem to be distributed relatively evenly, so that no single main predictor can be identified, but rather only the combination unlocks its effect. The influence of the contractual employment situation is more pronounced than in the group of countries with early employment stability and the influence of job satisfaction is weaker. In view of the low chance of getting a permanent job in the group of countries with late employment stability, the importance of the employment contract on the intention to leave is not surprising but emphasizes the tense situation. Achieving a permanent employment contract is a key factor in career planning in science, especially in this group of countries.

In the group of countries with early permanent employment, job satisfaction is the main predictor, and all other predictors have a significantly lower influence. Overall, the academics in this group of countries show on average a lower overall job satisfaction than the academics in countries with late employment stability (cf. Table 4). The high importance of job satisfaction in this group of countries could be due to the fact that in many countries with tenure systems, the rise of managerial structures endangers academic freedom and autonomy (Padilla-González/Galaz-Fontes 2015; Locke et al. 2011), leading to dissatisfaction, as studies suggest (Bentley et al. 2013). Although management structures are also used in countries with late permanent employment, the higher job satisfaction there may be explained by the fact that temporary employment may act like a filter and dissatisfied researchers select themselves out of the universities (and are no longer in the system).

In addition, some items of the integration block and the individual demographics play a role in the group of countries with early permanent employment and are not—or are only weakly—significant in the other group of countries, and vice versa. In the group of countries with early permanent employment, the sense of belonging to the university, influence in the department and the number of publications are negatively associated with the intention to leave the university; the three items are not—or are only slightly—significant in the other group. In LatePECs, the other main factors mentioned presumably overlay these items, which have a stronger influence on the intention to leave. A possible explanation for the higher importance of the institutional integration (sense of belonging to the institution and the influence in the department) can be the generally higher teaching orientation in the systems with early employment stability, which goes hand in hand with a higher orientation towards one's own institution. Conversely, one study (Höhle 2015a) shows that in systems that are more research-oriented, orientation towards the scientific community is stronger. It can therefore be expected that strength in publication plays a role there, which is not found in the results and will be discussed further below. Having a managerial gatekeeping function, on the other hand, only has a significant effect in countries with late employment stability. There, these activities may have led to contacts on the non-university labor market that facilitate the transition.

Another difference between the country groups lies in the family types. While there are no effects with regard to family types in the group of countries with late employment stability, the effect in the other group is pronounced. There, mothers are significantly more likely than fathers to stay in academia. Apparently, workplace security is even more of a support for mothers than it is for fathers. In these countries, the academic profession means having a safe workplace that allows for family life. There, being a parent/mother obviously encourages remaining in academia. In the opposite case, a study from Germany suggests that motherhood increases the dropout from academia for mothers (BMBF 2010), for which, however, empirical evidence cannot be found in this study. Still, offering more predictable and stable workplaces could mean better support for both women and families. The findings are relevant and have implications for HR management at universities but are also suitable for being transferred to other career systems with highly qualified occupations.

One of the intentions of employers in higher education systems regarding the excessive use of fixed-term contracts is to assure quality and to stimulate innovation through the selectivity of personnel (Meißner 2016). However, there is no evidence that fixed-term contracts help to compete for the best researchers, or that fixed-term contracts would increase productivity. If permanent employment made researchers 'lazy', the United Kingdom, for example, would not be able to achieve being a scientifically very successful country. Accordingly, in the group of countries with late employment stability, the number of publications—a recognized measure of research ability—does not correlate with the intention to leave academia. This means that research ability does not appear to be a criterion for self-selection into academia, so that high performers and low performers have similar intentions to leave academia.[14] This only applies to LatePECs, while in EarlyPECs the mechanism to support academics with stronger publication capacities seems to work better. This means that universities in LatePECs are not competing for the best minds, but risk losing them, often due to their employment conditions. This perspective is supported by the fact that scholars with leadership roles—signaling institutional and community integration, mid-leadership, and high performance—

14 In later career stages, however, studies from Germany do show a significant career effect of the number of publications when it comes to reaching professorship. At this point higher publication rates significantly increase the chances of becoming a professor (Jungbauer-Gans/Gross 2013; Plümper/Schimmelpfennig 2007; Schulze et al. 2008; Konsortium 2017).

have even higher intentions to leave the university. Although this finding needs further investigation, it should set alarm bells ringing with workforce planners and university leaders.

The study shows that for countries with late permanent employment, the political goal of providing the knowledge-based industry with a high number of PhD-holding researchers is successfully reached by educating large numbers on fixed-term positions in academia. The German Council of Science and Humanities, the 'Wissenschaftsrat', points out that an academic career would be more attractive if career paths were easier to plan and allowed an earlier decision for or against an academic career (Wissenschaftsrat 2014). The results show that mothers in particular would profit from earlier permanent employment—this might be a realistic contribution to more gender equality and family friendliness. The Science Council (Wissenschaftsrat 2014) also argues that the working conditions in Germany—as a country of late permanent employment—are not competitive either on the extramural labor market or on the international academic market. Therefore, such systems may not be able to attract and retain the best researchers. For countries with late permanent employment, the results show that publication capacity is not filtered, which may be read as an indicator for academic quality. The massive use of fixed-term employment does not lead to the selection of the best but rather selects those who have poorer opportunities on the non-university job market, who are satisfied despite the working conditions and who are already on permanent positions. In both types of systems, it is rather the younger researchers who intend to leave the system and from a career perspective this is certainly a good moment. For the universities, however, it would be advantageous if these researchers remain following completion of their doctorates, because this is probably a very productive phase, and it is precisely then that they are lost. In addition, since the academic education of ECRs does not always prepare them well for work outside (Best et al. 2016), a further implication can be drawn: Universities should prepare ECRs early enough for work outside academia. Such preparation should encompass their career planning, the teaching of key skills and the provision of cooperation with possible non-university employers (cf. Wissenschaftsrat 2014).

There are some limitations to the study. Being a secondary analysis, the data selection was limited to the available data, while the questionnaire was not specifically constructed for this particular analysis. Although it seems reasonable that the key question regarding the intention to leave is retrospective, the time span—the last five years—seems to be quite long and it is not certain whether the conditions (contract, satisfaction, integration, etc.) asked about were the same at this point as at the time when the interviewee thought about leaving. As a second methodical limitation, it must be mentioned that the direction of dependency between certain variables may be circular. For example, researchers considering leaving academia may not be as ambitious in finding permanent positions or in integrating as researchers with a clear goal of remaining in academia. However, it is my assumption that postdocs who have decided to remain in academia have decided at one point to pursue an academic career. In addition, the internal country group variation is greater than the variation between groups. The number of countries is still small, and it is not entirely clear to what extent they are representative of all systems with early or late permanent employment. A generalization of career systems with early or late permanent employment must therefore be made cautiously and provisionally. However, there is reason to believe that these results are not random and therefore tentatively generalizable, at least for systems in Europe. Höhle (2019) shows that a greater variety of countries follows the country typology.

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Collaboration and Competition in Academic Research

Experiences of Postdoctoral Researchers in the Life Sciences[***]

Abstract: While academic research often requires collaboration, the German academic career system is highly competitive due to the scarcity of permanent positions and follows a "winner takes it all" principle. Empirical research has shown both the positive and negative aspects of scientific collaboration. Within this qualitative interview study, we investigate how postdocs in the life sciences (medicine and biology) describe their experiences with collaborations. What are the benefits and the pitfalls, and what aspects predominate? Further, drawing on the concept of social capital and the theory of social interdependence, we analyze the situations in which conflicts arise, and those in which they do not. Our results suggest that it is the benefits of collaboration that are predominant; the postdocs often describe them as indispensable for their work. Access to human capital, i.e., knowledge, skills and experience of others, and in many cases, research projects are only made possible through the collaboration of scientists with different disciplinary backgrounds and expertise. However, postdocs also report conflicts regarding the order of authors, (fears of) being scooped by project partners and free riding. These problems were primarily expressed in relation to external project partners. Here, there is likely a weaker bond and less network closure, making it more difficult to sanction misconduct.

Keywords: Postdocs, Life Sciences, Scientific Collaboration, Social Capital, Social Interdependence

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Kollaboration und Wettbewerb in der akademischen Forschung

Erfahrungen von Postdocs in den Lebenswissenschaften

Zusammenfassung: Obwohl die akademische Forschung häufig wissenschaftliche Kollaborationen erfordert, ist das deutsche akademische Karrieresystem, aufgrund der Knappheit an unbefristeten Stellen, sehr wettbewerbsorientiert und folgt dem "winner takes it all"-Prinzip. Empirische Untersuchungen haben sowohl die positiven als auch die negativen Aspekte wissenschaftlicher Kollaborationen aufgezeigt. In dieser qualitativen Interviewstudie untersuchen wir, wie Postdocs in den Lebenswissenschaften (Medizin und Biologie) ihre Erfahrungen mit Kollaborationen beschreiben. Was sind die Vorteile und die Fallstricke, und welche Aspekte überwiegen? Unter Einbezug des Konzepts von Sozialkapital und der Theorie der sozialen Interdependenz analysieren wir außerdem, in welchen Situationen Konflikte auftreten und in welchen nicht. Unsere Ergebnisse weisen darauf hin, dass die Vorteile von Kollaborationen überwiegen; die interviewten Postdocs beschreiben sie oftmals als unverzichtbar für ihre Arbeit. Der Zugang zu Humankapital, d. h. zu Wissen, Fähigkeiten und Erfahrungen anderer, und in vielen Fällen auch zu Forschungsprojekten wird erst durch die Kollaboration von Wissenschaftler/innen mit unterschiedlichem disziplinärem Hintergrund und Fachwissen möglich. Aber auch Konflikte, über die Autorenreihenfolge, (Angst vor) Ideendiebstahl und Trittbrettfahren, werden von Postdocs berichtet. Diese wurden vor allem in Bezug auf externe Projektpartner/innen geäußert. Hier ist die vermutlich eine schwächere Bindung und geringere Geschlossenheit des Netzwerkes vorhanden, sodass Fehlverhalten schlechter sanktioniert werden kann.

Stichworte: Postdocs; Lebenswissenschaften; Wissenschaftliche Kollaborationen; Sozialkapital; Soziale Interdependenz

1 Introduction

While academic research merits individual achievements, it is increasingly performed by teams (e.g., Wuchty et al. 2007); a development fostered by increasing specialization of researchers, complexity of research problems, and policy makers (summarized in Leahey 2016). Collaboration has been shown to have many positive effects, such as on the visibility and productivity of individual researchers: Recognition in academia is predominantly awarded by the respective scientific community, e.g., through peer review and citations (Gläser/Laudel 2015). Being referenced by other scientists leads to a higher visibility and increases the impact of the scientific work. This is also the case if co-authors share joint publications (Bikard et al. 2015). Collaboration seems to be a necessity not only for successful funding (Abramo et al. 2014; Leahey 2016) but also for the research productivity of teams and individuals who can add to their publication list, e.g., through co-authorships (Wieczorek et al. 2020). This is specifically true in disciplines in which many (sub)disciplines need to work together to address complex research questions (Aldrich/Al-Turk 2018; Greene 2007; Wuchty et al. 2007), as in the life sciences; here, multi- or interdisciplinary work is rather the rule than the exception.

However, the scarcity of (permanent) positions inevitably turns postdocs, who are responsible for the bulk of research (Kreckel 2016), into competitors. This aspect is particularly important for German academia, in which—traditionally—permanent positions have been almost exclusively available for full professors (e.g., Afonso 2015; Kreckel 2016; Ullrich 2019), who constitute approximately 10 percent of the academic workforce (Kreckel 2017). This situation presents a dilemma, since collaboration is often necessary for achieving a mutual goal, e.g., to successfully manage a joint research project, but the goal of achieving a permanent position—in this case professorship—is only possible for a few. Empirically, competition has been negatively associated with knowledge-sharing within teams (Blumenthal et al. 2006). Moreover, collaborations may entail other conflicts and problems, such as free riding (Leahey 2016) or unfair distribution of work (Aldrich/Al-Turk 2018).

Another important aspect of collaboration may be the status of collaborators; not all scientific collaborations are equal as scientists differ with respect to their status, prestige and experience. Professors are central members of the scientific community. They hold a twofold powerful position as superiors with a quasi-employer function and as supervisors who evaluate scientific work. They decide whom to hire, to promote and to recommend (Gallas 2018; Ullrich 2019). In addition, they also function as gatekeepers to their scientific communities and can provide postdocs with access to their networks (Jungbauer-Gans/Gross 2013). Due to the above-described duality of the German academic labor market, postdocs are in a position in which they are very dependent on their superior professor until they reach full professorship themselves.

In this study, we use qualitative data to examine the ways in which scientists benefit from collaborations, but also to examine the pitfalls that collaborations may entail. In contrast to quantitative studies, which mainly focus on the bibliometric analysis of co-authorship (e.g., Lee/Bozeman 2005; Scaffidi/Berman 2011; Wieczorek et al. 2020), we aim to explore a broader spectrum of collaboration experiences, and we understand collaboration as any (informal) form of *professional* exchange between scientists and not only as formalized collaboration that becomes visible only after it has been successful through joint publications. We focus specifically on postdocs in the life sciences (physician scientists[1] and biologists), a traditional team science discipline in which the number of authors per paper has increased even further in

1 Physician scientists (also known as "clinician scientists" or "translational scientists") are physicians who are also engaged in academic research. As active (laboratory) researchers and clinical

recent decades (Schmidt et al. 2017; Vermeulen/Penders 2010). Research in the life sciences is predominantly conducted in an interdisciplinary manner, as the expertise of different sub-disciplines is needed to address important research questions. Medicine, e.g., translational research, that brings findings from basic research to the bedside/to the patient (and vice versa), relies on collaboration between basic life scientists and physician scientists (Deutsche Forschungsgemeinschaft [DFG] 2015; Epstein/Fischer 2017; Hendriks et al. 2019). Accordingly, we consider the life sciences to be particularly suitable and interesting when investigating collaboration.

Whereas a few (qualitative) studies have focused on collaboration specifically in the life sciences (Müller 2012; Parker et al. 2010), we aim to explore postdocs' collaboration experiences drawing on the concept of social capital (e.g., Coleman 1988, 1990; Granovetter 1973; Nahapiet/Ghoshal 1998) and the theory of social interdependence (Deutsch 2011; Johnson/Johnson 2005). In addition to previous studies, our aims are further:

1. to explore whether postdocs perceive positive or negative aspects of collaboration as predominant.
2. to specify the situations in which conflicts occur and competition prevails.
3. to specifically investigate postdocs' collaboration experiences with professors in general and the career support they receive from their superior professor.

This paper is structured as follows: In section two, we present the theoretical background of our study. In section three, we discuss previous empirical findings on the benefits and pitfalls of scientific collaborations in general and in the last subsection, specifically with senior scientists/professors. Section four describes the research methods and contains a description of the interview sample and the qualitative analysis. The results are presented in section five, and their implications and limitations are discussed in sections six and seven.

2 Theoretical Considerations: Social Capital and Social Interdependence

2.1 The Role of Social Capital in Academia

As already described in the introduction, collaboration is central to academic research—and continues to grow in importance—in order to address complex research questions and problems, and is important for the individual scientist's career. In the context of our study, we focus on the consequences that social capital has for the individual scientist. Therefore, we refer to authors who (also) focus on individual outcomes related to social capital, such as Coleman (1988, 1990), Nahapiet and Ghoshal (1998) and Burt (2001). While there are significant differences between these theorists, there is a common understanding that social capital describes resources that one can only access through social relations: "The

healthcare providers, they can bridge the gap between (biomedical) basic research and its application in health care (e.g., Hendriks et al. 2019; Vignola-Gagne 2014).

social capital metaphor is that people who do better are somehow better connected" (Burt 2001: 32). Nahapiet and Ghoshal (1998: 243) define social capital as "the sum of the actual and potential resources embedded within, available through, and derived from the network of relationships possessed by an individual or social unit".

Furthermore, these resources can be appropriated and transferred into other forms of capital, e.g., to human capital (Coleman 1988). By being connected to other scientists, postdocs, who are central in our study, can learn from the experiences and knowledge of others and increase their own human capital through learning. This may be specifically true, if the collaborators come from different (sub)disciplines or have different specializations. Aside from acquiring new knowledge themselves, postdocs also gain access to the human capital of their collaborators. This shared human capital might be needed to make a project successful, or to increase productivity (more publications). Postdocs may also gain access to other technical resources, i.e., research equipment. In addition, collaborating with and being known by others is important for the visibility of scientists, as the reception of their work by the scientific community is decisive for their career development (Leahey et al. 2016).

Also relevant to collaborations in academic research are the dimensions of social capital described by Nahapiet and Ghoshal (1998): the structural dimension, the relational dimension and the cognitive dimension. The *structural dimension* is a prerequisite for the emergence of collaborations and concerns the access to and the position within a network. The *relational dimension* develops out of experiences within a group/network and describes the personal relationship that people have developed over time (Nahapiet/Ghoshal 1998). Hence, the relational dimension describes the qualities of a relationship, which are actually important to explain and predict behavior. For example, through repeated interactions, individuals develop resources that can be beneficial for collaboration, such as trust/trustworthiness, commitment, expectation, and reciprocity (Coleman 1988; Nahapiet/Ghoshal 1998). These resources, which stem from strong ties and network/group closure, are important for collaborations because they facilitate coordination and knowledge sharing, and enable the enforcement of norms, e.g., via more opportunities for sanctions (Coleman 1988; Granovetter 1973). On the other hand, weak ties or structural holes are more likely to bring in new information (Granovetter 1973; Burt 2001). Out of these theoretical considerations, one might expect that repeated or internal collaborations are characterized by fewer instances of adverse behavior, like free riding and scooping. However, external collaborations may hold a higher potential for innovation.

Finally, the *cognitive dimension* of social capital refers to resources that enable shared understanding within groups/networks, such as shared languages and codes (Nahapiet/Ghoshal 1998). In reference to collaboration, a shared language and understanding will be more likely to occur in well-established teams (rather internal than external collaborations) and with researchers that share research domains and/or come from similar disciplinary backgrounds.

Coming back to the structural dimension of social capital (Nahapiet/Ghoshal 1998), the status and prestige of scientists may play an important role. Professors, on average, are likely to hold central positions (Burt 2001) within their scientific community. Actors who hold central positions “carry more valued resources and exercise greater power” (Lin 1999: 31) and hold more opportunities. One could also argue that professors are, on the one hand, part of the scientific community, and on the other hand, part of a further network of professors, to which postdocs do not belong. Therefore, professors can act as brokers and hold information that other members of the scientific community do not possess. In addition, professors are more experienced and may possess higher human capital, but also knowledge regarding political aspects of academia, such as how to negotiate within projects, how to talk with other professors, navigate delicate issues and competing interests. In that sense, professors may possess a habitus (Bourdieu 1983) that postdocs do not. As a result, postdocs could benefit from collaborating with professors in myriad ways, from their human capital/professional advice, but also from career advice and input, e.g., on research specializations, positions to apply to, with whom to collaborate, and where to ask for funding. They can also benefit from professors’ social capital for their own visibility through joint publications, and receive access to new information and to other scientists or scientific networks.

2.2 Social Interdependence: Collaboration and Competition

Team endeavors often require the expertise and knowledge, or just the workforce, of different team members. This renders team members interdependent; they must work together to achieve their personal goals, which are overlapping with the common team goal. According to Deutsch (2011) and Johnson and Johnson (2005) *social interdependence* exists when the realization of the collaborator’s goals is influenced by the action of others. According to the theory, there are two types of goal interdependence: positive (cooperation/collaboration) and negative (competition). *Positive interdependence* occurs when individuals’ success is bound to the success of others. For instance, postdocs can only publish research results of a project if the project as a whole is carried out successfully. On the contrary, *negative interdependence*, describes a condition in which only one person can achieve a goal, i.e., the success of one person is linked to the failure of others (Deutsch 2011; Johnson/Johnson 2005), e.g., only one team member can be listed as first-author.

Positive interdependence results in promotive interaction, i.e., individuals encourage and facilitate each other’s efforts in order to reach a common goal. Negative interdependence results in oppositional or contrient interaction, i.e., individuals discourage and obstruct each other’s efforts in order to reach their own individual goals (Deutsch 2011; Johnson/Johnson 2005). In accordance with social capital theories (see Chapter 2.1), collaboration is usually based on mutual support, exchange/sharing of resources and trust (Deutsch 2011). This leads to the conclusion that social capital cannot be optimally mobilized in competitive settings. In order to secure their own advantage and to reach their individual goals, individuals do not make their resources (e.g., their knowledge) (fully) available to the other team members.

Furthermore, there may also exist asymmetries in the degree of interdependence in collaborative relationships, depending on who is working together. This is the case when the collaborators are dependent on each other to a different extent. As a consequence, one person has more power in the relationship than the other (Deutsch 2011). This could apply to whole institutions or to individual scientists who collaborate with each other. At the institutional level, asymmetries may occur if, e.g., one institution receives more financial resources for a third-party-funded project, which may lead to different priorities. At the individual level, power imbalances may exist, e.g., due to the status of the collaboration partners. Professors have greater decision-making power through their role as superiors and can, e.g., decide what research priorities are set.

3 Literature Review: Collaboration in Academic Research

3.1 Development and Status Quo

A steady increase in scientific collaborations can be observed in academia, as research continues to move away from being conducted by single scientists and towards projects that are carried out in teams and whose results are published collaboratively (Aldrich/Al-Turk 2018; Greene 2007; Leahey 2016; Wuchty et al. 2007). Not only is there an increase in the number of articles that scientists publish as co-authors, but also an increase in the size of research teams (Wuchty et al. 2007). This undisputed trend towards team science is evident across all scientific disciplines and is also apparent in sciences that have traditionally been a team endeavor, such as the life sciences (Schmidt et al. 2017; Vermeulen/Penders 2010). Apart from the rise of collaborations within single academic institutions, there has also been an increase in collaborations across institutional, national and disciplinary boundaries (Jones et al. 2008; Leahey 2016; Mosbah-Natanson /Gingras 2014). This trend could be attributed to the immense progress in science which has led to a greater degree of specialization among scientists (Aldrich/Al-Turk 2018) and an increase in the complexity of research questions, many of which cannot be investigated by individual scientists or disciplines (Hara 2003; Jones et al. 2008).

3.2 Benefits of Collaboration: Productivity/Visibility and Learning Opportunities

Publications and the dissemination of one's work are essential for research careers. In fact, the number of publications seems to be the most important factor in achieving full professorship (Lutter/Schröder 2016; Moosa 2018; Plümper/Schimmelfennig 2007). The impact of collaborations for scientists' career development is reflected in the empirical link between the number of collaborations and scientists' productivity, i.e., their number of publications (Lee/Bozeman 2005; Scaffidi/Berman 2011; Wieczorek et al. 2020). In addition, scientists who work collaboratively produce more high-impact articles, i.e., receive more citations (Acedo et al. 2006; Bikard et al. 2015; Lee/Bozeman 2005). Also Wuchty et al. (2007: 1037) discover "[…] a broad tendency for teams to produce more highly cited work than individual authors". This could be explained by the larger number of co-authors who share their work with their various contacts which increases visibility (Bikard et al. 2015). However, it could also be attributed to the higher quality of the articles resulting from scientists' collaborative work as they, e.g., cross-check each other's work and apply complementary skills (Clark/Llorens 2012; Leahey 2016). Working in teams could also foster creativity and result in more novel ideas (Bikard et al. 2015). This seems to be attributed to the so called "Medici-Effect" that occurs when new ideas emerge from the interaction of scientists from different perspectives and various disciplines and backgrounds (Bikard et al. 2015; Johansson 2004). Studies have shown that atypical scientific ideas (as measured by which journal a paper cites) lead to a higher impact of research articles (Mukherjee et al. 2017; Uzzi et al. 2013). These results are also in line with the theoretical assumptions, that collaborating with other scientists can increase productivity through the access to their human capital or technical resources that facilitate the realization of research projects.

Moreover, collaborations can provide learning opportunities for scientists through professional exchange with other scientists (Aldrich/Al-Turk 2018). This aligns with the idea that scientists can expand their own human capital. Accordingly, the results of Freeman et al. (2015: 30) suggest that scientists are particularly interested in collaborations with other scientists from whom they can learn, in order to complement their "knowledge, expertise and capabilities".

In general, scientific collaborations might improve the overall research experience by enhancing motivation and discipline. Freeman et al. (2015), for instance, show that scientists perceive the research experience in teams to be more pleasant.

3.3 Competition in Academic Research: Secrecy and Credit Allocation

While most articles on the topic of competition in academic research are theoretical, Hong and Walsh (2009) find that competitiveness has increased among experimental biologists over a time span of 30 years. They further linked competitiveness to secrecy, i.e., withholding relevant knowledge due to "concerns about being anticipated" (Hong/Walsh 2009: 146). In line with these results, Blumenthal et al. (2006) find that data withholding is common in genetics and other life sciences, especially in environments in which scientists perceive a higher level of competition. Scientists, for example, omitted information from a manuscript and delayed publication in order to secure their own scientific lead. Furthermore, results of focus-group discussions support that competition negatively influences the exchange of information. The study participants reported the omission of relevant information in presentations and publications to prevent anticipation. The participants also voiced concerns about competitors interfering with peer-review processes and stealing their intellectual property (Anderson et al. 2007). These results match expectations according to the theory of social interdependence, that negative interdependence (only one group/scientist can publish the results) leads to contrient interactions (Deutsch 2011; Johnson/Johnson 2005).

Competition within research teams can revolve around credit allocation. When scientists work and publish alone they are the sole recipients of credit, whereas working in research teams forces scientists to share credit and individual authors only receive a fractional amount of credit, based on the number of co-authors (Aldrich/Al-Turk 2018; Bikard et al. 2015). While collaboration has a positive impact on scientists' overall publication record, empirical evidence regarding the influence of team science on the fractional publication count is less clear (Bikard et al. 2015; Lee/Bozeman 2005). Bikard et al. (2015) even find that collaboration can eventually decrease scientists' fractional productivity by over 30 %. One qualitative study indicates that postdocs may prefer to work alone in order to "[…] ensure first authorship, avoid authorship conflicts and keep the number of co-authors low" (Müller 2012: 289). Hence, the anticipation of conflicts or the competitive nature of the academic career may prevent some collaborations from the outset.

3.4 Coordination and Communication Challenges

One major source of pitfalls within collaborations can be coordination and communication challenges, which can be very time-consuming and can have various origins, such as conflicting goals, time horizons and communication difficulties due to different disciplinary or cultural backgrounds. Increased needs for coordination and communication can negatively affect the productivity of research teams and thus the productivity of individual scientists (Aldrich/Al-Turk 2018; Bikard et al. 2015). This observation was made above all in connection with multidisciplinary teams and collaborations between different institutes or universities (Cummings/Kiesler 2016). Freeman et al. (2015: 39) find that two of the biggest hurdles for scientists, who work collaboratively, are "insufficient time for communication" and "problems coordinating with team member's schedule". Collaborations can further hinder scientists' individual autonomy due to "less flexibility in how the research was carried out".

While on the one hand it is assumed that collaboration between scientists from different backgrounds and disciplines has a positive effect on the creation of novel ideas, there are also opposing views; working in multidisciplinary teams might entail more conflicts and challenges due to the diverse background and working habits of the collaborators. Understanding ideas and perspectives from other scientific fields can further be challenging and it might be difficult for reviewers to grasp and evaluate cross-disciplinary work. This could lead to a lengthening of the review process and thus to delayed publication, which could negatively affect scientists' productivity (Leahey et al. 2016). Based on these assumptions, Leahey et al. (2016) analyzed data from around 900 scientists and their 32,000 published articles and found that interdisciplinary research is associated with cognitive challenges and hurdles in peer review and lower productivity, but not with lower article quality.

3.5 Collaboration with Senior Scientists/Professors

Even from the very early stages, personal relationships with professors can help ease the transition into an academic career. Studies have shown that early personal contact (such as working as tutor or student assistant) with university lecturers increases the likelihood of transitioning into a doctorate (Jaksztat/Lörz 2018; Konsortium Bundesbericht Wissenschaftlicher Nachwuchs 2021).

While there is still no research on the influence of superior professors on their postdocs' careers, studies point to a career-enhancing effect of relationships with senior scientists and professors. Studies have shown that former PhD supervisors can increase postdocs' chances of reaching tenure (Combes et al. 2008; Godechot 2016; Lang/Neyer 2004). Moreover, empirical evidence supports the idea that being connected to senior scientists as a PhD student increases the chances of getting employment as a postdoc (Fuchs et al. 2001; Lang/Neyer 2004; Schubert/Engelage 2011). Lang and Neyer (2004), for instance, find that the supervisor's productivity increases the chances of finding a postdoc position. These findings support the idea that professors are well connected and can use their ties to support their (former) protégés in finding new positions.

In the context of mentoring, Davis (2009) shows that postdocs whose supervisors work with them on a research plan submit and publish more articles and are more successful in obtaining external funding. Scaffidi and Berman (2011) report a link between the quality of supervision and the publication output of postdocs. These findings support that professors' human capital, and experience within the academic context can affect the productivity and success of their postdocs. In the context of an interview study, both the interviewed professors and the young scientists described the dyadic relationship between professor and young scientist as decisive for the success or failure of academic careers (Richter/Reul 2016).

Despite these positive aspects of collaborating with senior scientists and professors, there can be negative aspects, too. Professors are often (informal) supervisors and at the same time superiors of their staff (e.g., Ullrich 2019). Since the many roles they incorporate are mainly informal, they face no sanctions for poor performance. They can leave the task of promoting their postdocs' careers unattended without personal consequences: "There is no systematic or organizational, let's say structured support. It's all individual, decentralized. If I am a nice person, I take care of my people, yes, if I am not, they are in the woods"[2] (quote from a professor in Richter/ Reul 2016: 323). Another negative aspect of collaborating with senior scientist/ professors can be free riding: Bikard et al. (2015) find that collaborating with higher rank scientists has a negative impact on the quality gain (measured by the number of citations) and on the fractional productivity of young scientists' publications. In this context, Hu et al. (2014) discover that scientists at a later career stage benefit more from collaborations than scientists at earlier career stages. In addition, junior scientists may not always receive adequate recognition for their contribution to a senior scientist's project. Studies suggest that particularly female junior scientists may profit less from collaborating in terms of publications as co- and lead author (Feldon et al. 2017, Epstein/Lachmann 2018). Moreover, Al-Herz et al. (2014) investigated the practice of adding honorary authors in biomedical journals in a survey study and found that one third of their respondents added authors to their publications even though they did not deserve authorship credit. Reasons for this practice include avoiding conflicts and facilitating acceptance of the article. These examples underline the effects that asymmetries in interdependence/power imbalance (Deutsch 2011; Johnson/Johnson 2005) can entail. Due to their inexperience or dependence on senior scientists/professors, there may be little that early career scientists can do against these malpractices.

4 Methods

4.1 Sample

This study is based on qualitative data from the E-Prom project[3] (phase 2, 2016–2019), which was funded by the "Bundesministerium für Bildung und Forschung (BMBF)". The project aimed to analyze the career paths of postdocs in the life sciences (primarily in the fields of biology and medicine) in Germany. Of particular interest were scientific careers that continued at the university, as opposed to research careers in the private sector.

The interviewees were selected from a previous longitudinal online survey in which postdocs at universities in Bavaria, Saxony and North Rhine-Westphalia participated (for details see project report[3]). For the qualitative interviews, participants who provided their contact details and who indicated that they continued their careers in academic research were contacted. When selecting the interview participants,

2 This quote is originally from a German interview study from Richter and Reul (2016) and was translated to English for the purpose of this article and is thus not quoted verbatim.

3 German title „Einflussfaktoren auf die Karriere Promovierter in den Lebenswissenschaften (E-Prom 2)", English title: "Factors influencing postdocs careers in the life siences" (Epstein et al. 2020).

attention was also paid to a balanced gender and subject (biology and medicine[4]) ratio.

Within this project, 22 qualitative interviews with postdocs from the life sciences (eight physician scientists and 14 biologists) were conducted between February and June 2017. Table 1 shows an overview of the study participants. Half of the respondents were female, the other half male. At the time of the interview, the interviewees were mainly working in various biological and medical sub-disciplines in academic research. However, two of the interviewees, contrary to their earlier statements, had already left academic research and were working in the pharmaceutical industry (ID9) and as medical technical assistant (ID11). Two other respondents were on parental leave (ID7, ID13) and one respondent was unemployed (ID12). Even though these respondents were not employed or not working in academia at the time of the interview, they were not excluded and were retrospectively interviewed on their postdoc time. Four respondents were working abroad at the time of the interview.

4.2 Interview Procedure and Topics

The interviews had a length of between 30 and 60 minutes. In addition to postdocs' career paths, goals and decisions, the interviews included the topics *collaborating with other scientists* and *career support by the superior professor*. The interviews conducted were standard structured interviews, based on a guideline. The interview guideline consisted of questions on five central topics: Current occupational situation, time investment on different tasks and overtime, scientific collaborations in (multidisciplinary) teams (with focus on benefits and pitfalls of collaborations), career support from the professor, career support from the university, and career aspirations.

4.3 Coding and Analysis of the Interviews

To address our research questions, we only analyzed the related interview sections, encompassing the topics of *1) scientific collaborations* ("Do you also work together with other scientists? Who do you work with and what does the collaborative work look like?", "In what ways can you benefit from working with other scientists?", and "What problems/disadvantages arise while collaborating with others?"), and *2) career support from professors* ("Do you talk to your professor about planning your (academic) career and what support do you receive in this?", and "Do you talk to your professor about opportunities outside academia?").

The interviews were transcribed verbatim and analyzed following Mayring's qualitative content analysis (2000, 2010). Following the interview guideline, we deduc-

4 As there is a shortage of physician scientists in Germany (e.g., Gerst/Hibbeler 2012), it was more difficult to recruit members of this discipline. Accordingly, the subject ratio is not entirely balanced.

tively developed a first draft of the coding scheme that incorporated all main categories but also some subcategories. This coding scheme was supplemented inductively with more subcategories that came up during the first rounds of coding. The relevant main categories were: *1) type of collaboration (internal/external, intensive/less intensive, monodisciplinary/multidisciplinary), 2) benefits of scientific collaboration, 3) pitfalls of scientific collaboration, 4) collaboration with professors, 5) career support from superior professors, 6) no support from superior professors,* and *7) strategies for conflict prevention.*

After the coding scheme was finalized, we coded the interviews independently. We calculated the interrater reliability using Cohens's kappa (Cohen 1968) and had a value of 0.85, thus considered "good" (Lombard et al. 2002). Since the exact location of the codes in the interviews was irrelevant for the interpretation, we calculated Cohen's kappa based on the presence of the code as a measure of agreement (Epstein et al. 2018).

Table 1: Overview of the Interview Study Participants (E-Prom 2)

Interview	Gender	Year of Birth	Field	Occupation at Time of Interview	Career Aspirations
1	male	1985	Medicine and Microbiology	Resident at university hospital and scientist	Completion of specialist medical training, Habilitation (with subsequent application for professorship)
2	male	1975	Biology (Pharmacology)	Scientist	Leaving academic research
3	female	1986	Biology (Environmental Biology)	Scientist	Permanent position as research assistant
4	male	1986	Medicine	Resident at university hospital and scientist	Completion of specialist medical training, Habilitation (with subsequent position as senior physician)
5	male	1986	Medicine (Nuclear Medicine)	Resident at university hospital and scientist	Completion of specialist medical training, Habilitation (with subsequent position as professor or senior physician)
6	female	1977	Medicine (Internal and Rheumatism)	Senior physician (mainly in research)	Extraordinary professorship, or possibly leaving academic research

Interview	Gender	Year of Birth	Field	Occupation at Time of Interview	Career Aspirations
7	female	1984	Medicine (Paediatric Medicine)	Scientist on parental leave	Completion of specialist medical training, Habilitation (if not too time-consuming), clinical and scientific career
8	male	1985	Medicine (Neurology)	Resident at university hospital and scientist	Completion of specialist medical training, Habilitation (if not too time-consuming), clinical and scientific career
9	male	1982	Medicine	Physician and employee in pharmaceutical industry (former postdoc in USA)	No academic career intentions
10	male	1984	Biology	Scientist	Leaving academic research
11	female	1984	Biology	Medical-Technical Assistant	Current position
12	female	1981	Biology	Unemployed	Research assistant or leaving academic research for research position in industry
13	female	1983	Biology	Scientist on parental leave	Permanent position as research assistant or leaving academic research
14	female	1981	Biology (Nutritional Science)	Scientist	No professorship intentions, in general undecided (research assistant or leaving academia)
15	female	missing	Biology	Scientist	Junior professorship (with subsequent application for professorship) or permanent position as research assistant, otherwise leaving academia
16	female	1986	Biology	Scientist (NL)	Junior-group leader (with subsequent application for tenure track program or full professorship)
17	male	1985	Biology	Scientist	Long-term academic career intention, professorship
18	female	missing	Biology	Scientist	Scientific management in public sector
19	male	1982	Biology	Scientist	Position as group leader, permanent position as research assistant

Interview	Gender	Year of Birth	Field	Occupation at Time of Interview	Career Aspirations
20	female	1983	Biology	Scientist (USA)	Research assistant or leaving academia
21	male	1982	Biology	Scientist	Research assistant or teaching
22	male	missing	Biology	Scientist (GB)	Research position in industry

5 Results: Scientific Collaboration in the Life Sciences

5.1 Benefits and Pitfalls of Scientific Collaboration

For a better understanding of how the respondents collaborate with other scientists, we were first interested in the *type of collaboration* the postdoctoral life scientists from our study sample engage in. When asked about the location of collaboration partners, respondents reported almost equally on collaborations within their own institution/working group and across institutional boundaries (including international collaborations and collaborations with economic partners). In this context, the interviewees also indicated that internal collaborations were predominantly more intensive than external collaborations. Hence, internal collaborations were rather emphasized as strong ties, and external collaborations as weak ties. As expected, almost all respondents stated that they frequently work with scientists from other disciplines, with multidisciplinary collaborations taking place with both internal and external collaborators. Only three of the interviewees mainly collaborated with scientists from their own discipline (ID15, ID21, ID22).

5.1.1 Benefits of Scientific Collaboration

Overall, the interviewees perceive collaborations as indispensable for their professional life:

> *"As a lone wolf, I think you get lost in the life sciences."*[5] (ID1, physician & microbiologist)

Most interviewees highlighted the importance of the **1) experience and knowledge of others/access to human capital**. In this context, the interviewees experience the mutual discussion and the professional exchange with other scientists as particularly beneficial not least for generating creative research approaches and increasing the quality of research:

> *"[Without collaboration] I think something very important would be missing, which is in the area of creativity. Because I believe that input is very important for creativity. I think in modern science we need this exchange. Very little works in the way that, I think about something for years and then come up with a brilliant idea. I think we are also very far away from the universal scholar who can know everything.*

5 All interviews (except interview ID22) were conducted in German. We translated the quoted interview sections into English.

> *So, we simply need this interaction and this collaboration, and the research I would produce [without collaboration] would simply be much worse."* (ID17, biologist)

Interviewees indicated that they benefit from collaborating with colleagues in their own discipline as they can seek expert advice, share experiences, and compare different research approaches. In addition, the respondents stated that they particularly benefit from the knowledge and experience of scientists from other disciplines and with different specializations. Physicians and biologists share this point of view:

> *"So, on the one hand, you have a very different, different mind-set. So, you approach it very differently. If you assume that we are cell biologists, we always have the cell in mind. And if you then look with these physicians, they always have the implementation in mind. So, these different perspectives are definitely very important."* (ID16, biologist)

> *"I believe that we as physicians have more of an eye for the medically relevant, but that we clearly benefit more from the biochemist when it comes to making any biochemical analyses, which far exceeds our competences."* (ID1, physician & microbiologist)

Hence, social networks generally bring in new ideas and foster creativity ("Medici-Effect", see Johansson 2004). They also bring in more human capital. This was specifically emphasized with reference to other disciplines. In contrast to our theoretical assumption that mainly external collaborations/weak ties (Granovetter 1973) bring in new ideas, our study respondents stated that this is the case for both internal and external collaborations. This is probably due to the high number of inter-/multidisciplinary collaborations that are very common in the life sciences in general, also in internal collaborations, and bring in new knowledge, perspectives and ideas.

Directly related to this is the 2) **realization of research projects**. Many research projects can only be carried out through collaboration of experts from different fields and with specializations:

> *"But I would say that the exchange with chemists and biochemists at the beginning is actually essential, without them it wouldn't work at all. You couldn't work at all."* (ID16, biologist)

> *"Well, here in nuclear medicine we would be limited to nuclear medicine questions. And many of the questions we are working on would probably not even be asked, because the input regarding the need for information that this research is supposed to generate in the end does not exist."* (ID5, physician)

Furthermore, two interviewees (ID7, ID14) pointed out that collaborations are important for the collection of big datasets that are needed to generate good clinical data and international recognition.

The fact that research projects can often only be realized if scientists collaborate highlights that research projects involving different partners do, generally speaking, establish a state of interdependence, which can be positive, if there are no conflicts of interest and the common goal is equally important to all project partners (Deutsch 2011; Johnson/Johnson 2005).

In addition, the respondents reported that they could 3) **expand their own knowledge/human capital** through the aforementioned exchange. The interviewees indicated that they learn from different perspectives and (methodological) approaches, and specifically from scientists with different skills, research specializations or disciplines. Apart from technical and professional knowledge, participants also mentioned social skills, such as learning to lead people, communicate and successfully manage research projects (ID17, ID3):

> *"[…] and on the interaction level, I think you also learn quite a lot when you work with different people. In terms of leading people or maybe understanding why some collaborations didn't work out or something like that."* (ID17, biologist)

In this context, one interviewee also mentioned that the gain of knowledge/human capital can also be useful to prevent errors:

> *"And if you use these techniques several times, of course it becomes easier and you can work together more effectively because you know the problems of both parties and you can address them from the beginning. And maybe also know the difficulties of some techniques directly and avoid problems."* (ID4, physician)

Another benefit of collaborations can be 4) **increased productivity** through the division of labor. In this context, the respondents mentioned that collaboration can be more efficient than working alone, as one can save time and work on different projects simultaneously:

> *"And you don't have to learn the methods for yourself and you don't have to learn the expertise to do certain things, so you just save time and you save money and you save nerves."* (ID20, biologist)

Importantly, collaborations are seen as an opportunity for joint publications, i.e. adding to one's publication record as collaboration *"[…] results in publications, which I need for my career"* (ID 15, biologist).

Respondents further benefit from 5) **access to technical resources**. Besides profiting from the collaborators' know-how, for instance regarding the implementation of methods, it is mainly technical resources—such as (already established and otherwise costly) technical equipment needed for certain experiments—that are mentioned:

> *"Yes, I can benefit from it in the way that I can carry out analyses or get results that I would not have been able to achieve myself, because you don't have the technical equipment and the technical background to do this analysis."* (ID4, physician)

5.1.2 Pitfalls of Scientific Collaboration

In addition to the benefits of collaboration, the life scientists also reported a variety of potential pitfalls to collaborative work.

Above all, the postdocs mentioned 1) **conflicts due to competition** as one negative aspect of collaboration. The interviewees reported that conflicts are predominantly tied to questions of authorship and the order of authors. For example, ID8 (physician) stated *"it's a bit of a question of who stands where on the paper and who benefits more or less. That's always a bit of a point of contention".* These conflicts were predominantly mentioned in the context of external collaboration/between working groups, as one interviewee states:

> *"[…] in the end you want to write something about it and publish it and so on. But the other working group that is assigned to us also has this interest. And then it's just a question of who is in charge of writing the article in the end."* (ID5, physician)

One of the interviewees (ID11, biologist) pointed out that sharing knowledge with external collaborators is a *"delicate issue"* since *"you have to trust that they won't publish beforehand".* Another respondent (ID15, biologist) is even under the impression that collaboration partners in some cases hinder the publication process of other team members to secure their own scientific lead:

> *"[…] there are often competing interests. I don't think that they want us to publish so quickly because they already have their own publication in the pipeline on the topic. And then, they might want to put the brakes on my publication. That's not very nice morally, but it does happen. […]. Sometimes it's just a bad suspicion. But I have the subjective impression that it does happen in individual cases, unfortunately."* (ID15, biologist)

In another case of international collaboration, the interviewee reported that the project partners had applied for a patent in their own name without consultation. While the postdoc herself was the author and inventor of the method in question, the project partners made a profit from their national law, that the first ones who apply for the patent are seen as the patent holders.

> *"[…]. And that led to difficulties in the patenting process. And that was rather negative, I would say, because we shared our results with them and thereby we cut our own flesh, so to speak."* (ID11, biologist)

As already mentioned, these conflicts primarily took place in the context of external collaborations, hence, rather weak ties with less closure and fewer opportunities for sanctions (Coleman 1988; Granovetter 1973). In contrast, self-chosen collaborations or internal collaborations were mostly described in the light of their benefits. Further, the described situations of conflicts have in common that there are individuals or teams that aspire to an individual goal that is incompatible with team success—being the first and/or only author. Hence, these situations can be characterized as situations of negative interdependence (Deutsch 2011; Johnson/Johnson, 2005). Negative interdependence/competition can lead to oppositional/contrient interactions, i.e., sabotaging others' efforts to reach their goals (Deutsch 2011; Johnson/Johnson 2005). Some of our interviewees' statements show contrient interactions: The interviewees mentioned, e.g., that they withhold information because they are afraid of being scooped by project partners (ID11, biologist) or that they assumed that project partners had thwarted them (ID15, biologist).

There was one interesting case, in which an interviewee described a highly competitive workplace (ID15, biologist), in which there is no real collaboration between employees and everyone "defends his sinecure".

> *"[…] everyone sits so on their assigned things. One is responsible for the technology; another is more responsible for teaching and defends that very much. Yes, so there is not much exchange among each other, little teamwork takes place"* (ID 15, biologist)

She further characterized her chair as a three-tiered society in which the post-docs/research associates with permanent contracts were the "ruling class", then the "regular" postdocs came second and lastly the PhD students. She attributed this state at least in some part to an absent professor and his lack of leadership. In this case, the network structure was present; however, resources could not be (optimally) mobilized due to a highly negative relational dimension (Nahapiet /Ghoshal 1998).

Further, **2) coordination and communication challenges/costs** were mentioned as obstacles to successful collaboration. In this context, the respondents spoke about reduced efficiency due to difficulties in arranging joint project meetings (ID3, biologist), as well as hurdles in joint decision-making (ID6, ID19). These issues were predominately mentioned in relation to external collaborations between institutions:

> *"[There are already problems] when you are spatially separated, i.e. when there are other institutions. That you can't exchange information so quickly and easily. You always have to arrange these project meetings and then everything has to be discussed there. That is also very inefficient, so you often can't exchange information as well or as deeply as you should." (ID15, biologist).*

Coordination challenges were also mentioned with regard to disciplinary discrepancies. For example, ID15 (biologist) described a potential for conflicts if different disciplines work together and team members want to analyze and present the results in a different way, e.g., some of them *"[…] want to look at it more scientifically, but the others are more implementation-oriented".* Moreover, ID2 (biologist) pointed out that there are often problems regarding the distribution of tasks and the roles within the teams especially at the beginning of the collaborative endeavor as *"[…] people don't want to or can't identify with the role*".

Besides these coordination costs, the interviewees reported communication issues, which were often described in connection with multidisciplinary collaboration. These communication challenges were mentioned by both the physicians and the biologists in our study sample:

> *"You have to move together on one level, which means that as a physician you sometimes lack the technical understanding that biologists have. On the other hand, biologists don't always have a full grasp of these physiological backgrounds or have to familiarize themselves with them."* (ID4, physician)

> *"Well, it's sometimes a bit difficult as a biologist when things get very medical, I'd say. So, when you're sitting in a meeting with all the physicians […] it's sometimes a bit difficult to follow as a biologist. Because you don't know all the abbreviations or idioms or whatever in detail. Because you simply come from a different perspective."* (ID13, biologist)

In addition to these disciplinary communication barriers, cultural/linguistic communication challenges were also addressed—especially while working with international partners or collaborators of different nationalities. Here the interviewees mentioned language-related barriers during meetings, as the following interview excerpt shows:

> *"Cultural problems, I would say. There can be communication problems, where people understand things differently and then don't come out of the discussion with the same conclusions, for example. […] I had an Indian colleague a few years ago, and it took a very long time until communication was clear and we understood each other well. So, I think you often have to adjust to each other more when you come from clearly different cultural backgrounds."* (ID19, biologist)

In general, it shows that coordination and communication costs of collaborations were especially high in reference to external and multi-/interdisciplinary collaborations, hence resulting in rather weak ties with little or no network/group closure (Coleman 1988; Granovetter 1973). Further, referring to the cognitive dimension of social capital (Nahapiet/Ghoshal, 1998) it becomes clear that shared language and codes are important for efficient collaborations.

Following the previous topic, some respondents mentioned **3) prioritization issues and loss of independence** as a negative aspect of collaboration. Prioritization issues can delay projects: Scientists often work on more than one project and *"[…] the prioritization of the projects is not always equally weighted"* (ID4, physician). Usually *"[…] everyone does their own main project first, and if you're involved in something with the others, that always takes a back seat"* (ID1, physician & microbiologist). This difficulty was also mentioned in the context of collaborating with physician scientists, who are often overburdened by multiple scientific and clinical tasks and cannot always fulfill their tasks in the collaborative project in a timely manner:

> *"Of course, with physicians at university hospitals who have a very tight program, you sometimes have to wait a little longer for things to progress. Because everyone is working on many projects and has the clinic at the same time." (ID14, biologist)*

One respondent (ID4, physician), for example, stated that working alone gives more freedom to *"work more independently"* and *"organize things better"* as you are not *"dependent on others"*. Another interviewee described the dependency on (interim) results needed from a project partner in order to advance to further research questions:

> *"The difficult thing about the project was that a lot of industrial partners were involved and some of them did it on the side instead of focusing more on it. That means that in some cases you had to wait for results or interim results before you could continue working yourself."* (ID12, biologist)

This shows that the degree of interdependence (Deutsch, 2011) is higher when collaborating with external partners and that (external) collaboration can entail asymmetries, in the sense that one person may be more dependent on intermediate results or in the advancement of the research project in general. In this case, the postdocs are more dependent on successful project outcomes than their industrial collaboration partners, as they need publications to advance their scientific careers.

Another statement by a respondent (ID15, biologist) points to the problem of 4) **free riding.** The interviewee complained that collaboration with others often does not take the form of a real collaboration *"[...] but you have to put the people on it [on the paper] because they somehow helped a bit at some point".*

5.2 Collaboration with Professors and Career Support from Superior Professors

This section describes the postdocs' experiences of working with professors within projects—this comprises the superior professors but also other professors. In addition, we analyze the career support that postdocs receive from their superior professors.

The interviewees reported **1) collaboration with professors** such as professional advice and joint work on publications or proposals:

> *"Yes, that's definitely the case. He is also very much involved in the whole publication process. So, it's also the case that with every publication we really sit at the computer again at the end and fine-tune the text."* (ID3, biologist)

> *"When I write proposals—but unfortunately this has not been successful so far—because he is very encouraging and helps and has ideas and says we'll try again. He also reads through it and so on, in that respect."* (ID17, biologist)

Another positive aspect of collaborating with professors is their experience of navigating within academia, e.g., how to talk about delicate subjects with projects partners. In this respect, postdocs can acquire a form of "Habitus" through observing their superior professors:

> *"And I also experience that it is the case that you have to be careful and diplomatic, and then maybe you don't ask or do certain things directly for strategic-political reasons. But the more experienced you become—and I can see that above all in my boss, who has many years more experience—the better you can deal with it, I think, and then you can also use it positively for yourself."* (ID5, biologist)

One interviewee (ID15) described that she is obliged to list the professor as co-author and that he slows down the publication process:

> *"No. He just says that I should publish as much as possible, or he actually always says that we all have to publish more. But if I then write a publication where he has to be co-author, that's simply the requirement from him, and put it on his desk to be corrected, then it stays there for at least a year. No matter how often I ask and put pressure on him. He tends to put the brakes on me when it comes to things like that. He says he wants us all to do it, but then he actually slows us all down."* (ID15, biologist)

This shows that collaborating with professors not only entails benefits through access to professors' human capital, but that postdocs are also highly dependent on them. Here, asymmetries in the degree of dependency (Deutsch 2011) become visible.

In a similar direction, another postdoc reported, that professors insisted on their "right" to first and last author positions in a project, not because of their contribution, but because of their reputation. While the postdoc needed the authorship for his publication record and his professor instantly supported him, the professor gave in to the demands of the other professors and also to the sponsors of the study and their right to have a say:

> *"Two or three days ago I had a discussion with my professor, hey, that wasn't the agreement, publication strategy or not. But he said, what can you do, of course the sponsor also has a say, and of course there are other authors, important authors, who also want their rights, blah, blah. And now there's a bit of arguing and negotiating. But I, as a small fish, will probably get the short end of the stick"* (ID2, biologist)

This example highlights the potential pitfalls of collaborating with professors due to the power asymmetry between postdoc and professor but also the discrepancy in dependency (Deutsch 2011): The authorship is more important for the postdoc's than the professor's career.

Half of the respondents stated that they received advice and **2) support for their career from their superior professors**. ID19 (biologist), for example, stressed that his career development is a *"very important topic"* for the professor and that he feels *"quite well advised"*. Others reported that career planning is *"an important part of our regular meetings"* (ID17, biologist) or that there is *"kind of a performance talk once a semester"* in which questions regarding career development could also be addressed (ID20, biologist). In terms of content, these discussions mainly relate to general recommendations on the Habilitation, publication goals and strategies, implementation of projects and recommendations about networking:

> *„So, in the end, it is agreed that it should lead to a Habilitation. And in this respect, you are also supported in the implementation of these academic projects. And there have already been consultations about whether you are on schedule or whether you should possibly initiate other projects, [...] and the goal is to sit down with your supervisor and set priorities. So, I can already see that there is support there."* (ID4, physician)

> *"And we also discuss the concept together beforehand and sit down together strategically more often and think about what projects we have, what could be published and what would be most effective for whom in our team as small research packages."* (ID3, biologist)

> *"Yes, that's true. It's more in the direction of who you meet, at which conferences you might talk to whom. In that direction, yes."* (ID20, biologist)

Another example of career support is provided by one interviewee, who was nominated for an award by her professor to enhance her CV:

> *"[...] and he is always on the lookout, for example. So right now, he suggested me for a water monitoring prize and I didn't have to come and say, hey, can you suggest me or something. To be honest, I didn't even notice that the prize existed and he saw it somewhere and thought of me and said, see if we shouldn't put you forward, because that would be great for your CV and so on. And he's definitely on board with that. So, I can't complain at all."* (ID3, biologist)

This example illustrates that professors occupy central positions within networks and have information that postdocs may not have, and therefore can act as brokers (Burt 2001).

One interviewee stated that the professor had also previously helped postdocs to find positions outside academia, making use of his networks. The interviewee also stated that the professor would support him in this direction too, if he asked for it:

> *"I could imagine something like the State Office for the Environment or the Ministry of the Environment or something like that, to somehow try to get a job there. But he would definitely support me there, […] then I would definitely approach him and say that I would like to be placed in such and such a direction, and whether he can support me there. And I know from other colleagues, from several colleagues for whom this has already worked, this support, that he would definitely do that."* (ID3, biologist)

This example shows that professors—presumably depending on the discipline—not only have access to networks within academia, but can also assert their position and influence and can use other networks outside of academia to accommodate their postdocs.

Some respondents also suggest that their professors provide support for continued employment. The respondents indicate that their professors discuss employment options with HR and try to get contract extensions for their postdocs (ID3, ID10). ID14 (biologist), e.g., pointed out that her professor *"would go to great lengths to accommodate us well"* and *"to open opportunities for us or to use her contacts to find another door for us"*. Again, this shows that professors can use their influence and central network positions to open career opportunities for their postdoc.

Three respondents (ID2, ID8, ID15) answered that they currently receive 3)**no support from superior professors**. ID8 (physician) pointed out that *"[…] there is no such thing [as career support], no, and I hardly know anyone who really has such conversations here"*. ID2 (biologist) even assumes that professors are generally not interested in supporting their scientific employees, because *"it's not in the nature of a professor to stand up for the individual staff members in that respect. No, you can forget that"*. Also, ID15 (biologist) feels that the professor is *"not interested at all"* in advising or promoting research assistants.

5.3 Strategies for Conflict Prevention

In addition, some interviewees mentioned strategies they use to avoid conflicts in collaborative settings, which usually included different institutions.

The postdocs stated that it is important to clearly communicate and define the individual contribution of the project partners and the individual and common goals within the joint project from the outset:

> *"That's why whenever I do something with someone, I always try to discuss clearly in advance with all the people involved what the distribution should be, what the effort is for each person and what everyone has to gain from it."* (ID8, physician)

Problems usually arise at the end of collaborative projects if the expectations were not set clearly from the beginning. In relation to this, one respondent stated that the negotiation over authors' positions is "*[…] mostly [conducted by] the hierarchical* *levels above the postdocs*" (ID5, physician). However, another interviewee mentioned that in spite of agreements made at the start of the project, problems can still occur. Conflicts would then arise between professors who want to "push" their own postdocs/scientific staff:

> *"That's usually at the end, when everything has already been done and then someone wants to push someone else in some way and then somehow thinks about changing everything. And these are often professors who somehow don't agree."* (ID8, physician)

6 Discussion and Conclusion

The aim of this study, set in the German academic career context, was to explore postdocs' collaboration experiences drawing on the concept of social capital (Coleman 1988, 1990; Granovetter 1973; Nahapiet/Ghoshal 1998) and the theory of social interdependence (Deutsch 2011; Johnson/Johnson 2005). Hereby, our aims were 1) to explore whether postdocs perceive positive or negative aspects of scientific collaborations to be predominant, 2) to specify the situations, in which conflicts occur and competition prevails, and 3) to specifically investigate postdocs' collaboration experiences with professors in general and the career support they receive from their superior professors in particular.

In terms of the benefits and pitfalls of collaborations, the benefits, overall, outweighed the pitfalls. The interview partners hereby highlighted the access to resources that were made possible through their collaborative network: human capital/cognitive resources and technical resources. Access to these cognitive and technical resources was described as indispensable for realizing certain projects, specifically multi-/interdisciplinary projects. Furthermore, and consistent with previous research (e.g., Freeman et al. 2015), learning from collaborative partners, within collaborations, was mentioned as a positive aspect—specifically in projects including multiple disciplines. This not only included professional/technical knowledge, but also social and project management skills. This shows that social networks generally bring in new ideas and foster creativity ("Medici-Effect", see Johansson 2004), not only in external but also internal collaborations, due to the strong multidisciplinary work environment. In addition, scientific collaborations can increase the productivity of individual scientists, as they have the opportunity to work on different projects simultaneously and act as co-authors, which increases their publication record (e.g., Wieczorek et al. 2020). The number of publications is crucial for an academic career, and studies suggest this is the most important factor of attaining tenure (e.g., Jungbauer-Gans/Gross 2013; Lutter/Schröder 2016).

Despite the positive aspects mentioned, our study supports the assumption that collaboration can be linked with, for instance, problems of coordination and communication (e.g., Bikard et al. 2015; Freeman et al. 2015), which are especially common in the context of external and multi-/interdisciplinary collaborations, characterized by rather weak ties with reduced network/group closure (Coleman

1988; Granovetter 1973). Coordination issues can arise, e.g., due to difficulties in arranging joint project meetings and prolonged joint decision-making on the basis of different disciplinary- and cultural/linguistic backgrounds. This shows that the cognitive dimension of social capital (Nahapiet/Ghoshal 1998), i.e., shared language and codes, is important for efficient collaboration. Also, some interviewees described prioritization issues and the loss of independence as negative aspects of collaboration. In summary, projects including multiple disciplines might be more innovative at the cost of a reduced efficiency—which is in line with the results of Leahey et al. (2016).

Furthermore, respondents' statements implied aspects of partner opportunism. Leahey (2016) describes free riding as a form of partner opportunism that occurs when team members are credited as co-authors, even though they did not make an adequate contribution. Consistent with this theoretical assumption, one interviewee complains that she has to include other scientists as authors even if they have only made a small contribution. Beyond that, partner opportunism/free riding seems to appear in situations of power imbalance; as one interview partner describes, the professors involved claimed their "right" to authorship based on their position and reputation.

Above all, the interviewees perceived competition as a major pitfall to scientific collaboration. Postdocs report conflicts especially regarding the order of authors and (fears of) being scooped by project partners. Interestingly, conflicts were mentioned almost exclusively in reference to external project partners that are probably characterized by weaker ties, less closure and fewer possible sanctions for misconduct (Coleman 1988; Granovetter 1973).

Further, as described by the theory of interdependence (Deutsch 2011; Johnson/Johnson 2005) the competitive situations described by postdocs have in common that one team member can only reach their goal if the others do not, e.g., being first or last author. Negative interdependence/competition can lead to oppositional/contrient interactions, i.e., sabotaging others' efforts to reach their goals (ibid.). Some of our interviewees' statements show contrient interactions: The interviewees mentioned that they withhold information because they are afraid of being scooped by project partners or that they suspected that collaboration partners tried to impede team members' publications in order to publish beforehand. Tendencies towards secrecy and unethical behavior in a competitive research environment have also been highlighted in a few previous studies by, e.g., Hong and Walsh (2009) and Blumenthal et al. (2006). In one case, an interviewee described a competitive internal working environment with very little teamwork. Her descriptions imply that the insecure career perspectives in academic research can lead to a general competitive mindset that hinders the emergence of collaboration from the outset.

In order to prevent conflicts in scientific collaborations with (external) project partners, the respondents mentioned some strategies they use: It is important to clearly define and communicate from the beginning the individual contribution and the position of the authors for joint project publications, as well as the individual and common goals. Conflicts often arise at the end of collaborative projects when expectations were not clearly formulated from the beginning or are changed (by professors) at the last minute after the project has ended.

In line with Müller (2012) our study shows that agreeing on the author sequence in particular is often fraught with conflict and perceived as burdensome and obstructive to collaborative work. This can lead to scientists preferring to work alone. However, scientific collaborations are not only important for individual careers, but serve a greater purpose: To generate novel and important research ideas and results that advance our society in various domains. As postdocs have to accumulate a certain number of publications as first, co- or last authors[6] in order to achieve their postdoctoral lecturer qualification but also to attain professorship, postdocs may often focus more on their number of publications and on their position on papers than on other research goals. This may lead to less innovative and less risky research. To counteract this "competition for reputation", we should think about possibilities for adjusting the current incentive systems in academia to encourage collaboration and the advancement of scientific knowledge (e.g., Ellemers 2021; Freeman et al. 2015; Müller 2012).

Referring to the structural dimension of social capital (Nahapiet/Ghoshal 1998), professors hold central network positions and may thus have access to more resources, which they can use to positively influence postdocs' career development. For this reason, we were particularly interested in postdocs' collaboration experiences with (superior) professors. Postdocs reported that professors collaborate with them by, e.g., working together on proposals and publications. Their superior professors also help them to find employment as they discuss options with HR and use their contacts to find new positions for their postdocs. Postdocs can further learn from professors' experiences with navigating academia, e.g., how to discuss delicate issues with project partners. In this respect, postdocs can acquire a form of "Habitus" (Bourdieu 1983) through the collaboration with their professors. In our study, we focused on the benefits and pitfalls of scientific collaborations for postdocs. However, it is also conceivable that professors' careers are influenced by collaborations with postdocs, in a positive sense, for instance, through increased visibility and reputation through joint publications.

Recently, the imbalance of power between established professors and their postdocs has been discussed in Germany. This discussion is part of a broader discourse on the working conditions of untenured scientists (e.g., Haug 2018; N² 2019). Even though empirical evidence on frequency, conditions, causes and consequences of

6 The position as last author is (besides the first author position) a key position in the life sciences, since the last author receives most credit for the initial conception and supervision of the research project (Wren et al. 2007).

power abuse is still sparse (e.g., Heckmann et al. 2019; Schraudner et al. 2020; Striebing et al. 2021), there seems to be potential for conflict in German academia. Our data shows that collaborating with professors is not only beneficial for postdocs: One interviewee described that she is obliged to list the professor as co-author even though he even slows down the publication process. This shows that postdocs are highly dependent on their professors and asymmetries in the dependency (Deutsch 2011) become visible. While in our sample only two respondents made statements about professors claiming authorships, regardless of their contribution, the issue of honorary authorships in the life sciences has been addressed by other studies. Al-Herz et al. (2014) find that it is common to include scientists as authors who did not deserve authorship credit, in order to avoid conflicts or facilitate the acceptance of the article.

Moreover, half of the respondents stated that professors advised them on their (scientific) career, e.g., suggesting them for scientific prices or using their ties for their postdocs to getting employed also outside of academia. The arbitrariness of the professorial support (Richter/Reul 2016) becomes clear by the fact that three respondents did not receive any support or career advice at all from their professors.

7 Limitations and Outlook

Our study focused on the life sciences, which differ from other disciplines in several respects. In comparison to other disciplines, for instance, the humanities, but also social sciences, they are multidisciplinary and collaborative by nature. Hence, a strong interdependence of the sub-disciplines/specializations may be not as relevant in these disciplines. For various disciplines within the social sciences with similar quantitative and qualitative research methods, the cost in time and money of acquiring new theories and methods is lower when compared to the life sciences, in which technical equipment is also usually much more expensive. Since we use qualitative data and our study sample does not cover a wide range of sub-disciplines, our results cannot be transferred to all sub-disciplines of the life sciences or to other disciplines. Further research should address the benefits and pitfalls of scientific collaborations—especially settings that lead to competitive behavior—in other scientific fields. Since our qualitative results cannot be generalized, it would be interesting to examine internal vs. external collaborations quantitatively, not only in terms of their level of competitiveness, but also in terms of innovative research. Future studies may examine whether a competitive atmosphere/mindset hinders collaborative projects or the results of such projects.

In our study, we specifically focused on postdocs' collaboration experiences with (superior) professors and the benefits and pitfalls for postdocs' career development. It would therefore also be interesting to explore the perceptions of professors and investigate their collaboration experiences with their postdocs/early career researchers. In what ways are they also dependent on fruitful collaboration with postdocs/early career researchers? In what ways can they profit from these collaborations career wise, despite already holding a professorship? In our sample there was no evidence that status differences were relevant in the conflicts in external collaborations, however we cannot rule out that such status differences were present. Future studies should consider status as a potential source of conflict—this could concern rivalries between researchers on the same status level or abuse of power in the case of status differences.

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Oliver Wieczorek*, Andreas Schmitz**, Jonas Volle***, Khulan Bayarkhuu****, and Richard Münch*****

Types of Collaboration and the Consolidation of Sociological Research

Evidence from publications in five German sociology journals 2000–2019.

Abstract: Research innovation can be fostered under the right circumstances, which include high levels of research autonomy, opportunities for collaborative research, and an open-minded research community able to combine innovation with more conventional lines of research. In the literature, different types of collaboration and team composition are linked to innovation. However, little is known about the association between collaborative research and the consolidation of thought products, innovative or not. We address this research gap based on 2,785 abstracts and 352 'thought products' (theories, methods, research topics) extracted from five German language sociology journals included in Scopus and published between 2000 and 2019. We apply a diachronic research strategy and combine correspondence analysis for topic extraction, network analysis to account for the embeddedness of scholars, and OLS regression to investigate which of the factors present in 2000–2003 are responsible for the consolidation of thought products in 2016–2019. We find that a focus on applied topics (such as management or governance) is positively linked to the consolidation of research. Furthermore, concepts used and disseminated by well-connected scholars between 2000 and 2003 tend to become peripheral over time. Finally, we establish a negative association between concepts used by female scholars and the consolidation of these concepts.

Keywords: Topic consolidation, sociology, geometric data analysis, social network analysis, bibliometrics, natural language processing

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Formen der Forschungskooperation und die Konsolidierung soziologischer Forschung

Eine Untersuchung anhand von Veröffentlichungen in fünf deutschsprachigen Soziologiefachzeitschriften 2000-2019

Zusammenfassung: Forschungsinnovationen benötigen ein hohes Maß an Forschungsautonomie von Forschenden, die Möglichkeit, Forschungskooperationen einzugehen sowie eine aufgeschlossene Forschungsgemeinschaft, die in der Lage ist, Innovationen mit konventionelleren Forschungslinien zu verbinden. Bisher wurden insbesondere die Zusammenhänge zwischen verschiedenen Kooperationsarten und der Teamzusammensetzung (z. B. Teamgröße, internationale Ausrichtung, Geschlechtszusammensetzung) mit Innovation in Verbindung gebracht. Es ist jedoch nur wenig über den Zusammenhang zwischen Forschungskooperationen und der Konsolidierung von Forschung – innovativ oder auch nicht – bekannt. Wir adressieren diese Forschungslücke auf Basis von 2785 Abstracts und 352 „Denkprodukten“ (Theorien, Methoden, Forschungsthemen) aus fünf deutschsprachigen, in Scopus gelisteten, Soziologie-Zeitschriften, die zwischen 2000 und 2019 erschienen sind. Wir wenden eine diachrone Forschungsstrategie an und kombinieren Korrespondenzanalyse zur Themenextraktion, Netzwerkanalyse zur Berücksichtigung der Einbettung von Wissenschaftlern und OLS-Regressionen, um Faktoren zu beleuchten, die in den Jahren 2000–2003 für die Konsolidierung von Denkprodukten in den Jahren 2016–2019 verantwortlich gemacht werden können. Unsere Ergebnisse zeigen, dass angewandte Themen (z. B. Management, Governance, usw.) positiv mit der Konsolidierung von Forschung verbunden sind. Darüber hinaus neigen Konzepte, die von gut vernetzten Wissenschaftlern zwischen 2000 und 2003 verwendet und verbreitet wurden, dazu, im Laufe der Zeit peripherer zu werden. Schließlich stellen wir einen negativen Zusammenhang zwischen den von Forscherinnen verwendeten Konzepten und deren Konsolidierung fest.

Schlagwörter: Themenkonsolidierung, Soziologie, Geometrische Datenanalyse, Netzwerkanalyse, Bibliometrie, Computerlinguistik

1 Introduction

Under specific conditions, scientific innovation can result in scientific revolutions (Kuhn 1962), the revival of scientific disciplines (Heinze et al. 2013), and technological progress (Wu/Wang/Evans 2019). If scientific innovation is to thrive, one crucial condition is a sufficient degree of scientific autonomy at the level of the entire academic system (Münch 2014b; Whitley/Gläser/Laudel 2018). Under these circumstances, the forms of collaboration between scientists are equally important to the development of innovation, for instance in facilitating the efficient division of labor and thus allowing novel combinations of specialized knowledge to emerge (Fontana et al. 2020; Wang/Veugelers/Stephan 2017). For example, recent research indicates a co-emergence of collaborative networks and new paradigms, thus describing how innovation diffuses (Liang et al. 2020). Yet, concurrently, most contemporary research focuses on the prerequisites for innovative research, the generation of scientific breakthroughs, and the processes of diffusion that immediately follow.

So that it does not vanish into obscurity, it is nonetheless essential for any innovation to be applied by a wide range of scholars from 'normal science' in different research contexts. While there have been numerous studies on the impact of the composition of research teams—disciplinary and interdisciplinary—as well as the impact of international collaboration on the primary processes of innovation and subsequent diffusion throughout scientific collaboration networks (Haeussler/Sauermann 2020; Leydesdorff/Ivanova 2020), little is known about the *consolidation processes* in which an original innovation (e.g., a new method) is increasingly adopted and widely recognized by the professional community. Some evidence has been provided by Heinze et al. (2013), but there is still a considerable research deficit, as it can be assumed that consolidation and different forms of collaboration are highly interdependent. Consolidation is not only based on the act of innovation alone, but crucially relies on the subsequent attribution of that innovation and the associated popularization of topics.

In this paper, we examine how the consolidation of research is associated with different forms of collaboration. We assume that consolidation processes apply to innovative as well as to non-innovative research, so that both can be studied together. Another deficit of existing research, however, is that it is primarily concerned with disciplines in the natural sciences (e.g., Lin/Evans/Wu 2022; Wu/Wang/Evans 2019), which may wrongly give the impression that findings can be extended to the entire academic field when they are—in fact—limited to the natural sciences. Consequently, we draw on sociology as a case study, a discipline which is, firstly, *multiparadigmatically structured*, aligned to both the humanities and natural sciences at once while being heavily differentiated internally (Schmitz et al. 2020; Schwemmer/Wieczorek 2020). Sociology is, secondly, simply one example of the many other multiparadigmatically structured disciplines in the social sciences (e.g., political science, communication science, ethnology, and geography c. p. Stinchcombe 1994) or the life sciences (e.g., psychology, see Unger et al. 2022; Wieczorek et al. 2021a). For this reason, we expect that our results will be applicable to these disciplines. At last, the alignment of sociology with both the natural sciences and the humanities will increase the likelihood of identifying consolidation patterns which—to varying degrees—might be typical for either STEM (Science, Technology, Engineering and Mathematics) disciplines or the humanities, rendering sociology a productive test case for different consolidation practices.

To address our research question, we first review the state of research on scientific innovation and research collaboration, as well as their interaction, discussing how consolidation processes and cooperation practices interrelate. We then take the inherent structural and cultural specificities of the various disciplines into account. For this purpose, we use the example of sociology with its paradigmatic and practice-related particularities to assess whether, or the extent to which, interpretative patterns derived from the natural sciences can be generalized. We then conceptualize the consolidation of *thought products (*especially *theories, methods,* and *research foci)* based on the literature. We proceed with a description of our analytical strategy and data basis, which comprises 2,785 abstracts from the five most relevant sociological journals in German-speaking sociology covered in the Scopus database.[1] As indicated by their low journal impact factor (ranging from 0.29 to 1.269 as of 2020), these journals are in a peripheral position when compared with the English-speaking international center of academic discourse.

This peripheral position, with low levels of acknowledgement outside of German-speaking sociology, renders these journals an interesting test case for established knowledge of the association between collaborative networks and the consolidation of innovative or non-innovative research. In fact, there may be unique structures and processes which are not apparent in the completely internationalized and paradigmatically consolidated natural and life sciences on which research to date has mostly focused.

We proceed by describing how we extracted topic dimensions from the corpus using correspondence analysis. To this end, we construct topic spaces from the abstracts mentioned above for the early 2000s and the end of the 2010s. Subsequently, we relate the position of the topical space in 2016–2019 to indicators on collaborative approaches and characteristics which correlate with thought products in the early 2000s. Note however, equally, that these timeframes leave enough time for potential innovations—or for less innovative but previously unused thought products—to spread, according to scientometric literature (Dey et al. 2017; van Raan 2004; 2015).

As one cannot compare the topic space in 2000–2003 to earlier periods due to a lack of availability of abstracts in the Scopus database, we cannot claim that everything in this topic space is an innovation. However, by focusing on consolidation patterns, our approach yields insights about the consolidation of more or less innovative thought products by implication. In this way, we reveal the particular characteristics of sociology as represented in the major German-language journals and, ultimately, argue for a more differentiated, comparative investigation of innovation and consolidation.

1 Scopus is an abstract and citation databased hosted by Elsevier since 2004. It includes data on more than 30,000 journals.

2 Innovation and research collaboration: state of research

Existing studies identify factors that promote or restrict research innovation. Regarding the former, Gläser and Laudel (2016) found that decentralized third-party funding enables research innovation to emerge. The same applies to low levels of monitoring of research practices by university administrators (Whitley et al. 2018). Regarding the latter, measures which reduce research autonomy inhibit innovation. These include the strong focus on acquiring third-party funding (Boudreau et al. 2016), the pressure to obtain high scores in research assessments and rankings (Münch 2014a: 22–37), and—in Germany with its chair structure—a strictly hierarchical organization of research (Münch 2014b).

For the *consolidation* of a new thought product, it is crucial that it be taken up by conventional research after a certain amount of time. Innovations are more likely to spread if they stimulate conventional follow-up research that is published in high-impact journals (van Raan 2015) and receive legitimacy in the form of scientific prizes (Farys/Wolbring 2021). Furthermore, as Wang/Veugelers/Stephan (2017) show, it is more difficult for innovations to disseminate if they lack connectivity to existing theories, or combine topics, theories, and methods in unusual ways. For an innovation to be considered as such post hoc, it must be recognized as an innovation and begin to accumulate large numbers of citations, lifting it out of obscurity (Dey et al. 2017). It is reasonable to conceive of the attribution of innovation as a genuine social process in which a thought product successfully spreads and diffuses widely (Herfeld/Doehne 2019). Consequently, scholars and publications which are not themselves considered innovative or central are nevertheless, through their reception practices, constitutive of innovation as a social phenomenon. For innovation in a traditional and narrow sense, there are numerous studies showing the relevance of the social organization of acknowledging, using, and disseminating research in the form of research collaborations, as we shall briefly recapitulate now.

Research collaborations are regarded as relevant for generating innovations (Zhang et al. 2018). Yet despite a universal trend toward increased scientific collaboration (Bozeman/Youtie 2017), opportunities for collaboration are unevenly distributed. This is reflected in the growth of center/periphery structures in scientific collaboration networks in recent decades (Wieczorek et al. 2021b). This holds true for individuals (Cugmas/Ferligoj/Kronegger 2019), institutions (Li et al. 2018), and countries alike (Barrios et al. 2019). These two aspects, innovation and its consolidation on the one hand and collaboration practices and strategies on the other, interrelate in various ways. Research collaboration fuels innovation insofar as it enables scholars from different fields of study to combine expertise on topics, methods, and theories. These combinations pave the way for incremental innovations, which then may be applied in different research communities (Zhai/Ding/Wang 2018).

Furthermore, collaboration aids in the emergence of completely novel lines of research, if the collaborators recognize that a research puzzle has not been sufficiently solved in each research community. In this case, they might seek to develop completely new theoretical concepts, methods, or approaches which negate older concepts previously central to the respective discourses (Wu/Wang/Evans 2019). At the same time, research collaboration can encourage the consolidation of formerly innovative research concepts. In this case, collaboration facilitates the spread of innovation by applying it to research questions or problems initially not intended by the innovators (Xu et al. 2020).

Even if research might be perceived as an activity that takes place in solitude and freedom, scientific innovations and their diffusion are undoubtedly driven by social factors. One important social aspect concerns the structure of a research team; innovation rarely originates from individuals or teams of two (Larivière et al. 2015). In fact, studies reveal an inverse U-shaped relationship between team size and scientific innovation (van Raan 2015; Wu/Wang/Evans 2019). In large teams, coordination efforts can become too great to generate innovation effectively (Wu/Wang/Evans 2019). Furthermore, the more collaborations maintained by authors associated with a particular thought product, the more widely these products are disseminated, as measured by citations (Uddin/Hossain/Rasmussen 2013). This is due to the fact that each collaboration partner can, at least partially, address and mobilize different audiences.

However, single authors or small teams might also play a significant role for the consolidation of (more or less) innovative concepts. Due to the internal differentiation within disciplines (e.g., life course analysis, or research on social movements), authors might be experts in limited knowledge domains, and as such aim to secure a position within these domains. To do so, they probably seek to address the most relevant theories, appropriate methods, or research puzzles in this domain, and, by doing so, signal their belonging to a specialist discourse. This strategy yields less opportunity for generating innovation, as the knowledge applied stems from a well-known, established canon.

Regarding the consolidation engendered by collaboration at the *university or interuniversity level,* studies provide evidence that an innovation is recognized more broadly if scholars affiliated with different institutions co-author articles. For example, forms of cooperation and article citation rates are associated, indicating higher degrees of recognition, and an increased likelihood of an innovation being linked with different scholarly discourses. In turn, the reception of an innovation in different areas of research renders consolidation more likely. For instance, Bornmann (2017) shows for the case of biomedicine that, regardless of their quality, articles are cited more frequently the more authors from different institutions are involved (cp. also Larivière et al. 2015). By contrast, Sud and Thelwall (2016) show with the example of biochemistry that the association between the number of institutions and citation count is inversely U-shaped, indicating that a moderate number of institutions is linked with the highest level of recognition for a research innovation.

With regard to *international cooperation*, studies indicate a positive but weak effect of transnational collaboration on the number of citations of articles and, indirectly, on the probability of dissemination of concepts and research innovations (Adams/Gurney 2018; Leydesdorff/Wagner/Bornmann 2018). This is for the same reasons as discussed earlier: International teams are socialized in different disciplinary contexts, and thus their scholars might add a diversity of expertise to the collaboration and have access to different research communities. Therefore, they provide the necessary prerequisites for innovation, and for the dissemination of their innovations. Yet international collaborations also lead to less innovative and more conventional research (Wagner/Whetsell/Leydesdorff 2017). This counterintuitive finding may be attributed to the high degree of coordination required between researchers from different nationally embedded academic cultures. Consequently, researchers cooperating internationally may only be able to agree on the lowest common denominator: a well-known, established line of research. However, a key aspect that lies behind a general discourse of international collaboration is the position in the global scientific hierarchy of the collaborative partners involved. Thus, the same collaboration between an American and a German scientist may prove to be beneficial for the German participant, while it may not be beneficial—or may even be detrimental—for the American colleague. 'Internationality' must therefore be differentiated by taking the global hierarchy of the respective national fields into account.

Another social factor associated with the consolidation of research innovation is linked to the researcher's socio-demographic characteristics. Most notably, research has assessed the impact of gender and gender diversity in research teams on the recognition of innovations, and thus the chances for the consolidation of research innovation. In general, female researchers are less likely to be cited (Lerchenmueller/Sorenson 2018), which is true even in fields where female researchers are strongly represented (Dion/Sumner/Mitchell 2018). Lower citation counts may indicate that innovations spread more slowly when presented by female scholars. This may be attributed to two potential gender effects: the level of embeddedness in scientific collaborative forms, and the authors' choice of topics. Male scientists collaborate more with other men, while female scientists tend to collaborate in mixed-gender groups (Kwiek/Roszka 2021b). In addition, male scholars collaborate more internationally than their female counterparts, although this varies by discipline (Kwiek/Roszka 2021a). In other words, male scientists may facilitate the dissemination of innovative lines of inquiry by mobilizing colleagues across research communities and national borders.

For mixed-gender teams, Kwiek and Roszka (2021b) show with a sample of 25,463 Polish scholars that these teams are more likely to publish in high-impact journals compared to single-gender teams. Consequently, mixed-gender teams have higher chances of disseminating their research innovations compared to gender-homogeneous research teams. Maddi and Gingras (2021) confirm these effects for research in management and economics, while also showing that the effect is weaker when a female researcher is the first author. As research has not, to date, focused on the association between gender composition and consolidation of research innovation, we must utilize our empirical findings to establish whether mixed-gender teams promote or prohibit consolidation.

As it turns out, the majority of scientometric studies base their findings on specific contexts, namely the natural sciences in Anglophone practices of publishing and collaboration. While this provides important insights into the dynamics of scientific innovation, and allows us to derive assumptions on subsequent consolidation, it should not be ignored that disciplines differ from each other; they differ not only in terms of their objects and approaches, but also in terms of how innovations are produced, disseminated, and recognized (Xu et al. 2020; Zhai/Ding/Wang 2018). In particular, the aspect of consolidation introduced above, which is essentially based on attribution and recognition, is likely dependent on the particular structural and cultural conditions of a (nationally framed) discipline (Ylijoki/Lyytinen/Marttila 2011).

To conceptualize these structural and cultural specifics of a discipline, the field-theoretical perspective has proven useful (Schwemmer/Wieczorek 2020; Warczok/Beyer 2021). If we consider the evidence from existing research, we can conceive of the conditions of consolidation as a disciplinary field (e.g., Jansen/Von Goertz/Heidler 2009), in which forms of cooperation and networks typical of the field shape scientific discourse in a specific way and define what counts as innovation in each case. A disciplinary field is a differentiated and semi-autonomous sector of the academic field that is comprised of scholars, different types of institutions (e.g., universities, professional societies, publishers), scholarly discourses, and a shared idea of how to conduct research (and on what topics) properly (Bourdieu 2004).

Within a field, actors collaborate and compete for the acknowledgement of more or less innovative research products, and in turn secure a place within the academic discourse. Scholars develop a taste for research (Bourdieu 1989, 19–20), which is mirrored in the way they collaborate, formulate their ideas and whether they follow novel lines of research or consolidate previously innovative research. In turn, both the ideas of how to conduct research properly as well as the taste for research topics, collaborations, and investigating (more or less) innovative research, should be present in the respective articles investigated.

In the context of the current state of research, it can be assumed for scientific fields as a general principle that innovations are introduced and consolidated into the discourse by well-connected authors. This will manifest itself in the form of co-authorships and institutional and international collaborations, since cooperation of this kind grants access to further important networks. Concepts already present in or introduced into a field at t_0 will eventually be consolidated by occupying a central position in the discipline's discursive space at t_1.

Despite the fact that some studies establish positive relations between research impact and transnational collaboration, we take a more critical stance in regard to the field of German-language sociology. With its *specific conditions*, it is to be expected that these general assumptions cannot simply be transferred. To take into account this special object of study, we set up the following general counterhypothesis: The special structural properties of sociology, and especially of sociology restricted to the German-speaking field, may well counteract ostensibly universal processes. (German) sociology is traditionally separated into different paradigmatic styles of thinking that do not systematically mutually connect (see Collins 1994; Smelser 2015; Varga 2011). There is no unanimous consensus on methods, basic assumptions, and problems among sociologists. As a consequence, there is no expectation of common epistemic progress and the corresponding accumulation of knowledge. The combination of sociology's multiparadigmatic organization and nationally embedded research cultures renders international collaboration even more difficult and increases additional coordination costs among collaborators (see Wagner/Leydesdorff/Bornmann 2017).

Consequently, the attributive definition of innovation and consolidation is not subject to any criteria that are generally valid for the discipline. For example, national or international cooperations should not be associated with consolidation: The significance of both national and international collaborations, and research foci stemming from these, are acknowledged by some fellow sociologists, and refuted by others (strong orientation towards US sociology vs. strong rejection of US hegemony) (Schmitz et al. 2020). It is possible that scholars with an international orientation conduct research on topics relevant for US sociology (e.g., research on race, gender, and class), but are irrelevant to other, specifically national sociologies. At the same time, nationally-oriented sociologies might be centered around certain schools of thought. As seen taking the example of the dispute between the Academy of Sociology and the German Sociological Association, collaborating with scholars aligning to other paradigms might hinder consolidation, at least to the extent that different schools of thought do not acknowledge the arguments provided by others as scientifically valid. For these reasons, we expect international collaboration not to be associated with the consolidation of sociological concepts.

In the case of institutional actors, we expect scientific institutions of high reputation to attract more attention. This, in turn, yields a positive effect on cooperation opportunities between (also highly reputable) scientists who are affiliated with highly reputed universities—and thus increase the attention for thought products, which can be expected for those disciplines that are close to the institutional pole (cf. Münch 2014a, 79–92).

According to our expectations, consolidation in German-speaking sociology should, to a considerable extent, occur for other reasons. The disciplinary field we are looking at is largely and increasingly dependent on its external relations. As in other disciplines, this should be reflected in socio-structural terms, especially in the particularly great importance that gender has for personal chances of success, but also for the expected success of the topics and concepts researchers deal with. Since there are clear gender differences in sociology, in terms of preferred topics (Heiberger/Munoz-Najar Galvez/McFarland 2021), and since there are also fewer publications by female than male authors in sociology, despite the majority of scholars being female, publications and topics published by women should be less likely to occupy a central position in the discourse space in the future (Turner 2016, pp. 99–103).

The special relevance of the field's external relations is also reflected in its content: The field of (German) sociology is characterized by a high degree of reactivity to the actual prevailing circumstances in a society. Schmitz et al. (2020), for example, show that German sociology is strongly oriented towards a state logic of the ascription of value, on the one hand, and the various forms of social criticism, on the other. Accordingly, it is to be expected that those topics that deal with applied research in the context of management and political governance will become of central importance—be this attention positive or negative in nature. Finally, we have to consider larger, structural forces that may shape the thematic structure of sociology and the opportunities for collaboration among scholars, as well as their ability to follow original lines of research autonomously. These include the funding incentives and research demands introduced by funding agencies and other third parties (Wieczorek/Beyer/Münch 2017).

3 Data and Methods

3.1 Dataset

In light of our theoretical considerations on the interplay of collaboration forms and consolidation, we seek to analyze how different sociological concepts (operationalized as unigrams)[2] become more central to the German-speaking sociology discourse. To do so, we base our analyses on 2,785 journal articles published between 2000 and 2019 in the following five German-speaking outlets covered throughout our period of observation in Scopus: the *Berlin Journal of Sociology*, the *Cologne Journal of Sociology and Social Psychology*, the *Journal of Sociology*, *Forum Qualitative Social Research*, and *Soziale Welt*. These are the core journals of German-

2 In our case, a unigram is a single sociological term. Unigrams are otherwise defined as a single item stemming from an n-gram (e.g., a sentence in this manuscript counts as n-gram).

speaking sociology according to Leydesdorff and Milojevic (2015). This is why we assume that consolidation of (more or less) innovative research outcomes is most likely to occur in these journals. With their impact factor ranging from 0.29 to 1.269 (as of 2020), these journals are also well suited to reflecting the consolidation process of innovative thought products and to linking them to varying collaborative approaches. Access to the Scopus repository was provided via the Competence Center of Bibliometrics, an association of German research institutions that provides a quality assured data infrastructure for bibliometric applications.[3]

3.2 Data pre-processing

The Scopus repository was subjected to automatic and semi-automatic checks and error corrections. Specifically, numerous unifications and standardizations (including on journal names and country information) were carried out.

The dataset is particularly characterized by the implemented institution coding for German institutions, which makes it possible to assign publications unambiguously to institutions (see https://bibliometrie.info/index.php?id=infrastruktur for further information). The collected data contain English article abstracts from which we extract thought products. Additionally, the data contain author information, which serves as foundation for the construction of network measures and collaboration forms. This comprises first and last names as well as the author identifier generated by Scopus. The Scopus author ID assigns unique author profiles to publications and is the result of an automated disambiguation algorithm which is supplemented by manual entries by individual authors (Baas et al. 2020).[4] The data also contains information on the institutional affiliations of the participating authors, including name of the institution, the country in which the institution is located, publication year, and outlet name.

We then applied a disambiguation algorithm based on Momeni and Mayr (2016) to check for the correctness of author IDs assigned by Scopus. Similarity measures were then used to assign author IDs to unique individuals, such as similar or identical email addresses, coauthors, self-citations, keywords, affiliations, or bibliometric couplings. The main advantage of this approach is that we were able to draw on information that is exclusive to the KB,[5] such as institution coding. Discrepancies in our disambiguation approach to the Scopus author ID were manually checked and improved.[6]

Additionally, data on the gender of all authors were collected in a manually-conducted web search, linked to the Scopus data, and merged with the author, insti-

3 The data and workflow (in Python and R) are provided by the authors upon request.

4 According to bibliometric literature, the disambiguation algorithm of Scopus is of high quality (Moed/Aisati/Plume 2013; Aman 2018).

5 KB stands for ‘Kompetenzzentrum Bibliometrie’ (‘competence centre for bibliometrics’).

6 We identified 51 incorrect ID assignments by using this approach.

tution, and abstract data into a unified dataset. The successful consolidation of a concept during an observation period is characterized by its central position in the research discourse at the end of the observation period, in our case the years between 2016 and 2019. This applies to all topics that are part of the scientific discourse in German sociology. To examine the positions of sociological concepts within this particular discourse, we construct a topic space in which the individual terms related to these concepts are located.

We apply correspondence analysis (CA) (Le Roux/Rouanet 2010) to define our topic spaces at the beginning and the end of our observation window.[7] CA allows us to use a set of active variables to construct this topic space and to passively project terms into this space that are relevant but occur too infrequently on their own to identify them as separate topics. In this procedure, topic dimensions are extracted based on the common occurrence of terms in abstracts. Each dimension ideally expresses a contrast between two mutually exclusive topics and the associated methods (e.g., qualitative versus quantitative methods).

We set the initial time frame for the construction of the topic spaces t_0 to the years 2000–2003, and the end time frame t_1 to the years 2016–2019. The years between our chosen time frames are in line with studies on so-called 'sleeping beauties' (van Raan 2004), which propose that at least 10 years are needed for a research innovation to be accepted by the academic community (Dey et al. 2017). We decided to define a four-year time frame, since smaller time periods yielded an insufficient number of relevant sociological concepts in several CA trial runs, which in turn led to the construction of unstable topic spaces. Conversely, defining longer time windows would largely obscure the view of potential changes.

To conduct the initial CA, text data from the scholarly abstracts were preprocessed using common natural language processing techniques. First, abstract data were tokenized before stop words were removed. The tokens were then stemmed by using the PorterStemmer algorithm implemented in the Python nltk library (Bird 2006). Stemming converts words to their word stem (e.g., "running", "ran", "runs" are all converted into "run"), thereby reducing text complexity and combining tokens that are spelled differently but have the same meanings.

Secondly, we included only terms present in a minimum of 7.5 percent and a maximum of 90 percent of all abstracts in each time frames.[8] We employ the criterion of a threshold for including items between five percent and 10 percent

7 The factoMineR package was used to conduct the CA (Lê and Husson 2008).

8 To calculate the optimum thresholds, we calculated topic spaces based on five percent, 7.5 percent, and 10 percent thresholds for the appearance of tokens at the lower bound, and 85 percent, 90 percent, and 95 percent at the upper bound. We then interpreted the topic dimensions for each combination. Although the topics remained stable, the topics extracted by the model including tokens appearing in at least 7.5 percent of the abstracts and maximum 90 percent abstracts yielded the highest interpretability.

at the lower bound and between 90 percent and 95 percent at the upper bound (Hjellbrekke 2019; Greenacre 2010). Consequently, we projected all terms that occurred in at least 2.5 percent and at most 7.5 percent of the abstracts as passive variables in our CA. Last, the selection of tokens, and thus sociological concepts, was limited to nouns in order to focus on theoretical and methodological concepts such as 'regression analysis', 'function', or 'system'. As a result, 352 concepts present in both time frames either as active or passive variables were extracted from the data. Figures depicting their distance from the center of the topic space, and any change between these two time frames, are provided in online appendix B. Finally, we create and export a document-term matrix for use in R. A four-dimensional solution for both time periods emerged after communicative validation and review of the most relevant and related texts.[9]

We determined the Euclidean distances to the coordinate origin in 2000–2003 and 2016–2019 for the 352 concepts represented by the terms used in the abstracts based on their location on these four dimensions.[10] Note that a concept can be said to have arrived in the mainstream of German-language sociology if the Euclidean distance 2016–2019 is small, meaning the relevant term is used frequently and equally across all topics. Conversely, if the term's Euclidean distance is high, this indicates a peripheral position in German-language sociological discourse. In this way, we scrutinize the extent to which terms in a central position in 2000–2003 are still in a central position in 2016–2019, or whether they have been replaced by other terms. Periphery at the beginning and centrality at the end of the observation period means consolidation.

3.3 Variables

The Euclidean distance, a ratio-scaled dependent variable, referring here to the distance of a term from the center of the topic space in 2016–2019, with values ranging from zero to 3.44, is used as the dependent variable in this regression

9 We interpreted the dimensions as "inequality vs. quantitative research on governance and management", "qualitative vs. quantitative research (labor, inequality, family)", "theory-free, applied, micro research vs. sociological (macro-) theory", "meso/macro-embeddedness vs. quantitative methodological individualism" in 2000–2003 and "qualtitative, theoretical and historical sociology versus quantitative rational choice research on education, family, and labor markets", "social problems/engagement and reflexion of the qualitative paradigm versus economy, institutions, organizations", "empirical educational research", "practical applications versus academic self-referentiality" in 2016–2019. We define articles as theory-free if the abstracts are devoid of tokens relating to any sociological theory. Furthermore, we found that theory-heavy abstracts congregate on the opposite side of the dimension, supporting our interpretation of theory-free empirical research.

10 To calculate these distances, we used the scikit-learn package implemented in Python (Pedregosa et al. 2011). The Euclidean distances are calculated as follows: We first subtracted the coordination of a token from each of the four extracted topic dimensions from the point of origin. Secondly, these differences were squared and, thirdly, added. Fourthly, we took the square root of the summed distances.

model. In our analysis, we aim to explore how this variable is associated with forms of collaboration, network characteristics, and research topics.

We begin with introducing the collaborative forms. Note that these were calculated on the level of individual papers, whereas the following centrality measures are calculated on author level. We calculate the *average number of co-authors per article* in which the term appears.[11] To assess the influence of inter-institutional cooperation on the consolidation of the terms representing different sociological concepts, we computed the number of participating institutions for those papers in which the terms are applied. We use the *log number of participating institutions* due to a small number of outliers with the participation of more than ten institutions, rendering the distribution highly right-skewed. We recorded the *number of international collaborations dichotomously* (1 = yes, 0 = no) at the article level and then calculated the average value for all papers in which the concept appears.

We also included the gender composition of the authors and research teams who used the concepts. For this purpose, we established two variables. First, whether an *article was written only by female researchers*. This value is dichotomous (1 = yes, 0 = no) at the individual article level. For consistency, we averaged this value across the articles in which a term occurs. Second, we constructed the presence of *mixed-gender author teams* the same way.

In order to construct network centrality measures, we apply *normalized degree centrality* (Opsahl/Agneessens/Skvoretz 2010) and *betweenness centrality* (Newman 2005) to explore the association between authors' collaborative relationships and the consolidation of terms. *Normalized degree centrality* measures the strength of cooperation between authors, normalizing it by the size of the overall network. In our case, degree centrality depicts the number and strength of collaborations. By contrast, *betweenness centrality* measures how many of the shortest paths are assigned to a node, i.e., an author. This is commonly considered a measure of how quickly an author is able to access information circulating in the network. In our case, this would represent the ability to quickly access or disseminate sociological concepts.[12] For example, if an author A is connected to two other authors B and C, but B and C are not connected, then author A has control over the flow of information between B and C. In this case, author A has a high betweenness centrality, authors B and C have a low betweenness centrality.

Since the terms are tied to articles, we calculate the average values of the degree centrality and betweenness centrality of the authors involved in the publication of

11 We have also included authors^2 in our model in a test run. However, this showed that there was no correlation between the quadratic term and the consolidation measure. For reasons of clarity in the presentation of our model, we therefore decided to exclude the quadratic term.

12 Centrality measures were calculated using the networkx package (Hagberg/Swart/Chult 2008) in Python. An overview of the most productive and most central authors is provided in appendix E.

the concepts. Finally, we included the *positions of the terms on the four topic dimensions* listed above as well as the *Euclidean distance to the coordinate origin of the years 2000–2003 in the models*. The former is intended to test whether there are topics that are beneficial for the consolidation of a term, the latter whether peripheral topics move into the center of the discourse or remain peripheral regardless of network measures or topic affiliation.

4 Statistical Analysis

Subsequently, the dependent variable—the terms' positions in the topic space 2016–2019—will be explained using OLS-regression.[13] Table 1 summarizes the results of our regression model. Beginning with forms of collaboration, we see that a sociological concept becomes more proximate to the center of the discourse in 2016–2019 with an increasing number of authors per paper in 2000–2003. The negative sign indicates that terms associated with a higher number of authors in 2000–2003 reduces their distance to the point of origin, therefore becoming more central in the discourse space. However, the effect loses its significance when taking other variables controlled for into account, as we shall subsequently discuss.

Next, we turn to the association between the presence of *international collaboration* and the positions of terms in the topic space 2016–2019. Whereas Leydesdorff/Wagner/Bornmann (2018) and Wagner/Whetsell/Leydesdorff (2017) find that ideas spread faster when published in international collaboration, we do not find a significant effect for this phenomenon. This result can be interpreted as resulting from German-language sociology being largely confined to the national scale (Schmitz et al. 2020), distinguishing it from, for example, the discipline of international management (Wieczorek et al. 2021b), or the natural sciences in general (Barrios et al. 2019). However, it is also plausible that the aggregated category 'international' conceals opposing effects that correspond to the global hierarchy of national fields, such as positive effects of cooperation with colleagues from the US and negative effects with partners from less dominant countries.

Regarding *the number of institutional affiliations of authors* using a term in 2000–2003, we identify that a term gets closer to the center of the topic space in 2016–2019 the more affiliations are present (β = -0.130, $p < 0.05$). This finding implies that terms used by research teams situated at different universities can positively

13 Point estimates and dispersion parameters are provided in the online appendix A. We also tested for compliance with the model assumptions. The Breusch-Pagan test (BP = 13.82, $p = 0.31$) indicates homoscedasticity, while the Shapiro-Wilk test (W = 0.9534, $p < 0.001$) indicates normal distribution of the residuals. Last, the variance inflation factor values indicate that the independent variables assume low levels of multicollinearity with two exceptions of moderate multicollinearity ($4 < \text{VIF} < 7$). However, the VIF values always remained below 10, indicating that the models are suitable for running an OLS regression. To ensure comparability of effect sizes, all independent variables were z-standardized. The online appendix C reports stepwise nested regression models.

Table 1: OLS regression model of collaborative forms, centrality in co-authorship networks, and a term's position in the topic space on its consolidation.

Dependent Variable: Distance of terms from the center of the topic space 2016–2019	Model
Average # of authors p. article	-0.035
	(0.031)
# of int. collaborations of authors	-0.001
	(0.025)
# of participating institutions of authors	-0.130*
	(0.065)
% of female authors per article.	0.044†
	(0.023)
% of mixed-gender teams per article	0.035
	(0.030)
Average degree centrality of authors	0.126*
	(0.050)
Average betweenness centrality of authors	0.042†
	(0.024)
Distance from the center of space 2000–2003	0.136 ***
	(0.021)
Inequality vs. quant. research on governance and management	0.075 ***
	(0.021)
Qual. vs. quant. (labor, inequality, family)	0.007
	(0.024)
Theory-free, applied, micro research vs. sociological (macro-) theory	-0.011
	(0.022)
Meso/Macro-embeddedness vs. quantitative meth. individualism	-0.025
	(0.021)
Constant	0.508 ***
	(0.011)
Observations	352
Adjusted R^2	0.214

*Note: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, † $p < 0.1$. Standard errors in parentheses, z-normalized effect coefficients.*

impact on the concept's future centrality in German sociology. These scholars, being situated at different institutions, are able to convert their different institutions' prestige into 'surplus' recognition. Being able to jointly mobilize a wider audience seems to have a positive impact on the future consolidation of sociological concepts. Turning to the effect of *gender composition* on the distance of a term from the center in 2016–2019, we see that the higher the percentage of female authors within a research team, the more distant a term from the center in 2016–2019 (significant at the 10 percent level). If we inspect the terms extracted from our text corpus, we see that female scholars seem disproportionately frequently to use terms such as *crisis, democracy, student, teacher, state, gender, citizen,* or *qualitative design*. These terms are related, for example, to educational research and qualitative approaches. It is not so much that they have not been widespread in the broader German sociology discourse in recent decades, but rather a matter of specialized research milieus. Concepts or tokens associated with male scholars, in contrast, may have higher chances of consolidating over time (for example *variables, company, actor, measure, transition, management, network, employment,* or *unemployment*).

This was to be expected, if only due to the initial statistical situation: Women tend to address peripheral topics more strongly compared to their male counterparts (Bandelj 2019; Heiberger/Munoz-Najar Galvez/McFarland 2021). Female sociologists are also quantitatively less represented in our data (71.76 percent of authors who published in 2000–2003 are male), which may also account for the peripheral position of their thought products in the topic space. However, we control for topics in the model with five variables, so that an additional malus is quite conceivable, namely that work by women tends to be not used. The effect is stable, even under control of *mixed*-gender teams. The latter effect is not significant, but if at all, one can discern the tendency that the higher the percentage of mixed research teams using a term, the more distant the term is from the center in 2016–2019. Mixed-gender teams used terms such as *student, teacher, state, gender, qualitative design, status*, or *occupation*. Initially, these terms overlap with concepts used by female scholars or teams composed of female researchers only. This in turn indicates that peripheral or less prestigious topics were addressed by female and mixed-gender research teams alike.

We now turn to the network measures that depict the network structures underlying the collaborative production of a paper and the concepts thus employed. We see that the higher the *degree centrality* in the collaborative network of the authors applying a term in 2000–2003, the more distant from the center the terms are in 2016–2019 ($\beta = 0.126$, $p < 0.05$). Thus, the higher the centrality of the authors involved in the earlier period, the less relevant the terms they used became over time.

There might be different reasons why thought products used by scholars once central in the collaboration network become more peripheral over time. One potential explanation is the simultaneous control by the numbers of co-authors per paper included in our model. Also, and conversely, degree centrality might suppress an effect of the number of authors as discussed above. Yet there is also a possible substantive mechanism behind this effect: First, decreasing activity on the part of the formerly productive researchers itself must be taken into account. Beyond that, however, those who were central in the past may have lost this central position, as indicated by the declining levels of attention paid to the concepts they had disseminated. This might be due to the incessant progress or the constant fluctuations of what is and what is not scientifically *en vogue*. Authors who had a central position in 2000–2003 but became more peripheral include prominent figures, some of whose subject areas and concepts have become less central in contemporary sociology (e.g., comparative political economy and social inequality). It also turns out that German sociology is both institutionally and paradigmatically multipolar, i.e., there are several networks, of which each has at least a certain chance of being represented in German journals.[14]

We see that the higher the *betweenness centrality* values of the authors applying a term in 2000–2003, the more distant from the center a term becomes in 2016–2019, meaning that the more central the authors are in 2000–2003, the more peripheral the terms they use become in 2016–2019. The effect coefficient is $\beta = 0.042$ ($p < 0.1$). Again, this may be a counterintuitive finding at first sight, and one has to take into account the simultaneous presence of the numbers of authors and degree centrality. Beyond that, there might be a substantive interpretation for this finding as well: High values of betweenness centrality indicate the ability to span different research discourses, or simply eminence in the field. Researchers with high betweenness centrality values were representative of different sociological sub-discourses in the early 2000s, but lost their ability to do so in the late 2010s. Subsequently, they were replaced by scholars who became the establishment by focusing on more recent topics and concepts. These concepts include *welfare state, gender, qualitative design, occupation, mechanism, status, validity, school, marriage, men,* or *couple*. These terms may have been mediated between discourses by the aforementioned researchers, resulting at first in these concepts becoming more relevant, but by the end of our observation period (e.g., through further differentiation into various sub-discourses), they had moved to the periphery. By 2016–2019, these terms had gone out of fashion and were replaced by terms like *company, firm, manage, employee, movement, practice, choice,* or *transition*.

High betweenness values also indicate locally dense cooperations, for instance within certain larger institutions. Thus, similar to the effect of the number of affiliations, the negative effect may also be due to the relatively modest innovative potential and only temporarily relevant research such contexts entail. In light of a disciplinary culture characterized by its low structural potential for discipline-spanning cumulative advancement in knowledge (Schneider/Osrecki 2020), an affiliation between different discourses, instead of specializing, appears to be a

14 This interpretation is in line with the declared policy of the journals to be open to all paradigms.

detrimental strategy for consolidating research concepts in the German sociological discourse. At the same time, however, we see that journals show a certain openness to change in authorship (different networks can become active) and in topics.[15]

Continuing with the impact of a *term's distance from the center of the overall topic space in 2000–2003* on its position in 2016–2019, we see that terms in close proximity to the center in 2000–2003 remain proximate in 2016–2019, whereas tokens peripheral in 2000–2003 remain so in 2016–2019. This indicates a certain inertia of the thematic structure of German sociology, which however, is far from a deterministic relationship. Still, overall, terms—e.g., theoretical concepts, methods, and certain areas of research—are of durable interest for the German-speaking research community.

This might point towards a shared, common core of knowledge that was stable for German sociology throughout the observational window. More specifically, this stable core seems to engender a certain paradigmatic substance: Based on a semantic inspection of the underlying abstracts it turns out that the terms include *effect, level, (life) course,* and *individual*. Such concepts are—to a considerable extent—employed by quantitative researchers within the framework of methodological individualism. This is research which has taken a rather important position both at the beginning and the end of our observed time frame.

Finally, we focus on the association between a *term's position in the four separate dimensions of the topic space in 2000–2003* and its distance from the center of the topic space in 2016–2019. Beginning with the first topical dimension extracted from our corpus, we observe that the more a term was distant from the '*social inequality*' pole in 2000–2003 and the closer it was to the '*governance and management oriented quantitative research*' pole, the closer it was to the center of the discursive space in 2016–2019. Thus, research present in 2000–2003 that engaged with issues of governing and managing (a range of different subjects) applying quantitative methods continues to be of utmost relevance in contemporary German sociology. In other words, the more strongly a term was associated with applied or application-oriented topics from the fields of management and governance research in 2000–2003, the more central it became in German-speaking sociology in 2016–2019.

Applied topics are embedded in research with a particular connection to extra-scientific institutions and stakeholders: The terms thus employed comprise *management, company, industry, behavior, control, govern, governance, corporation,* and *measure*. Therefore, the consolidation of research concepts in German-speaking

15 Another reason for this finding may lie in the fact that established scholars at the beginning of the millennium began to publish in English-language journals and thus took collaborations and research concepts with them, i.e., left our observational window. As many scholars decided to publish predominantly in US journals, the concepts applied necessarily became more peripheral in German outlets.

sociology since the year 2000 can be assumed to be a function of relevance for the political, administrative, and economic fields. Such research provides information for powerful (corporate) actors, who seek to use steering knowledge to shed light on their organizations (firms), or politically relevant actors (governance, control, power). This corroborates our earlier interpretation of German sociology's openness to change and implies a particular responsiveness of the discipline towards demands external to academia. These demands are subject to societal trends and are deeply inscribed in science through the corresponding funding programs.

Beyond affirmative research, this phenomenon of the relevance of applied topics may also—at least partially—occur in the form of critical reflections on governmentality, represented by those researchers who dedicate themselves to its service. At the same time, the effect of the first dimension attests to the fact that traditional forms of research on social inequality have become less relevant in contemporary German sociology. This might be interpreted as a manifestation of ongoing differentiation of social inequality into different forms, as actually addressed in current research (cp. Schwinn 2021: p. 383f.). Today, relatively autonomous discourses, such as intersectionality, educational inequality, or the relations between Europe and the global South, have taken the place of the traditional notions of social inequality such as class structure. These 'classical' forms and concepts of social inequality have lost their dominance in each of these different discourses, again, not least due to the changing societal demands which have been increasingly imposed on the scientific field, including sociology.

In the case of dimensions two to four, we found no significant effect in our data. In short: The core antagonistic positions of the beginning of our observation do not impact on the question as to which topics are central or peripheral in current German sociology. This may be caused by the fact that sociological constructs characteristic of these dimensions became equally more central and more peripheral, which would cancel out any average single effect.

In the sub-discourses unfolding over time, some of the concepts have become central, but peripheral in every other topic dimension. Regarding the second dimension, 'theory-free, applied micro-sociological research vs. sociological (macro) theory' for example, terms that have become peripheral include *partner, couple, marriage, children*, and *occupation*, whereas terms such as *transition, income, choice,* and *labor* become more central. It is plausible that these terms were used to describe domestic division of labor in 2000–2003, but split into two distinct fields of study in life-course analysis (e.g., with focus on fertility and divorce, or shifts in the labor-market and analysis of (un)employment histories).

Similarly, in the third dimension—'theory-free, applied, microsociological research versus sociological (macro-) theory'—concepts like *network, function, company, control,* and *actor* became more central, whereas terms like *system, institution, theorize, structure*, and *state* moved to the periphery. This is not least a consequence of recontextualization and reconfiguration of concepts. For example, *function* has become more central over time, albeit not in its earlier theoretical context but rather in association with very different research endeavors (theoretical, qualitative, and quantitative research, as well as research in the context of political economy, action research, and educational and political systems). This corroborates our perception that sociology in German-language journals is responding to societal demand, and increasingly so over time (cf. Münch 2018).

Finally, the fourth dimension, "meso/macro-embeddedness versus quantitative methodological individualism", provides us with concepts like *manage, behavior, model, choice, response*, and *game*, which have taken on more central positions. At the same time, *state*, *crisis*, *democracy*, *welfare*, and *citizen*, have become peripheral. Combined with the findings from the first topic dimension, we observe, firstly, that terms strongly associated with methodology and readily transferable to other topics have migrated to the center of German discourse. Secondly, concepts that describe state structures and civil society, on the other hand, have been pushed to the margins.

Finally, we carried out a sensitivity analysis of our model to check for the robustness of our interpretations. We conducted the same analysis as depicted in table 1, but instead used the years 2003–2006 as t_0 and 2013–2016 as t_1. The results are listed in appendix D and reveal stable effects of the number of authors per paper, number of participating institutions, average degree centrality, and distance from the center of the topic space at t_0. Gender effects were not detected and betweenness centrality was not significant, meaning that in the case of German sociology, these two effects presumably only materialize after longer periods of time.

5 Discussion

Research innovation is crucial for the advancement of scientific knowledge and for the enlightenment of society. This may explain, and indeed justify, why there has been an enormous amount of research on scientific innovation. However, the majority of studies focus on the conditions for the emergence of research innovation in a narrow sense, as they tend to exclude and neglect the subsequent phase of consolidation. These less exalted processes are of equal importance for the academic field, as novel ideas must be tested thoroughly by critically-minded peers and translated into different applications. Crucially, these subsequent activities serve to retrospectively attribute innovation to the field, especially if one considers that innovation takes at least a decade to be adopted by fellow scholars in the same discipline (Dey et al. 2017; van Raan 2015).

While much is now known about the social conditions of innovative research in the sense of its initial occurrence, it is still largely unknown as to whether the mechanisms that drive innovation are responsible for the consolidation at the end of the innovatory chain. Yet the everyday production of 'normal' science may well be subject to different conditions and situations (constraints, resources, strategies, experiences, etc.) than the scientific practice that generates innovations in the narrower sense. To shed light on this consolidation process, we focused on the interplay between collaborative forms and the consolidation of 'thought products' in German sociology. Our findings, based on the five most relevant German outlets, reveal similarities and dissimilarities when compared with the findings on the initial conditions of innovation.

Research has established an inverse U-shaped effect of the number of authors on the dissemination of innovation (Wu/Wang/Evans 2019). At first, there is a positive effect, since the actors involved can contribute their expertise and enact a division of labor; subsequently, however, the effort of coordination increases and has a negative effect on the novelty of a publication and its dissemination in the field. In our case, we find no negative or positive effects, which indicates that a sufficiently established concept can be made equally productive (or not) regardless of the collaborative form, i.e., of whether we are dealing with single authorships, dyads, numerous authors, etc.

A further difference can be observed with regard to the role of the relevant researchers' embeddedness in networks. For the beginning of the innovative process, collaborations between central and eminent researchers are involved in the production of research innovation (cp. Uddin/Hossain/Rasmussen 2013; Wu/Wang/Evans 2019). Conversely, in our analysis, more peripheral authors seem to contribute to the consolidation of concepts, as measured by degree and betweenness centrality. We find that terms used by centrally-placed and highly interconnected scholars become more peripheral over time.

Centrality in collaborative networks seems to hinder consolidation in two ways. This might be attributable to the fact that a given scholar's ability to span different discourses and to collaborate with numerous colleagues has somewhat lost its value. Secondly, the same scholars (along with their concepts) have left the field to specialists, who have then become well-established researchers. This finding differs clearly from the beginning of an innovative chain, where well-connected scholars collaborate, link different areas of the discourse, and enable new research concepts to emerge. For strategic reasons, whose prevalence can be attributed not least to the decreasing autonomy of the scientific field (Münch 2014a: pp. 121–123), it is not profitable for 'consolidators' to engage in the combination of different topics and thought collectives.

Nevertheless, our finding of a positive effect of the number of institutions involved in a collaboration on the future dissemination of its concepts is comparable to existing research (Bornmann 2017; Larivière et al. 2015). Thus, in this regard, the economy of scientific attention in sociology seems to follow a similar pattern throughout the whole process of innovation.

Further, whereas studies have established both a positive (Adams/Gurney 2018; Leydesdorff/Wagner/Bornmann 2018) and a negative relationship between international collaboration and research innovation (Wagner/Whetsell/Leydesdorff 2017), our results show no such effect. Since the field scrutinized in our study is represented by a purely German-language dataset, international cooperations are apparently not associated with consolidation. One possible interpretation is that sufficiently established concepts which are published in German outlets together with international collaborators yield no positive or negative effects, since an original innovation may well date back to before the collaboration came into being. Due to the center-periphery structure of the international field, international co-authorships are mainly successful when authors are involved who work in the USA, the UK, Canada or Australia.

Also, whilst research on innovation in a narrower sense has demonstrated that the focus on broad, abstract topics which connects different strands of research is a prerequisite for innovation (Wu/Wang/Evans 2019; Xu et al. 2020; Zhai/Ding/Wang 2018), the same cannot be observed for German sociology in the timeframe under investigation. Our results rather indicate that concepts related to applied topics have a particularly high chance of consolidation over time. We observe adaptation to overall societal circumstances, outside academic discourse, and a trend towards having to meet expectations of usefulness. This is achieved by focusing increasingly on applied quantitative empirical social research, making sociology less autonomous in its thematic focus.

This is by no means a contradiction: While innovation is in need of concepts spanning knowledge domains in order to address previously unaddressed research puzzles (about which, moreover, there is no agreement in sociology) with novel concepts, this is not the case at the end of the innovative chain. In the process of disseminating thought products, the actual innovative character loses its meaning relative to the applicability of the concepts.

Ultimately, ‘practice-oriented’ studies consolidate established lines of research even further, as they demonstrate the usefulness of associated thought products to actors outside academia. Consolidation might stem from the strategic orientation of universities and departments in the wake of the Excellence Initiative and increased third-party funding. Researchers and departments have to align themselves with topics that guarantee the acquisition of third-party funding. Only by doing so can researchers be employed; they, in turn, provide the necessary publication output. These researchers are subsequently socialized in such a way that they are exclusively familiar with research oriented towards third-party funding, leading to a loss of recognition of abstract concepts that are not directly applicable. An increasing lack of research autonomy is accompanied by the rise in *applied and applicable* research, which is conducted in a building-block research style, a scientific practice which may increase the chances for consolidation, but lowers the chances of *innovation by* *combination (of topics)* and *integration (of scientists).* However, these mechanisms are expected to drive consolidation, not actual innovation.[16]

Specifically, research on social inequality and its associated concepts as published at the beginning of the millennium is scarcely referred to in contemporary German sociology. Since the 1980s, the discourse on social inequality has differentiated into research on gender inequality, intersectionality, educational inequality, regionality, etc.—marginalizing traditional conceptualizations of social inequality such as class-structure. Despite the proliferation of the semantics of inequality, 'classical' forms and concepts of social inequality, as a coherent paradigmatic framework, have lost their relevance in each of these different discourses (cp. Schwinn 2021: p. 383f.).

Also, the thematic structures of the German sociological discourse in the early 2000s have lost their relevance over time: A focus on any of the poles of the remaining dimensions does not have any relevance as to which topics are currently central to the field. This can be explained in the context of the ongoing polarization and disintegration of sociology (Moebius 2021; Münch 2018; Turner 2016; Schwemmer/Wieczorek 2020; Schmitz et al. 2020). No single position (e.g., constructivism, methodological individualism, etc.) has become central to the field over time. Instead, they are now increasingly discussed within their own scientific subfields.

Finally, our findings support the negative association between the spread of innovation and publishing as a female scholar (Lerchenmueller/Sorenson 2018; Dion/Sumner/Mitchell 2018). Gender processes are effective across all special structural properties, due to the underrepresentation of women in networks and the marginalized position of themes preferred by female scholars in the topic space. However, our investigation also sheds light on the fact that the topics chosen—which to a considerable extent remain gender-specific—might hinder the consolidation of the concepts applied by female sociologists. Whereas male scholars apply concepts easily transferable between topics, such as generalizable thoeries, quantitative methodology, and concepts linked to economic sociology, management, and governance, female scholars use qualitative methods linked to different dimensions of social inequality. These in-depth approaches and findings are geared towards specific problems or research puzzles, and therefore cannot easily be tested or applied

16 The assumption that the instrumental usability of empirical social research for political agendas has increased over time and that application-oriented research is therefore more represented in 2016–2019 than in 2000–2003 can be further substantiated by way of contextualization: First, the funding of this research through third-party funding has increased (but not through the DFG and the Excellence Initiative), second, the researchers in the service institutes are encouraged by evaluation to publish journal articles rather than gray literature or book contributions, and third, because these scholars often work with (or are even involved in the production of) datasets that can be readily used for standard quantitative articles. In contrast, much of the research at university departments still takes place individually.

to different topics, which is the prerequisite for consolidation according to the literature (Xu et al. 2020; Zhai/Ding/Wang 2018).

Taken together, our results show that German sociology as presented in the journals studied does not conform to the pattern of consolidation of innovations expected on the basis of a research literature that is predominantly focused on natural and life sciences. Assumptions that are highly plausible for specific disciplinary and national contexts cannot be applied to (or confirmed by) German-language sociology, due to its specific characteristics. The special structural properties of sociology, especially of sociology in the German-speaking field, counteract the assumed association between collaborative patterns and the consolidation of thought products. A decisive element is the multipolar structure that is characteristic of the field of German-language sociology.

Here, we find no uniform or even single form of knowledge accumulation according to which patterns of innovation and its consolidation through scientific cooperation networks would take place. This is not only because there is no consolidation across the different sociological paradigms, but also because breaks (e.g., 'turns') with their previous stock of knowledge and with the positions of competing approaches are frequent occurrences within many of these paradigms (Schneider/Osrecki 2020). This may facilitate innovation, but it certainly makes cumulative knowledge development—and ultimately consolidation—much more difficult. It is a key factor for the discipline that its internal development is strongly subjected to external factors, such as conjunctures of topics.

The author's gender is another 'extra-scientific' factor, with an additional malus possibly at work apart from the unfavorable statistical starting conditions of female scholars and their thematic preferences. This is because, even controlling for topics, the proportion of female authors on a paper yields a negative effect on the future consolidation of the concepts they deal with. Likewise, the positive effect of the number of institutions involved can be interpreted as resulting from the accumulation of academic institutional capital (Münch 2014a: pp. 144–177).

Yet, even if the field is evolving towards instrumentally exploitable research, our findings also attest that the non-hierarchical multipolar institutional structure of German sociology is conducive to change in concepts, theories, methodologies, and themes. In this respect, there are favorable conditions for the emergence and dissemination of new thinking.

Thus, we do not find much support for the expectations regarding the consolidation of thought products based on investigations of other disciplines. Instead, special conditions with counteracting structures and processes are at work. These include (1) a closed German discourse space and (2) a discipline (a) with less established collaboration and co-authorships compared to the natural and life sciences, (b) with a multipolar, non-hierarchical institutional structure, (c) without a paradigmatic core, (d) without epistemic progress with corresponding knowledge accumulation, and (e) with high reactivity to actual societal circumstances.

6 Conclusion

The aim of our study was to investigate the association between different forms of collaboration and the consolidation of thought products in German-speaking sociology outlets. To do so, we examined 2,785 abstracts and meta-data published in five German sociology journals between 2000 and 2019. Additionally, we extracted centrality measures from the co-authorship network of authors who issued articles between 2000 and 2003. We then applied correspondence analysis to construct the topic spaces in 2000–2003 and 2016–2019 and conducted a linear regression analysis on the terms used in the abstracts. By doing so, we were able to calculate the shift of thought products towards the center of the academic discourse or their drift to the periphery, and investigated their associations with types of collaboration, author centrality, gender composition of research teams, and research topics extracted from the topic space of 2000–2003.

Three findings stand out in particular: Firstly, we found that consolidation is positively associated with the number of institutions linked to an article. Secondly, consolidation is negatively associated with the number of collaborations with authors using different terms, as well as their initial distance from the center of the sociology discourse in 2000–2003. The latter indicates a certain degree of stability of the discourse prevailing in the five sociology outlets under investigation. Finally, we observed that tokens associated with social inequality research become peripheral over time, while tokens which are associated with research on governance and management become more central. These effects also hold after sensitivity analysis (see online appendix D).

In light of our findings and considerations outlined in the discussion section, future research should engage in the investigation of scientific consolidation processes and, in doing so, employ a more differentiated, comparative perspective, one that takes into account how scientific fields differ and the significance of the embeddedness in national contexts. This is especially true inasmuch as our paper focuses on sociology as the case study, which bears little resemblance to the natural sciences, but may yield indications regarding consolidation mechanisms present in other multiparadigmatically-structured disciplines.

Future research should also assess whether our findings hold for sociological research communities in different countries, especially in Anglophone countries with greater potential to reach audiences globally. We suspect that international research teams that can agree on a common, already proven research program and publish only in English are more likely to consolidate concepts—especially since national journals are more likely to publish topics and associated research concepts that address problems from that country.

Moreover, future research should investigate whether the topics derived from our topic space remain stable, or are re-embedded into new contexts. By focusing on the movement of thought products in the topic space, future studies could trace the reconceptualization and re-embedding of sociological concepts (e.g., from social structural analysis to empirical education science or gender studies) into new topics.

Future studies should also examine whether the central authors have strategically migrated to other (especially Anglophone) journals where they can make use of their ability to link discourses and thus consolidate concepts. This would amount to a *parallel internationalization* of some German authors (who increasingly orient themselves toward international journals) and a *de-internationalization* of the remaining German sociologists. Thus, it might be the case that we are dealing with a kind of migration flow between journals, leading to an impression of consolidation and marginalization of research concepts. Eminent researchers from specific paradigmatic milieus may leave the German-language discourse and enable the consolidation of research content in other research communities, while sociologists and their thought products from other countries or research institutes may, conversely, begin to publish in the journals under investigation.

As is the case in bibliometric studies, our investigation is prone to some limitations. First, our findings may be the result of period effects associated with the Excellence Initiative and Bologna reforms. These might have an impact on forms of collaboration and the spread of ideas, measured in citations. As both are linked to the consolidation of thought products, as argued in section 2, future studies should seek a way to determine possible confounders in the consolidation of thought products. Second, our model of consolidation cannot distinguish between genuine research innovations and thought products which were innovated in different contexts (e.g., the US sociology discourse) and only belatedly adopted by German sociology. Consequently, we treat innovation as the introduction and dissemination of different concepts into the German sociology discourse. Third, our sample is relatively small. Thus, we may have missed some aspect of the dynamics of consolidation in German sociology; future studies should expand the sample to include more obscure journals and also Anglophone journals. The space occupied by researchers specialized in providing useful knowledge in the sociology journals serving as the data basis for this study has been increasingly extended in the observed period of time.

While our findings nonetheless suggest that distinct and relatively autonomous collectives populate the younger field of German sociology, future research should also expand the database to consider publications in books, an approach to publication important to large segments of German sociology. Furthermore, the observational window should be extended, in analyses based on our proposed approach, in order to minimize the problem of left censoring. Most importantly, in doing so, it should be kept in mind that research is a collective process that requires not only innovative 'superstars', but many researchers who adopt these innovations and implement them productively in different disciplinary contexts. Sadly, this is increasingly forgotten in an academic system which focuses on visibility, increasing publication output, and attracting external funding, and which is also increasingly geared towards competition and addressing externally set research goals.

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Appendix A: descriptive statistics

Table A1: Descriptive statistics of the variables included in the OLS regression model.

	Observations	Mean	Median	Minimum	Maximum	Range	Standard Deviation	Skewness	Kurtosis
Dependent variable: Distance of the terms from the center of the topic space 2016–2019	352	0.72	0.65	0.1	3.44	3.34	0.4	2.17	9.11
Distance of from the center of space 2000–2003	352	0.87	0.83	0.12	2.46	2.34	0.39	0.89	1.13
Av. # of authors p. article	352	1.44	1.43	1	2.43	1.43	0.21	0.68	1.37
Number of international collaborations of authors using the thought product in 2000–2003	352	0.62	0	0	6	6	0.93	2.01	5.34
# of int- collaborations of authors	352	27.15	20	4	250	246	24.51	3.73	23.49
# of participating institutions of authors	352	0.18	0.17	0	0.8	0.8	0.11	1.17	3.5
% female authors per article.	352	0.15	0.14	0	0.57	0.57	0.1	0.72	1.12
% of mixed-gender teams per article	352	0.003	0.002	0	0.01	0.01	0.001	0.69	2.31
Average degree centrality of authors	352	$8.88e^{-06}$	$6.69e^{-06}$	0	0.0001	0.0001	$9.65e^{-06}$	2.6	13.23
Average betweenness centrality of authors	352	0.01	0.01	-1.24	2.02	3.25	0.43	0.49	1.71
Inequality vs. quant. research on governance and management	352	0.04	0.06	-2.18	1.73	3.91	0.58	-0.17	0.26
Qual. vs. quant. (labor, inequality, family)	352	0.03	0.04	-1.33	1.37	2.7	0.46	-0.17	-0.12
Theory-free, applied, micro research vs. sociological (macro-) theory	352	0.05	0.06	-1.29	1.79	3.08	0.41	-0.07	1.06
Meso/macro-embeddedness vs. quantitative meth. individualism	352	0.01	0.01	-1.24	2.02	3.25	0.43	0.49	1.71

Appendix B: Distances to the point of origin of the topic spaces in 2000–2003 and 2016–2019

Figures B1–B4 summarize the central/peripheral positions of each active/passive term included in our regression model. On the x-axis, we plotted the distance of the terms to the point of origin in our topic space in 2000–2003, whereas the y-axis depicts the distance of the terms to the point of origin in our topic space in 2016–2019.

Figure B1: Distance of tokens active 2000–2003 and 2016–2019 from the point of origin in the topic space.

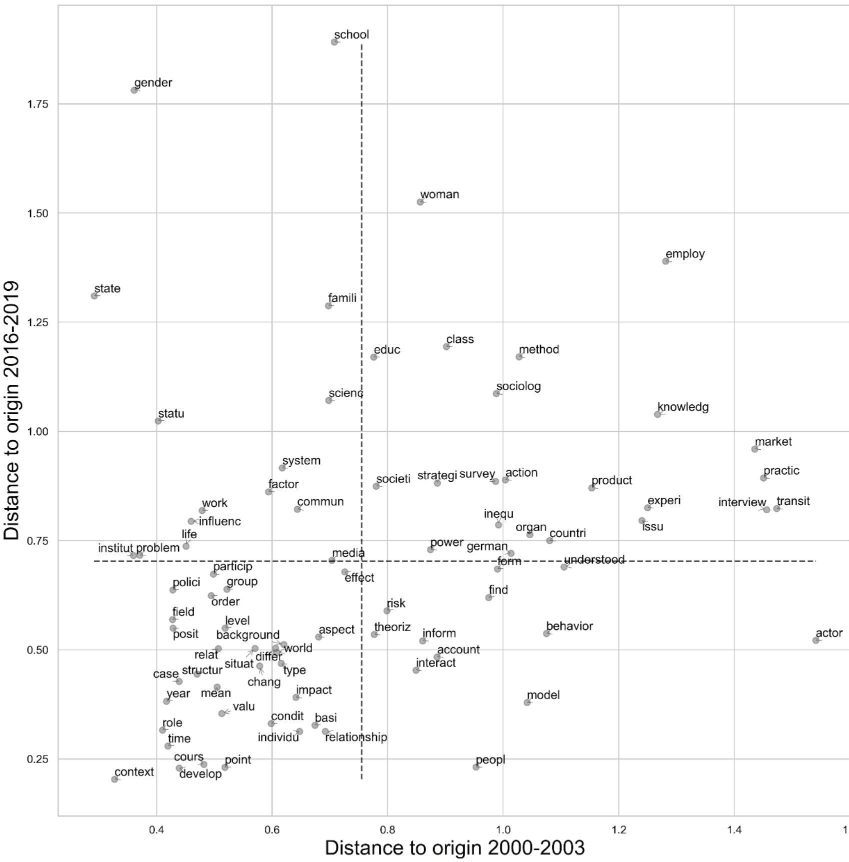


Figure B2: Distance of tokens passive in 2000–2003 and 2016–2019 from the point of origin in the topic space.

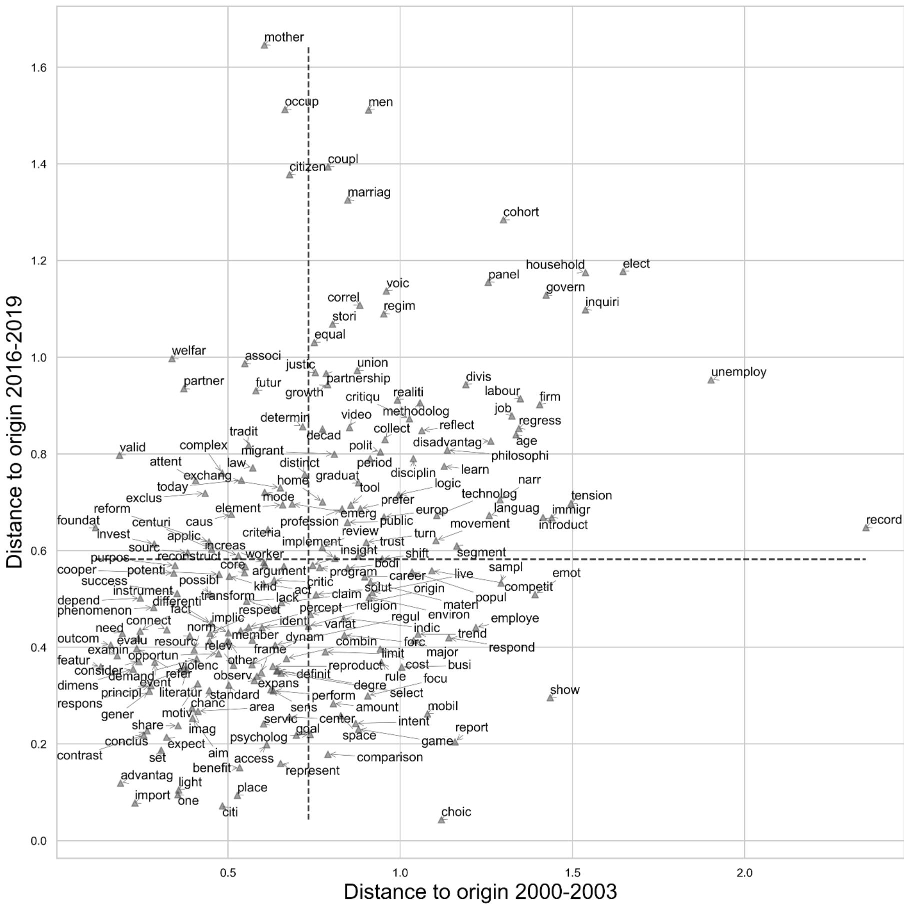


Figure B3: Distance of tokens active in 2000–2003 and passive in 2016–2019 from the point of origin in the topic space.

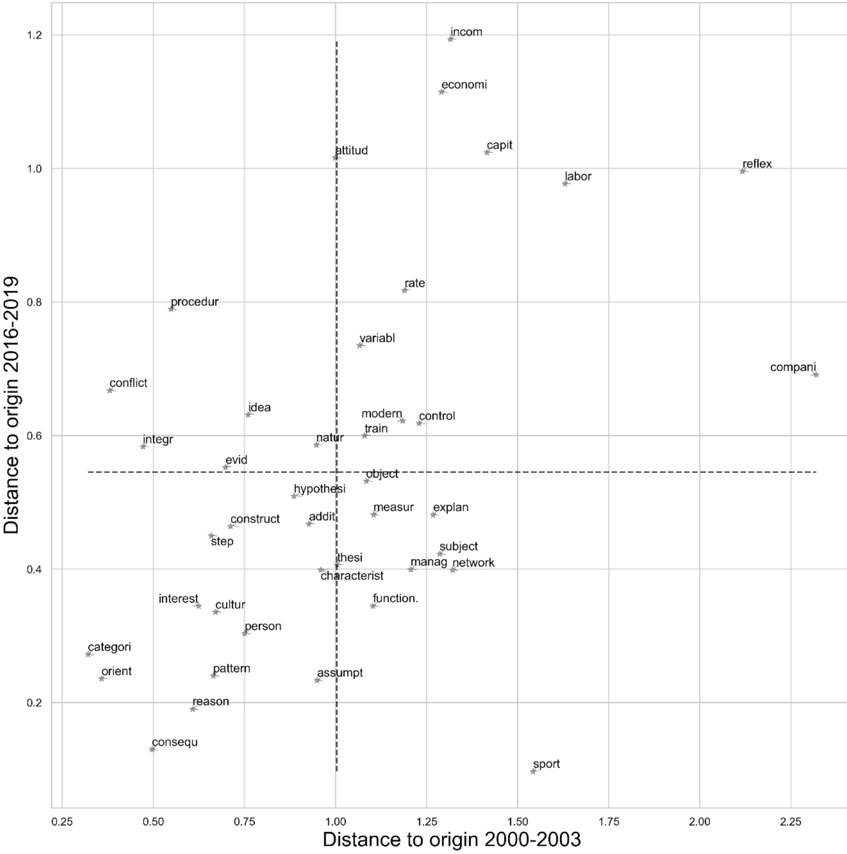
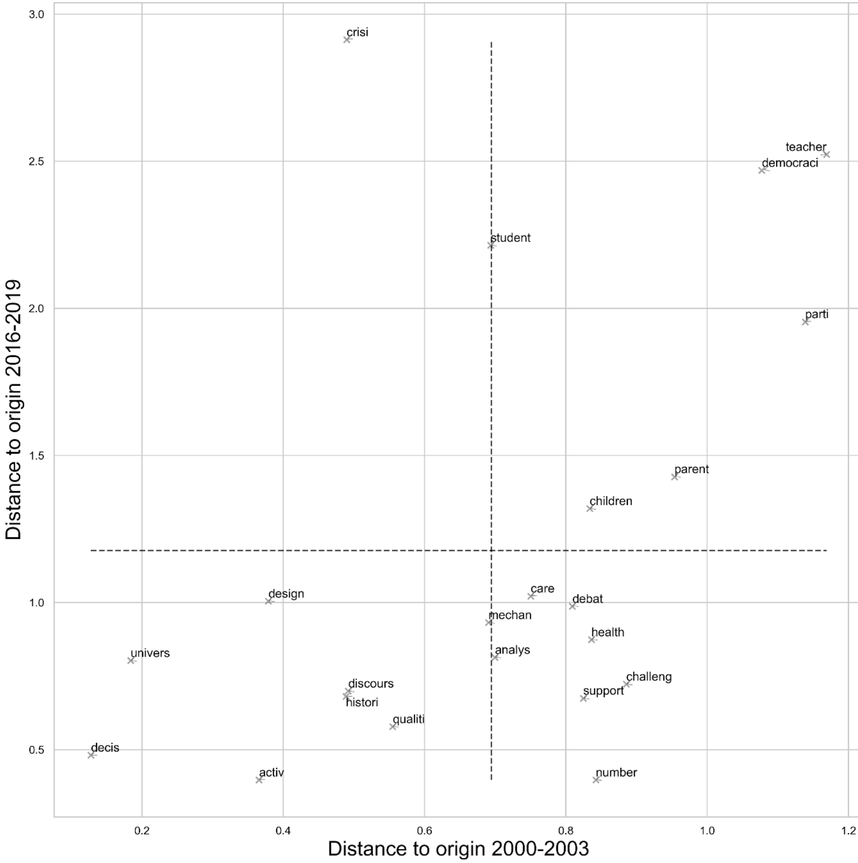


Figure B4: Distance of tokens passive in 2000–2003 and active in 2016–2019 from the point of origin in the topic space.



Appendix C: Hierarchical nested regression models

Table C1: OLS regression models of collaborative forms, centrality in co-authorship networks, and a term's position in the topic space on its consolidation.

DV: Distance of terms from the center of the topic space 2016–2019	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Av. # of authors p. article		-0.03			-0.06 †		-0.03
		(0.03)			(0.03)		(0.03)
# of int- collaborations of authors		-0.01			-0.01		-0.01
		(0.02)			(0.02)		(0.03)
# of participating institutions of authors		0.01			-0.12 †		-0.13 *
		(0.03)			(0.07)		(0.07)
% female authors per article.		0.04 †			0.06 **		0.04 †
		(0.02)			(0.02)		(0.02)
% of mixed-gender teams per article		0.04			0.05 †		0.04
		(0.03)			(0.03)		(0.03)
Average degree centrality of authors			0.03		0.12 *	0.03 †	0.13 *
			(0.02)		(0.05)	(0.02)	(0.05)
Average betweenness centrality of authors			0.05 *		0.05 *	0.04 *	0.04 †
			(0.02)		(0.02)	(0.02)	(0.02)
Distance of from the center of space 2000–2003	0.14 ***	0.15 ***	0.14 ***	0.13 ***	0.14 ***	0.14 ***	0.14 ***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Inequality vs. quant. research on governance and management				0.08 ***		0.08 ***	0.08 ***
				(0.02)		(0.02)	(0.02)
Qual. vs. quant. (labor, inequality, family)				0.02		0.00	0.01
				(0.02)		(0.02)	(0.02)
Theory-free, applied, micro research vs. sociological (macro-) theory				0.01		0.01	-0.01
				(0.02)		(0.02)	(0.02)
Meso/macro-embeddedness vs. quantitative meth. individualism				-0.01		-0.01	-0.03
				(0.02)		(0.02)	(0.02)
Constant	0.52 ***	0.52 ***	0.52 ***	0.52 ***	0.51 ***	0.52 ***	0.51 ***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Observations	352	352	352	352	352	352	352
Adjusted R^2	0.13	0.14	0.15	0.18	0.18	0.19	0.21

Legend: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, † $p < 0.1$.
Confidence interval in parentheses, z-normalized effect coefficients.

Appendix D: Sensitivity analysis of the regression model

Table D1: OLS regression models of collaborative forms, centrality in co-authorship networks, and a term's position in the topic space on its consolidation with t1 = 2013–2016.

DV: Distance of terms from the center of the topic space 2013–2016	
	Model
Average # of authors p. article	-0.07 **
	(0.02)
# of int- collaborations of authors	0.02
	(0.03)
# of participating institutions of authors	-0.19 ***
	(0.05)
% female authors per article.	0.02
	(0.02)
% of mixed-gender teams per article	0.03
	(0.02)
Average degree centrality of authors	0.15 **
	(0.05)
Average betweenness centrality of authors	-0.01
	(0.02)
Distance from the center of space 2003–2006	0.16***
	(0.02)
z.Dim_1_2003_2006	-0.01
	(0.02)
z.Dim_2_2003_2006	0.01
	(0.02)
z.Dim_3_2003_2006	-0.06 ***
	(0.02)
z.Dim_4_2003_2006	0.02
	(0.02)
Constant	0.57 ***
	(0.01)
Observations	367
Adjusted R^2	0.30

*** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$; $^{\dagger}p < 0.1$.

Appendix E: Most productive authors, most central authors, and biggest component of the co-authorship-network 2000–2003

Table E1: The ten most productive authors according to the number of papers issued in 2000–2003.

	Name	Number of Observations
1	ROTH, WOLFF-MICHAEL	5
2	KONIETZKA, DIRK	5
3	GERHARDS, JÜRGEN	5
4	BREUER, FRANZ	5
5	NOLLMANN, G	4
6	KLEIN, THOMAS	4
7	WINDZIO, MICHAEL	4
8	LIEBIG, STEFAN	4
9	KUHL, STEFAN	4
10	ROSSEL, JÖRG	4

Table E2: Most central authors in 2000–2003 by normalized degree centrality. Own calculations.

	Name	Normalized degree centrality
1	MARTIN_HÖPNER	0.0186
2	RAINER_ZUGEHÖR	0.0149
3	ANKE_HASSEL	0.0149
4	BRITTA_REHDER	0.0149
5	ANTJE_KURDELBUSCH	0.0149
6	THOMAS_KLEIN	0.0149
7	DIRK_KONIETZKA	0.0149
8	JUDITH_PRINGLE	0.0112
9	SUSAN_COPAS	0.0112
10	BRIGID_CARROLL	0.0112

Table E3: Most central authors in 2000–2003 by normalized betweenness centrality. Own calculations.

	Name	Normalized betweenness centrality
1	STEFAN_LIEBIG	0.00019
2	ROLAND_VERWIEBE	0.00017
3	THOMAS_KLEIN	0.00014
4	DIRK_KONIETZKA	0.00014
5	MARTIN_HÖPNER	0.00011
6	UWE_WILKESMANN	0.00006
7	FRANZ_BREUER	0.00006
8	MICHAEL_GROTHEER	0.00006
9	JÜRGEN_GERHARDS	0.00006
10	JÖRG_RÖSSEL	0.00006

Kai Mühleck* and Ulrike Schwabe**

Challenging the intuition: Is a same-gender supervisor beneficial for doctoral students?***

Abstract: It continues to be a puzzle that women are disproportionally often dropping out of academic careers. Researchers and policymakers have suggested that same-gender supervisors are important for tightening this 'leaky pipeline'. Especially in subjects with a strong overrepresentation of men, it seems likely that female supervisors work as positive role models and help preventing discrimination. Anticipating this effect, female doctoral students might also prefer supervisors of the same gender.

Therefore, we ask how widespread a gender match is between doctoral student and supervisor in Germany and whether a gender match between supervisors and doctoral students is beneficial for the doctorate and for a possible scientific career thereafter. For our data we draw on the first survey of the 'German National Academics Panel Study (2018)'; to address causality concerns we apply entropy balancing for our estimations.

Our analyses confirm that both female and male doctoral students are more likely to have a supervisor of the same gender. Furthermore, results show that female supervisors have a positive effect on satisfaction with mentoring and academic self-concept for both female and male doctoral students.

Keywords: Doctoral students, gender-match, Nacaps, same-gender, supervisor, scientific career

Eine Herausforderung für die Intuition: Sind Betreuende gleichen Geschlechts für Promovierende von Vorteil?

Zusammenfassung: Es ist nach wie vor nicht gänzlich klar, warum Frauen überproportional häufig aus der akademischen Karriere ausscheiden. Wissenschaftler:innen und politische Entscheidungsträger:innen haben die Vermutung geäußert, dass

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Betreuende gleichen Geschlechts wichtig wären, um die sogenannte „leaky pipeline" zu schließen. Vor allem in Fächern, in denen Männer stark überrepräsentiert sind, könnten Betreuerinnen als positive Vorbilder fungieren und dazu beitragen, Diskriminierung zu verhindern. In Erwartung dieses Effekts könnten weibliche Promovierende auch weibliche Betreuende bevorzugen. Vor diesem Hintergrund fragen wir, wie verbreitet es in Deutschland ist, dass Promovierende und Betreuende das gleiche Geschlecht haben und ob dies für die Promotion und für eine mögliche anschließende wissenschaftliche Karriere vorteilhaft ist. Als Datengrundlage verwenden wir die erste Befragung der „National Academics Panel Study (2018)". Um das Problem der Kausalität der Zusammenhänge zu adressieren, verwenden wir entropy balancing für unsere Schätzungen. Unsere Analysen bestätigen, dass sowohl weibliche als auch männliche Promovierende mit höherer Wahrscheinlichkeit Betreuende desselben Geschlechts haben. Darüber hinaus zeigen die Ergebnisse, dass Betreuerinnen sowohl bei weiblichen als auch bei männlichen Promovierenden einen positiven Effekt auf die Zufriedenheit mit der Betreuung und das akademische Selbstkonzept haben.

Stichworte: Betreuende; gleichgeschlechtlich; Nacaps; Promovierende; wissenschaftliche Karriere

1 Introduction

In the course of educational expansion, the representation of women in academia has considerably increased in recent decades, with women outnumbering men among entrants to higher education as well as among higher education graduates for most degrees, in most OECD countries (OECD 2020a, b). As a consequence, today the share of tertiary-educated women within the working-age population in the majority of OECD countries is larger than the share of tertiary-educated men (OECD 2020c). In fact, many countries have started promoting higher education among men (OECD 2019a) with a view to redressing the balance.

While women are close to having reached parity among doctoral graduates (OECD 2019b), they are underrepresented at higher levels of the academic career such as among university teachers (OECD 2020c). To some extent, this difference certainly reflects 'historical' gender-inequalities. However, even 10 years ago women had almost reached parity among doctoral graduates (OECD 2012) and among first-degree graduates they have now outnumbered men for at least one and a half decades (OECD 2008).

Thus, it is unlikely that persisting gender inequalities are exclusively due to student cohorts with a female majority not yet having reached these levels. Studies on countries such as Switzerland (Schubert/Engelage 2011) and Germany (Lörz/Mühleck 2019), with particularly low proportions of female professors (OECD 2020c; Konsortium Bundesbericht Wissenschaftlicher Nachwuchs 2021, Russ 2021), have corroborated that at each step of the academic career the share of women dropping out continues to be greater than the share of men. This phenomenon has been described with the catchy metaphor of a 'leaky pipeline' in education and in science (e.g., Berryman 1983; Alper 1993). Thus, equal participation of women and men, especially in leading positions, in academia is still an important subject of higher-education research and remains on the agendas of higher-education policymakers and professionals (e.g., Cheung 2021, BMBF 2021a 2021b, Forschung und Lehre 2020).

Despite its importance, the leaky pipeline phenomenon remains a puzzle. Researchers and policymakers have suggested that same-gender supervisors are important for fostering the academic careers of women. Especially in subjects with a strong overrepresentation of men, female doctoral students could be confronted with negative stereotypes, distorted perceptions of their performance, and less academic integration, resulting in e.g., less satisfaction, lower self-esteem or even dropout. It seems likely that female supervisors lessen these negative effects and work as positive role models (Kanter 1977, Hirshfeld 2010, Solanki/Xu 2018). Anticipating this effect, female doctoral students might also prefer supervisors of the same gender. More generally, it has been supposed that supervisors show more understanding towards students of the same gender and that cooperation with them is more enjoyable (Gaule/Piacentini 2017). Thus, we intuitively assume that a same-gender supervisor is beneficial for doctoral students, be they male or female.

While such thoughts seem initially compelling, empirical evidence is mixed and differs substantially by field of study (e.g., Edmunds 2016; Gaule/Piacentini 2017; Hilmer/Hilmer 2007, Neumark/Gardecki 1998, Solanki/Xu 2018). There is a considerable body of empirical research referring to the United States but, to the best of our knowledge, there exists as yet no study for the German case. Moreover, little is known about the social mechanisms behind the association of a gender match and an academic career. Mostly, empirical research either does not or cannot tackle the question of the causality of this association (an exception is Carrell et al. 2010). Against this backdrop we ask (i) how widespread gender-matching is between doctoral students and supervisor in Germany and (ii) whether gender-matching between doctoral student and supervisor is beneficial for a successful doctorate and a possible scientific career afterwards.

The paper is structured as follows: Firstly, we give an overview of previous research. Thereafter, we present theoretical and conceptual considerations also addressing the question of causality. This is followed by a description of our database, the 'German National Academics Panel Study (Nacaps)' and our analytical strategy. We then present bivariate results and multivariate results of regressions using entropy-balancing weights. We close with a summary and discussion including limitations, future research avenues, and policy implications.

2 Previous research

Looking at the existing literature, a couple of specific focuses, imbalances, and lacks of research come to the fore. Firstly, most of the research comes from the United States and also focuses on the United States, i.e., for reviewing the state of empirical research, we did not intentionally focus on the United States, but there are hardly any studies on the effect of gender-matching supervisors that refer to other countries. Moreover, analyses focusing on doctoral students only are scarce and therefore, we also consider studies on students or graduates at bachelor's and master's levels. Finally, most studies focus on a specific field of study and rarely fields of study are compared to each other. We will use this feature of previous research and structure our brief literature review along the lines of fields of study.

Looking at STEM subjects, first, evidence from the United States clearly supports the positive effect of same-gender faculty, especially for women. Doctoral students of chemistry tended to pick same-gender advisors and both male and female students with a same-gender advisor were more productive and more likely to become professors themselves (Gaule/Piacentini 2017). These positive effects of a gender-matching advisor were greater for female doctoral students then for the males (Gaule/Piacentini 2017). Female doctoral students in STEM subjects had a higher chance of graduating if they had a female advisor or if a relatively large proportion of the faculty at their institute was female; for male doctoral students no such effect was observed (Main 2018). Female bachelor students achieved better grades in facultative math and science classes if they were taught by women (Carrell et al. 2010). Moreover, the proportion of female faculty in introductory math and science courses was found to be positively associated with female bachelor students choosing further math and science classes as well as with going for a master's in STEM subjects (Carrell et al. 2010). Female students were less active in STEM classes then their male peers and less often asked for help; this difference lowered if courses were taught by women (Solanki/Xu 2018). Grades of students were generally lower if instructors were female, but this disadvantage lessened if students were female as well (Solanki/Xu 2018). Female students had a lower subject-specific self-efficacy; female instructors did not have a significant effect on this difference (Solanki/Xu 2018). Interestingly, the studies of Solanki and Xu (2018) and Carrell et al. (2010) reported that the (relative) positive effect of female faculty on the performance of female students was particularly large for the highly-skilled, i.e., those that may be suited to an academic career.

Regarding the field of medicine, Edmunds et al. (2016) reviewed 52 studies (most of them referring to the United States) on the question of why women are less likely than men to pursue an academic career. Many studies reported that women had more problems than men in finding adequate mentors and also that women had difficulties in finding gender-matching mentors. One study, however, found that both female and male students thought that the other gender had better mentoring (Edmunds et al. 2016) Some studies reported that female students were more likely to choose advisors of lower rank and that they valued a supportive relationship with the mentor more than the reputation of the mentor (Edmunds et al. 2016). There was also some evidence that women might have specific mentoring needs (Edmunds et al. 2016). These findings suggest that the career outlook of female doctoral students might benefit from more female advisors. However, to our knowledge no study on medicine has so far directly investigated the effect of a student-advisor gender match.

In contrast to STEM fields, studies on doctoral students in economics revealed no clear evidence for a positive effect of same-gender advisors. Neumarck and Gardecki (1998) found that female doctoral students of economics in the United States had slightly higher completion rates and graduated more quickly at institutes with higher numbers of female faculty. Numbers of female faculty, however, did not shorten the time till first job placement for women or result in higher chances of securing a first job at a PhD-granting institute. This might be due to the fact that institutes with larger numbers of female faculty were also lower tier institutions. What's more, the gender of the dissertation chair for female doctoral students had no significant effect on any of the outcome variables (Neumarck/Gardecki 1998). About 10 years after Neumarck and Gardecki's study, Hilmer and Hilmer (2007) did another study focusing on U.S. doctoral students in economics. Surprisingly, they found a positive gender-mismatch effect in the sense that female students with male advisors were more likely to attain a research-related first job then male students with male advisors. Looking at female students only, the gender of advisors had no significant effect. Generally, female students issued fewer publications then male students with male advisors. This was associated with female students being more likely to enrol in programs with less reputation and to pick dissertation advisors of lower rank (Hilmer/Hilmer 2007). Hilmer and Hilmer (2007) assume that economics is lacking female 'star-advisors' that could (additionally) push careers of female doctoral students. While this may be the case, all in all, the results of both studies suggest that the student-advisor gender match has little or no effect on the academic career outlook of doctoral students in economics.

An exception with respect to field of study is the paper of Bettinger and Long (2005) covering first-year students of colleges with a range of subjects. Using longitudinal data, they analyze the impact of having female faculty members in initial courses on additional course attendance, the overall number of credit points, and the choice of the major for female students. Overall, the results indicate some positive effects of matched gender for female students. It turns out that the effects of having female instructors for female students' outcomes vary significantly between the subjects, without a clear pattern, however. In contrast, focusing on male students in female-dominated fields, findings show strong positive effects of having male instructors for the acquisition of credit points and choice of major for male students in education. Despite the fact that this study is not restricted to certain subjects, it also provides a sophisticated estimation strategy. Based on the argument that selection into initial courses is far from random, an instrumental variable approach is applied to deal with endogeneity. The term-specific variation in the likelihood of female-taught courses functions as a valid instrument to capture selection into courses based on students' gender preferences.

All in all, the literature shows that advisors of the same gender are generally preferred. There is some evidence supporting the claim that female advisors have positive effects on the study results and career prospects of female students. Evidence further indicates that a gender match has positive effects, generally with possibly greater effects for women than for men. However, results differ quite strongly across subjects, e.g., contrasting between economics and STEM. Moreover, other socio-demographic characteristics, e.g., race or ethnicity (Alston et al. 2017; Riegle-Crumb et al. 2020), seem also to be relevant.

By summarizing the state of the empirical literature, we see research gaps in a couple of aspects; the *first aspect* is the restricted geographical scope. Empirical evidence almost exclusively refers to the U.S.-American context. This raises the question of whether the U.S. results can be generalized towards other countries. To the best of our knowledge there exists as yet no empirical study on German higher education in general or on German doctoral students in particular (for secondary education in Germany, see Helbig 2012, Neugebauer et al. 2011). However, Germany seems to be an interesting case. The share of women among professors is relatively low compared to other European countries (European Commission 2021) and this continues to be raised as a pressing challenge on the political agenda (most recently e.g., Konsortium Bundesbericht Wissenschaftlicher Nachwuchs 2021). At the same time, Germany addresses this issue with policy measures and, which, in fact, do seem to contribute to recent improvements (Löther 2019).

The *second aspect* refers to the selected set of subjects analyzed, such as STEM fields. Often, only one subject is covered, and thus, the question of generalization of findings to other subject/discipline-specific contexts also arises. Referring to differences among subjects, it is still an open empirical question, how single subjects differ from the 'average effect' of gender matching across all subjects.

Such analyses require large-scale surveys with a sufficient number of observations, the *third aspect* that we have detected. Existing evidence is often based on administrative data (e.g., Bettinger/Long 2005; Carrel et al. 2010; Gaule/Piacentini 2017; Hilmer/Hilmer 2007; Neumarck/Gardecki 1998), on smaller local surveys (e.g., Riegle-Crumb et al. 2019) or qualitative data (e.g., Alston et al. 2017; Hirshfield 2010). While administrative data usually provide sufficient samples sizes, they lack subjective evaluations like motivation to obtain a doctoral degree, relationship to supervisor or satisfaction with mentoring during doctoral studies. Since suitable data at the national level are already rare, international comparisons are currently not possible at all.

A *fourth aspect* is the obvious problem of endogeneity. Students selecting into a mentoring relationship with an advisor of a specific gender is not a random assignment. Thus, factors like e.g., goals or personality traits may drive this self-selection process and may at the same time influence the academic career trajectories. Only a few studies referred to in the literature review explicitly address the issue of gender matching being an endogenous variable and that 'selection into treatment' may be due to unobserved variables. However, this is highly relevant for causal reasoning. By design, experimental studies are a good way to fully debilitate the (self-)selection concerns but, of course, such experiments would be hard to accomplish and probably immoral. Only one study that we are aware of made use of a natural experiment; Carrell and colleagues (2010) conducted research on students at the U.S. Air Force Academy from graduating classes 2001 to 2008. In this institute, students are randomly assigned to professors in required core courses. Since all faculty members use the same syllabus and test scores, equivalence in teaching has been ensured. The findings indicate only small effects of professor's gender for male students' performance, but, substantial effects for female students, especially in math and science. Since students can usually not be randomly assigned into courses or to supervisors, ex-post estimation approaches are necessary when using survey data. As described above, Bettinger and Long (2005) used an instrumental variable approach to meet the objection of selection on unobservables. As described below, we will use entropy balancing to account for systematic differences between students with and without a gender-matching advisor.

Finally, the *fifth aspect* concerns theoretical considerations. Many studies start from the assumption that a gender match would have a positive effect on educational or academic careers. While such a correlation hypothesis seems intuitively compelling, without some theoretical considerations it is unclear why a gender match should have such an impact, i.e., which social mechanisms are at stake. A more sophisticated theoretical framework could strongly contribute to strengthening our understanding of the social mechanisms and also help in a causal interpretation of findings. However, there is no established theoretical framework telling us why a gender match should impact educational or academic careers. Developing such a framework clearly goes beyond the scope of this paper, but we will in the next step present theoretical considerations leading to several testable hypotheses.

3 Theoretical considerations and hypotheses

Following our intuition, gender matching is beneficial for doctoral students: Doctoral students and supervisors of the same gender might get along with each other better, leading to stronger, more trustful and enjoyable relationships. Same-gender advisors may better understand gender-specific problems such as combining family responsibilities with doctoral studies. But besides intuitive reasoning, why should that really be the case? Why should gender matching lead to positive student outcomes during doctoral studies?

One line of reasoning is the 'theory of proportions' (Kanter 1977a, 1977b) and, related to that, the 'identity threat' (Hirshfield 2010). Both argue that it is the number of females compared to their male peers within a given context, 'skewed groups' (85:15 ratio of majority to minority; Kanter 1977a), that lead to stressful and challenging work environments. According to Kanter, members of small minorities (so-called 'tokens') stick out, are confronted with negative stereotypes by the majority, and are exposed to negative expectations that they would need to disprove. An example related to the topic of this paper could be female doctoral students in subjects where women form small minorities, e.g., in engineering. As a consequence of the social mechanisms described, performance of female doctoral students would be perceived more critically by the majority group. Moreover, the majority tends to maintain borders between groups, i.e., women would not be included in scientific networks to the same extent as men. In sum, this would lead to lower motivation and productivity among female doctoral students and poorer academic career prospects. A core assumption is that doctoral students anticipate this situation and thus choose a supervisor belonging to their own minority group, i.e., a female supervisor, in our example. A female supervisor could mitigate the 'identity threat' and the discrimination that goes with it. Obviously, this argumentation only holds if women form a small minority group. Consequently, the effect of a gender match would strongly depend on the share of females and males, both for doctoral candidates as well as for supervisors, in each respective field of study. Therefore, building on the tokenism theory, we would expect the positive effect of a gender match for women in male-dominated fields to be larger.

Another social psychological explanation, leading to similar conclusions is the 'identity-based motivation theory' by Oyserman (2007, 2009; for an application of this theory to gender matching see Solanki/Xu 2018). The core argument is that during higher education in general and the doctorate in particular students develop their academic identities, which help them to act and react in the academic world. During this process of identity-building, advisors, mentors and supervisors serve as important *role models*. If these role models have the same socio-demographic characteristics as the student, e.g., socioeconomic background, gender, ethnicity or race, it is much easier for the student to establish an analogue identity, which would then be in line with an academic career. Such a congruent academic identity leads to higher motivation, better academic performance, and developing a resilient personality to overcome difficulties in the academic system. In other words: Same-gender supervisors may be better suited to serve as role models, thus giving encouragement to same-gender students and being examples for how to pursue an academic career in the field—as a woman or as a man. Again, one might suspect that role models are especially relevant in environments where the specific role is less-established and few examples exist, i.e., female role models of being a professor could be more relevant in male-dominated fields.

A different argument could be made using theories of social networks. McPherson and colleagues (2001) argue that networks are often built following the 'homophily principle', i.e., ties between sociodemographically similar people are formed more often and are more stable. This would mean that female doctoral students could make better use of the network of a female supervisor and male doctoral students could make better use of the network of a male supervisor and therefore a gender match would again be beneficial. The homophily in academic networks might lead to the reproduction of gender pattern in the science system.

Network theory identifies factors which make networks more beneficial for their members, amongst others "the size of the network […] and resources of the tie" (Forret 2006: 151). If so, the social tie in a female-dominated (or rather, less male-dominated) field of study would be more beneficial than in a male-dominated subject. It would grant access to a larger network, and, in a field with a more balanced gender composition, female professors are more likely to have already reached outstanding positions associated with especially high resources.

While these explanations are based on coherent theoretical models, the literature additionally provides assumptions that do not belong to any parent theoretical framework. These arguments either refer to concrete and gender-specific behavior or to differences in productivity between men and women in academia.

With respect to behavior, male and female supervisors may differ in their specific mentoring styles, and, in turn, male and female doctoral students may differ in their specific mentoring needs (Gaule/Piacentini 2017). Supervisors of the respective gender might show more understanding for these gender-specific needs in mentoring and, e.g., support reconciling work and family life (Bettinger/Long 2005; Etzkowitz et al. 1994). These challenges may take on different scope and forms for male and female students, depending on gendered family roles (Lörz/Mühleck 2019).

Quite generally and intuitively comprehensible, one could assume that cooperation between mentors and students of the same gender could be more pleasant (Gaule/Piacentini 2017) which would ease work, add to motivation, and could thus promote the satisfaction and success of doctoral students.

With respect to productivity, male and female supervisors may differ in scientific reputation, productivity in terms of research output as well as in their status within organizations, e.g., being dean of a faculty (Etzkowitz et al. 1994; Gaule/Piacentini 2017; Hilmer/Hilmer 2007; Jaksztat 2017). Due to seniority, it seems likely that male advisors, on average, have a higher reputation, more resources and larger networks. If doctoral students do prefer advisors of the same gender, this would lead to differences in access to academic resources being dependent on the supervisor's gender. A gender match might thus have different consequences for the career prospects of male or female doctoral students, if, on average, a male supervisor could grant access to more resources that are relevant for advancing an academic career.

A last argument, from an economic perspective, is directed to the supply of supervisors within doctoral subjects. Gaule and Piacentini (2017) argue that one reason for the surprisingly persistent gender gap at higher levels of the academic career is the overrepresentation of male doctoral advisors, specifically in fields like science and engineering. In this view, the underrepresentation of women in faculty positions may perpetuate itself through a lower availability of same-gender mentors for young female researchers. Likewise, an overrepresentation of women in faculty positions in specific fields could start reproducing itself through a lower availability of same-gender mentors for young male researchers.

Based on these theoretical considerations, we derive the following five hypotheses.

Firstly, several theoretical arguments lead us to expect a general preference among doctoral students for gender-matching supervisors. Female students in male-dominated fields could prefer female supervisors to avoid tokenism in male-dominated subjects. They might more generally tend to choose female supervisors to learn from a role model. Doctoral students of both genders might prefer supervisors of the same gender due to expecting this to be a more pleasant working relationship.

When testing these theoretical assumptions, we face the problem that we don't know whether the students have chosen their supervisors, or the supervisors have chosen their students. Our data unfortunately tells us relatively little about the process of how students and supervisors have selected each other. The form of doctorate is likely to influence this; looking at the different forms, we argue that student preferences do have a certain impact, even though the strength of the impact may vary.

The most prevalent form of doctorate in Germany (accounting for close to half of the students in our sample) is that of doctoral students being employed as researchers. In such cases, the supervisor and the superior are often (not always) one and the same, and therefore the supervisor has chosen the student by hiring them. At the same time, the student has decided to apply for the job or at the very least to accept the job offer. In contrast, doctoral students in structured programs or freely pursuing their doctorates (together these two forms account for slightly less than half of the students in our sample) often take the initiative and approach the professor of their choice, asking to be supervised; professors usually accept such a request. At the same time, supervisors may have encouraged being approached. Finally, a smaller share of doctoral students in Germany has scholarships without pursuing a structured program. They could have approached supervisors on their own initiative, or the supervisor could have encouraged the student to apply for a scholarship. In sum, forming a couple made up of doctoral student and supervisor is sometimes driven by the preferences of the student and sometimes rather by the preferences of the supervisor. However, it seems very unlikely that the preferences of students have no effect. Therefore, if students tend to prefer supervisors of the same gender, this would, *ceteris paribus*, lead to a higher prevalence of gender-matching combinations between students and supervisors.

Clearly the prevalence of gender-matching combinations may also be driven by opportunity. Thus, it is important to check whether gender-matching combinations are still more likely if we distinguish between fields of study.

While we cannot test whether doctoral students prefer supervisors of the same gender, students are arguably always involved in the choice, which would, based on the theoretical arguments above, lead us to expect that the share of doctoral students with a supervisor of the same gender is disproportionally higher, i.e., female doctoral students would have a larger share of female supervisors than the overall share of female supervisors and male doctoral students would have a larger share of male supervisors than the overall share of male supervisors.

Hypothesis 1a: The share of doctoral students with a supervisor of the same gender is disproportionally higher.

Kanter's theory of proportions leads to a more specific hypothesis in this regard.

Hypothesis 1b: The share of female doctoral students with a supervisor of the same gender is disproportionally higher especially in male-dominated subjects.

Secondly, we expect that a same-gender supervisor has positive effects on a students' doctorates in various respects, i.e., that students are generally more satisfied with mentoring, that they build more academic self-esteem or self-efficacy, and that they are more optimistic about their academic career prospects after graduation.

Hypothesis 2: Doctoral students with a gender-matching supervisor are more satisfied with supervision.

Hypothesis 3: Doctoral students with a gender-matching supervisor believe more strongly in their own research abilities.

Hypothesis 4a: Doctoral students with a gender-matching supervisor are more optimistic about their career prospects in academia.

As described above, male supervisors may provide access to larger networks and resources, may have a higher reputation in the scientific community or may be more productive (e.g., due to age). This leads to a hypothesis 4b which, in contrast to hypothesis 4a, assumes that the gender-match effect differs between male and female doctoral students.

Hypothesis 4b: Male doctoral students with a gender-matching supervisor are more optimistic about their career prospects in academia and female doctoral students with a gender-matching supervisor are more pessimistic about their career prospects in academia.

Finally, the share of female doctoral candidates and also the share of female supervisors substantially vary across subjects. Tokenism theory and the identity-based motivation theory suggest that a gender match is especially beneficial for women in male-dominated subjects. According to tokenism theory we would expect discrimination against women especially in male-dominated fields, and a female supervisor could limit such discrimination. Moreover, she could serve as a role model, which is more important in fields where such role models are rare. In contrast, applying network theory, one could argue that social ties to a larger network with a wealth of resources are more beneficial than social ties to a small network with fewer resources. Thus, a female supervisor in a field offering a larger network of other female professors could be more beneficial to students' careers than a female supervisor in a male-dominated field. This reasoning leads to two conflicting hypotheses on subject-specific differences in the effect of a gender match for female doctoral students:

Hypothesis 5a: Female doctoral students in fields of study with a relatively *low* proportion of women benefit more strongly from a gender-matching supervisor.

Hypothesis 5b: Female doctoral students in fields of study with a relatively *high* proportion of women benefit more strongly from a gender-matching supervisor.

4 Data and methods

4.1 Data and measures

We use data from the 'German National Academics Panel Study (Nacaps)' on a recent cohort of doctoral candidates that were registered for doctoral studies in December 2018 at German higher education institutions (Briedis et al. 2020, Briedis et al. 2022).[1] The data of this initial cohort 2018 comprises all doctoral subjects, different forms of doctorate—e.g., being employed at a university or a research institution, getting a grant—and different stages, from just registered through to almost finished. Within the entire study design, this cohort is an exception as it presents a cross-section of all doctoral candidates registered as of 1st December 2018. A follow-up cohort was interviewed two years later; the Nacaps cohort 2020, however, only considers those doctoral candidates that had been newly registered in the interceding two years. Generally, Nacaps is designed as a multi-cohort panel study including multiple measurement points for each respondent in a given cohort (for more details see Briedis et al. 2022).

1 The scientific use file of Nacaps 2018, first wave, is available via the Research Data Centre of the German Centre for Higher Education Research and Science Studies (FDZ-DZHW): Adrian, D., Ambrasat, J., Briedis, K., Friedrich, C., Fuchs, A., Geils, M., Kovalova, I., Lange, J., Lietz, A., Martens, B., Redeke, S., Ruß, U., Sarcletti, A., Schwabe, U., Seifert, M., Siegel, M., Teichmann, C., Tesch, J., de Vogel, S. & Wegner, A. (2020). National Academics Panel Study (Nacaps) 2018. Datenerhebung: 2019. Version: 1.0.0. Datenpaketzugangsweg: On-Site-SUF. Hannover: FDZ-DZHW. Datenkuratierung: Weber, A., Birkelbach, R., Hoffstätter, U. & Daniel, A. https://doi.org/10.21249/DZHW:nac2018:1.0.0.

We only consider the first wave of Nacaps cohort 2018, because of the overall high number of observations—information on more than 20,000 respondents—which allows field-specific analyses (for details see Tables 3 and 4). As has been highlighted in the section on previous work, findings quite strongly differ by field of study. Together with the overall lack of empirical evidence for Germany, we therefore see the strongest contribution of our study to be in describing the phenomenon in as much detail as possible by also taking issues of self-selection into supervisor relationships and doctoral contexts into account.

Moreover, detailed analyses on data quality, for the representation side in particular, are available for this first wave of Nacaps cohort 2018 (Briedis et al. 2022). By design, Nacaps is a complete enumeration of registered doctoral candidates at all German higher education institutions that are legally allowed to award doctoral degrees. In order to be comparable with official statistics, the date of reference for sampling is 1st December of the corresponding year (HstatG § 5). In practice, however, there exists no official register for doctoral candidates in Germany. Thus, higher education institutions function as important gatekeepers for field access by contacting the target population. One result of these conditions in Germany is that coverage bias due to non-participation in the study can occur on two levels: The level of higher education institutions (comparable to primary sampling unit) and the level of doctoral candidates (comparable to secondary sampling unit). On the level of higher education institutions, larger higher education institutions are more likely to participate in the Nacaps study, whereas higher education institutions in East Germany and special types like church-sponsored higher education institutions and colleges of the arts are less likely to participate (for more details see Briedis et al. 2022). This coverage bias on the primary sampling unit does, however, not affect our analyses as long as respondents' gender and their field of study do not systematically vary from the entire population (secondary sampling unit). Indeed, comparisons with official statistics for registered doctoral candidates provided by the Federal Statistical Office indicate no systematic bias by gender and field of study due to unit-nonresponse at the level of doctoral candidates (Briedis et al. 2022, Vollmar 2019). Thus, we argue that results based on Nacaps can largely be generalized to the German population of doctoral students, although a complete enumeration as proposed by design has not been realized. Beyond this, Nacaps is unique as it provides current information on the situation of doctoral students in Germany.

For our analyses, we exclude from the entire sample those respondents stating that they have dropped out of doctoral studies at the time of the interview.[2] However, we have included those who reported only a temporary interruption. Most important for our purpose, we have information in the dataset on students' and main advisors' genders, so that we can model 'gender match' for each respondent. After

2 For purposes of transparency, our replication files can be found here: https://doi.org/10.21249/DZHW:muehleck2023:1.0.0.

listwise deletion on analytical variables, we ended up with a sample for our main analyses of 15,350 respondents from 53 German higher education institutions.[3]

Dependent Variables

We focus on three outcome variables as indicators for success during doctoral studies: (1) satisfaction with mentoring, (2) belief in one's own research abilities and (3) career prospects of obtaining a postdoc position after completing the doctorate. In this way, we cover different dimensions: Doctoral students' satisfaction with the supervision can be assumed to be strongly related to the overall satisfaction with the doctorate and thus with motivation to successfully complete the doctorate. Academic self-efficacy seems to be another important ingredient for an academic career as it is the belief that one holds the necessary abilities and talents. The perceived career prospects in academia, finally, can be assumed to be another important factor for motivating the successful candidate as they measure the belief of being able to further pursue an academic career after the doctorate. From a theoretical perspective all these three outcome variables can be assumed to be positively influenced by a gender-matching supervisor.

Table 1 shows the measurement as well as the means and standard deviations (SD) for our three outcomes.

On average, doctoral students are rather satisfied than dissatisfied with the supervision of their supervisors. The mean value of 3.73 is clearly above the neutral value of 3 and therefore on the positive side of the scale but also clearly below the value of 5 which would indicate being very satisfied.[4] With respect to group differences, some interesting results can be reported. Please note that all group differences in Table 1 are highly significant. First, male doctoral students are slightly more satisfied with mentoring than their female peers. The difference is far from dramatic but still highly significant. When comparing students with and without a gender-matching supervisor, we observe that, as expected, doctoral students with a gender-matching supervisor are more satisfied with supervision. A similar pattern emerges for the belief in one's own research abilities. Female doctoral students are less confident about their research abilities and, likewise, doctoral students with a supervisor of a different gender have slightly lower academic self-efficacy. As we will see below, women are more likely to have a supervisor of a different gender. Female doctoral students are more skeptical regarding their chances of becoming a postdoc then their male peers. For this dependent variable the gender differences

3 This way of handling missing data results in a reduced analytical sample; about 5,800 cases out of 21,100 are excluded from the entire analyses. However, we expect no systematic bias in results due to this procedure.

4 It might be that those doctoral candidates being less satisfied with their supervision or their situation during doctoral studies in general have not taken part in the survey at all. However, we cannot provide empirical evidence for this selectivity due to unit nonresponse on the level of doctoral candidates.

Table 1: Measurement and descriptive results for outcome variables

Dependent variable		Measurement and descriptives			
Satisfaction with mentoring		"How satisfied are you ... with the supervision of your PhD/ doctorate by your supervisor?", 5-point Likert scale: (1) "not at all satisfied", ..., (5) "very satisfied"			
	All	Male	Female	Gender-match	No gender-match
Mean	3.73	3.77	3.68	3.76	3.67
SD	1.18	1.16	1.20	1.17	1.20
Belief in own research abilities		"I have the necessary skills for a job in academia.", 5-point Likert scale: (1) "not at all certain", ..., (5) "very certain"			
	All	Male	Female	Gender-match	No gender-match
Mean	3.67	3.77	3.60	3.70	3.60
SD	1.07	1.02	1.11	1.05	1.09
Career prospects of obtaining a postdoc position		"How easy would it be for you personally to get ... a post-doc position in academia?", 10-point Likert scale: (1) "very difficult", ..., (10) "very easy"			
	All	Male	Female	Gender-match	No gender-match
Mean	4.90	5.21	4.57	5.00	4.67
SD	2.85	2.85	2.81	2.82	2.79

Source: Nacaps 2018, first wave. Own calculations. N = 15,350.
Note: All reported differences between groups are significant at $p<0.001$.

are somewhat stronger than for the other two variables (also taking into account the different scale). And, again confirming the familiar pattern, we find that students with a gender-matching supervisor evaluate their chances more optimistically.

All in all, these descriptive results show, that (1) women score less well on all three outcome variables, i.e., they could be among the factors explaining why women are more likely to drop out of an academic career. (2) Doctoral candidates with a gender-match score better on all three outcome variables, suggesting that this might indeed be a way to foster the academic career prospects of female doctoral candidates. Below we will test whether the multivariate models confirm this first descriptive impression.

Core Independent Variable

Our core independent variable is a dummy variable for a gender match indicating whether doctoral candidates' gender equals supervisors' gender. Following the Nacaps-specific concept of 'main supervisor', for male Ph.D. students this dummy equals 1 if their (main) supervisor is a man, respectively for female Ph.D. candidates, if their (main) supervisor is a woman. As Nacaps data provides detailed information on up to three different doctoral supervisors and advisors, we defined 'gender match' based on the answer to the question 'Who is your main supervisor?'[5] According to the instruction in the questionnaire, this means the person who supervises your work in everyday life most intensively. This is not necessarily the same person who officially supervises the doctorate (in the sense of first supervisor respectively first reviewer of doctoral thesis). Reflecting typical German doctoral studies, for 63 percent of our analytical sample, however, the self-reported main supervisor equals the first reviewer of the thesis.

4.2 Analytical strategy

We are interested in the effect of a gender match between doctoral candidate and (main) supervisor on success during doctoral studies. Identifying this effect is complicated by the fact that assignment into matched or unmatched gender relationships during doctoral studies is *not random*. Students with and without a gender match may have differed systematically in characteristics relevant for our outcome variables *prior* to (self-)selection into gender-matched supervisory relationships. Claiming causality in 'simple' regression models based on cross-sectional data might therefore be misleading. We neither know all factors that account for (self-)selection into gender-matched supervisory relationships nor have we measured all factors that could be relevant.

However, entropy balancing offers a way to at least partially account for *pre-treatment* differences in the treatment and the control group also using cross-sectional data. Entropy balancing is a reweighting method for balanced samples (Hainmueller 2012, Hainmueller/Xu 2013). We are interested in the 'average treatment effect (ATE)' for doctoral candidates with the same gender as their (main) supervisor on success during doctoral studies. Thus, our treatment variable, gender match, is binary. Following the entropy balancing approach, we design a synthetic control group, those whose gender is not matched, on the basis of a wide range of observables that are in the data. Based on these observed characteristics, the control group is weighted with the purpose of being comparable to the treatment group. For designing the control group, we use all available information that captures differences between both groups *before* registering as doctoral students (see Table 2). To account for ascribed and further socio-demographic characteristics, we control for age, migration and social background, stable relationship, partner's education and employment as well as children. Further, we include self-rated health (Carstensen 2020, GESIS 2015) and personality traits such as Big Five (Schupp/

5 Further details on this specific question can be found here: https://metadata.fdz.dzhw.eu/en/questions/que-nac2018-ins1-B30.1?page=1&size=10&type=surveys&version=1.0.0. Last accessed: 21.3.2022.

Gerlitz 2014), general self-efficacy (Beierlein et al. 2012) and locus of control (Kovaleva et al. 2012). And finally, we consider grade-point average of higher education degree that allows for doctoral studies, doctoral subject (differentiating between STEM, biology, medicine, social sciences and arts),[6] form of doctorate (differentiating between employment at higher education institution or research institute, structured doctoral program and grant or free/external doctorate), reasons for obtaining a doctoral certificate, reasons that the respective higher education institution has been chosen and the desired characteristics of a job after completing the doctorate (Roach/Sauermann 2010).

As suggested by the literature, we use exactly this information as additional control variables in order to increase the precision of coefficient estimates in our subsequent analyses (Oster 2019). To be transparent on our estimation approach, we present the results for four different estimation strategies for each outcome variable in the appendix: (1) 'naïve' regression coefficient without balancing and without controls, (2) with control variables, but without balancing weights, (3) with balancing weights, but without control variables, and finally (4) with control variables and with balancing weights. From a methodological perspective, these comparisons of different estimation strategies give interesting insights into the deviation of point estimates by neglecting important factors as well as the quality of entropy balancing. As a rule of thumb, the entropy balancing has been successful; the closer point estimates are by comparing models with and without control variables (Oster 2019). As we strongly believe in providing the 'best' results using the fourth estimation strategy, combining entropy balancing with control variables, we only present these results for our three outcome variables in the main text.

As our outcome variables are measured on symmetric Likert scales with 5 or 11 points respectively, we run linear regression models. To test our theoretical hypotheses (compare chapter 3), we are mainly interested in two coefficients: (1) the direct effect of gender-matching on success during doctoral studies (ATE), and (2) the interaction of gender-matching with gender, and thus heterogeneity of effects. For each outcome, we report results for the whole sample in a first step as well as for subject-specific analyses in a second step. Results for the relations of interest are presented as coefficient plots (Jann 2014).[7]

With our analytical approach, we account for selectivity into treatment for the purpose of causal reasoning. However, we cannot completely refute the objection of selection by unobserved characteristics even considering a wide set of covariates.

6 When defining groups for doctoral subject, we considered the share of female doctoral candidates as well as the number of supervisors. We have separated biology from the other sciences that are combined with the other STEM fields. We did so due to the strong difference in the gender composition of biology as opposed to the other sciences and as we suspect that the gender composition in a field of study moderates how the gender match impacts on outcome variables.

7 Regression tables are provided in appendix 2.

One might think of other factors influencing a gender match as well as outcome variables that we have not measured, e.g., supervisor's reputation within the scientific community. However, our coefficient estimates are closer to the 'true causal effect' than are 'simple' regression results (also compare Figures A1-A3 in the appendix). Moreover, choosing balancing variables has forced us to think about control variables in more sophisticated way.

Table 2: Variables used to balance the control group

Variable	Measurement/Operationalization
	Ascribed characteristics
Respondent is female	Binary, yes = 1, no = 0
Match of gender of respondent and supervisor	Binary, yes = 1, no = 0
Age	Continous, age in years
Father's level of education	Categorical, 3 categories (higher education degree, doctorate; reference category: no higher education degree)
Mother's level of education	Categorical, 3 categories (higher education degree, doctorate; reference category: no higher education degree)
Respondent born outside Germany	Binary, yes = 1, no = 0
Father born outside Germany	Binary, yes = 1, no = 0
Mother born outside Germany	Binary, yes = 1, no = 0
	Characteristics of doctorate
Doctoral subject	Categorical, 6 categories (arts and humanities, biology, medicine, stem, others; reference category: social sciences)
Form of doctorate	Categorical, 3 categories (program and scholarship, free/external; reference category: appointment)
Grade point average at master's level	Continous, according to the German grading system: 1.0 – 4.0
	Socio-demografic characteristics
Children	Binary, yes = 1, no = 0
Partner/Stable relationship	Binary, yes = 1, no = 0
Partner's level of education	Categorical, 3 categories (no or occupational training, doctorate; reference category: higher education degree)
Partner's employment status	Categorical, 4 categories (part-time or other employment status, training or parental leave, not employed; reference category: full-time employment)
Partner not employed in academia	Binary, yes = 1, no = 0

Variable	Measurement/Operationalization
Health and personality traits	
Health (self-rated)	Categorical, 5 categories (ranging from "very bad" to "very good")
Risk-taking	Categorical, 7 categories (ranging from "not at all willing to take risks" to "very willing to take risks")
Locus of control	Factor variable, 2 factors (internal and external)
Self-efficacy Personality traits as Big Five	Factor variable, 5 factors (extraversion, neuroticism, openness, conscientiousness, agreeableness)
Individual attitudes	
Goals for doctorate	Binary, yes = 1, no = 0 (9 items: interest, contribution to scientific progress, common in discipline, social environment's expectations, nothing else came along, work in academia permanently, solving societal problems, reputation, career prospects outside academia)
Importance of job characteristics after doctorate	Binary, yes = 1, no = 0 (11 items: managerial responsibility, compatibility of work and family, availability of resources, opportunities for advancement, societal recognition, job security, societal benefits of work, salary level, autonomy in decision-making, working in a team, intellectual challenge)
Reasons to choose higher education institution	Binary, yes = 1, no = 0 (7 items: location, good research conditions, supervisor, university's reputation, attractive services for doctoral candidates, just came about that way, others)

5 Results

5.1 How widespread is a gender match between doctoral students and supervisors?

To begin with, our data show that a gender match between student and supervisor is more prevalent than a non-gender-match (see Table 3). Generally, the share of male supervisors among all supervisors is an astounding 75 percent. Accordingly, only a quarter of all supervisors are female. For male doctoral students the share of male supervisors is even larger and at 82 percent. In contrast, the share of female supervisors is disproportionally larger among female doctoral students and reaches one third. As argued before, this may indicate a preference of doctoral students for gender-matching supervisors. Note, however, that we cannot test to what extent this result is driven by preferences of students or by preferences of supervisors.

Table 3: Proportions of gender-matching between doctoral students and supervisors (Absolute and relative numbers)

		Supervisor		
		Male	Female	**Total**
Doctoral Student	Male	6,745 (82.36)	1,445 (17.64)	8,190 (100.00)
		(58.52)	*(37.76)*	*(53.35)*
	Female	4,778 (66.73)	2,382 (33.27)	7,160 (100.00)
		(41.48)	*(62.24)*	*(46.65)*
	Total	11,523 (75.07)	3,827 (24.93)	15,350 (100.00)
		(100.00)	*(100.00)*	*(100.00)*

Pearson chi2(1) = 498,3151 Pr = 0,000.

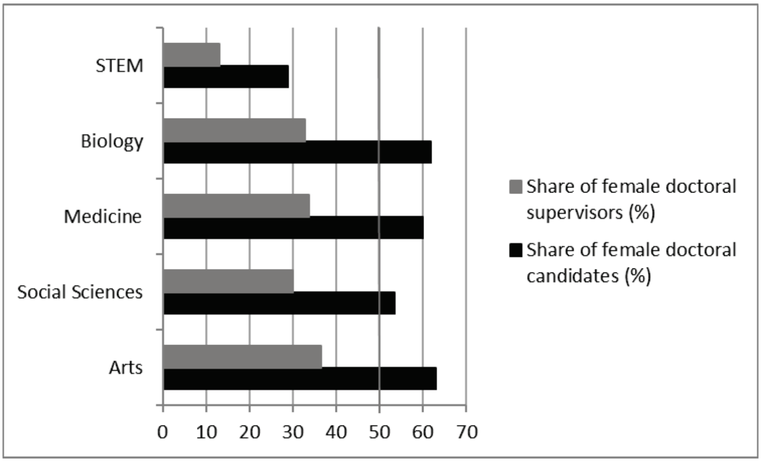
Source: Nacaps 2018, first wave. Own calculations. N = 15,350.
Note: Row percentages in parentheses, *column percentages* in parentheses and italics.

Due to the generally larger share of male supervisors, female doctoral candidates are much less likely to be matched in terms of supervisors' gender than are male doctoral candidates. Figure 1 shows another interesting result: While women are strongly underrepresented among supervisors, the gender ratio among doctoral candidates almost reaches parity (47 percent females and 53 percent males).

Of course, the relatively larger share of female doctoral students with female supervisors—or male doctoral students with male supervisors respectively—could also be due to differences in the gender composition of supervisors across subjects, i.e., due to opportunities rather than preferences. Therefore, in the next step, we look at subject differences (Figure 1, Table 4).

Not surprisingly, the share of female doctoral candidates and also female supervisors differs substantially across subjects. As displayed in Figure 1, both shares are lowest in STEM fields, and highest in biology, medicine and arts. For the latter subjects, the proportion of women among doctoral students is 60 percent or more, thus clearly crossing the line that indicates gender parity. In contrast, even in subjects with a comparatively high proportion of female supervisors, the share is far from reflecting gender parity. Biology differs considerably in the gender composition of both students and supervisors. Therefore, we look at biology separately from the other STEM fields, which are more homogeneous in this respect.

Figure 1: Proportion of female doctoral students and female supervisors across subjects

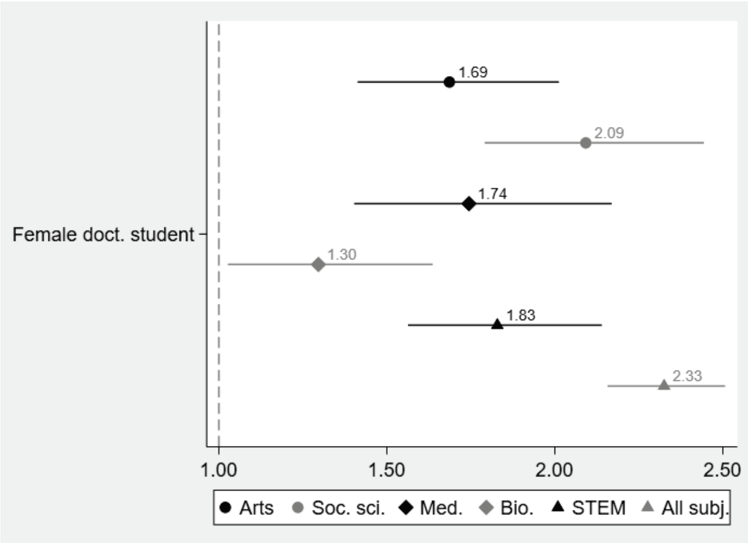


Source: Nacaps 2018, first wave. Own calculations. N = 15,350.

From a perspective of demand and supply, it could be that the observed tendency of male students having male supervisors and female students having female supervisors is primarily driven by the supply of supervisors of the respective gender in the different fields. But the results of Table 4 show that the pattern observed in Table 3 also holds across subjects. In all fields of study, the share of male doctoral students with a male supervisor exceeds the overall proportion of male supervisors and likewise the share of female doctoral students with a female supervisor exceeds the overall proportion of female supervisors. However, there are slight differences across subjects and the overall pattern is somewhat mitigated when taking on a subject-specific perspective.

To check how the pattern varies, we compared the chance of attaining a female supervisor for female and male doctoral students by running bivariate logistic regressions with gender of the doctoral student as explanatory variable. Figure 2 shows the odds ratios for all doctoral students and by subject. All odds ratios are above 1 and statistically significant, i.e., the chances of female doctoral students having a female supervisor are greater than those for male doctoral students. Generally, the chances of a female doctoral student having a female supervisor are 2.33 times higher than the chances of a male doctoral student having a female supervisor. The odds ratios vary to some extent across subjects with social sciences showing the largest odds ratio (2.09) and biology the lowest (1.30). The difference between these two subjects is statistically significant but the other differences between subjects are not.

Figure 2: Odds ratio of having a female supervisor by field of study (Coefficient plots from logistic regressions for being a female doctoral student)



Source: Nacaps 2018, first wave. Own calculations. N = 15,333.
Note: Regression results are available on request.

Note that, due to the different 'supply' of female or male supervisors across subjects, the proportions of doctoral students with a gender-matching supervisor vary (Table 4). In STEM fields, for example, nearly 90 percent of male doctoral candidates are matched; however, only about one fifth of female doctoral candidates are matched. Biology is the exception among the natural sciences; for more than 70 percent of the male doctoral students and about one third of the female doctoral students, the gender of the supervisor equals that of the doctoral candidate. The figures for medicine and social sciences are quite similar. With more than 40 percent matched female doctoral candidates, arts has the highest share of female doctoral students with a gender-matching supervisor, obviously due to the highest share of female professors.

Summing up, male doctoral students are more likely to have a supervisor of the same gender while female doctoral students are more likely to have a supervisor of a different gender. But considering the overall gender distribution of supervisors, the likelihood of having a supervisor of the same gender is disproportionally higher for both male and female candidates. This can be shown in an overall perspective and also, with minor differences between subjects, in subject-specific perspective. Thus, hypothesis 1a is confirmed with recent data for Germany. Hypothesis 1b suggested a specifically strong overrepresentation of a gender match for female candidates in male-dominated subjects. The STEM fields would be an example of a male-dominated field. Biology would be an example of a natural science with a relatively large proportion of women among supervisors and candidates. While indeed the odds ratio in Figure 2 is relatively small for biology and differs significantly from the social sciences it does not differ significantly from STEM. In fact, the odds ratio for the STEM fields does not differ significantly from any other field. Thus, our results do not confirm hypothesis 1b.

Table 4: Proportions of gender-matching between doctoral students and supervisors across different subjects (Absolute and relative numbers)

STEM

		Supervisor		
		Male	Female	**Total**
Doctoral Student	Male	3,850 (89.10) *(73.98)*	471 (10.90) *(60.85)*	4,321 (100.00) *(72.28)*
	Female	1,354 (81.71) *(26.02)*	303 (18.29) *(39.15)*	1,657 (100.00) *(27.72)*
	Total	5,204 (87.05) *(100.00)*	774 (12.95) *(100.00)*	5,978 (100.00) *(100.00)*

Pearson chi2(1) = 57,9669 Pr = 0,000.

Source: Nacaps 2018, first wave. Own calculations. N = 5,978.
Note: Row percentages in parentheses, *column percentages* in parentheses and italics.

Biology

		Supervisor		
		Male	Female	**Total**
Doctoral Student	Male	403 (72.09) *(41.42)*	156 (27.91) *(35.29)*	559 (100.00) *(35.51)*
	Female	570 (66.59) *(58.58)*	286 (33.41) *(64.71)*	856 (100.00) *(60.49)*
	Total	973 (68.76) *(100.00)*	441 (31.24) *(100.00)*	1,415 (100.00) *(100.00)*

Pearson chi2(1) = 4,7698 Pr = 0,029.

Source: Nacaps 2018, first wave Own calculations. N = 1,415.
Note: Row percentages in parentheses, *column percentages* in parentheses and italics.

Medicine

		Supervisor		
		Male	Female	**Total**
Doctoral Student	Male	497 (74.51) *(54.31)*	170 (27.91) *(32.20)*	667 (100.00) *(41.05)*
	Female	600 (62.57) *(54.69)*	359 (33.41) *(67.80)*	959 (100.00) *(58.95)*
	Total	1,097 (67.47) *(100.00)*	529 (31.24) *(100.00)*	1,626 (100.00) *(100.00)*

Pearson chi2(1) = 25,8536 Pr = 0,000.

Source: Nacaps 2018, first wave. Own calculations. N = 1,626.
Note: Row percentages in parentheses, *column percentages* in parentheses and italics.

Social Sciences

		Supervisor		
		Male	Female	**Total**
Doctoral Student	Male	1,197 (78.08) *(51.58)*	336 (21.92) *(33.98)*	1,533 (100.00) *(46.50)*
	Female	1,110 (63.00) *(48.15)*	652 (37.00) *(66.02)*	1,762 (100.00) *(53.50)*
	Total	2,307 (70.02) *(100.00)*	988 (29.98) *(100.00)*	3,295 (100.00) *(100.00)*

Pearson chi2(1) = 88,8636 Pr = 0,000.

Source: Nacaps 2018, first wave. Own calculations. N = 3,295.
Note: Row percentages in parentheses, *column percentages* in parentheses and italics.

Arts

		Supervisor Male	Female	**Total**
Doctoral Student	Male	644 (71.24) *(41.62)*	260 (28.76) *(29.71)*	904 (100.00) *(37.31)*
	Female	903 (59.49) *(58.38)*	615 (40.51) *(70.29)*	1,518 (100.00) *(62.69)*
	Total	1,547 (63.87) *(100.00)*	875 (36.13) *(100.00)*	2,422 (100.00) *(100.00)*

Pearson chi2(1) = 4,7698 Pr = 0,029.

Source: Nacaps 2018, first wave. Own calculations. N = 2,422.
Note: Row percentages in parentheses, *column percentages* in parentheses and italics.

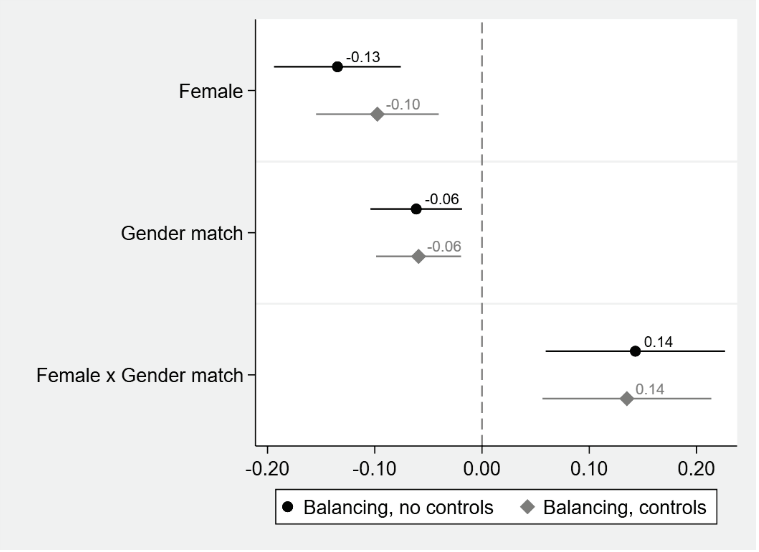
5.2 *Is gender-matching beneficial for doctoral studies?*

We now turn to the analytic modeling of our three dependent variables. If a gender match of students and supervisors has a positive effect on these dependent variables, as theory suggests, this would indicate that academic careers of women, or men, would benefit from a gender match.

5.2.1 Satisfaction with mentoring

Firstly, we look at the effect of a gender match on satisfaction with mentoring (Figure 3). The conditional main effect of being female is negative, i.e., compared to their male counterparts female doctoral candidates are less satisfied with mentoring. The main effect of gender matching is also negative. Note, that due to the interaction term and male students being the reference group, this is the effect of a gender match for male doctoral students. In other words, male doctoral students with a male supervisor are less satisfied with mentoring than are male doctoral students with a female supervisor. In contrast, female doctoral students with a gender match, i.e., with a female supervisor, are more satisfied than their female peers with a male supervisor, as shown by the positive interaction effect. The size of the positive effect of a female supervisor almost exactly compensates the generally lower level of satisfaction among female doctoral students.

Figure 3: Satisfaction with mentoring (Coefficient plots from linear regression)

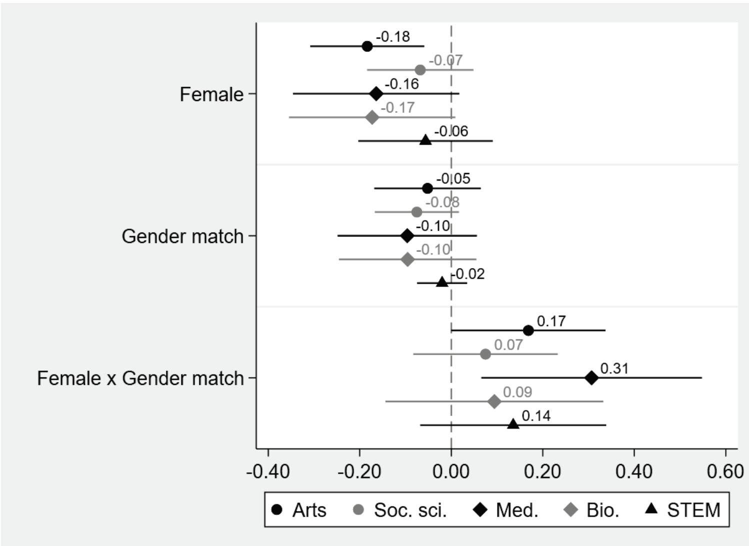


Source: Nacaps 2018, first wave. Own calculations. N = 15,333.
Note: Plot of regression coefficients for main effects of gender, gender match and interaction effect of models without control variables and with control variables. For control variables see Table 2 above. Table with full regression coefficients is provided in the appendix 2 in Table A1, models 1a and 1b.

Reconsidering our second hypothesis on a positive effect of gender-matching supervisors, results are therefore mixed. For female students, the gender match indeed has a positive effect on satisfaction; however, this is not the case for male students. This means that doctoral students with female supervisors are generally more satisfied with mentoring, irrespective of their own gender, even though this positive effect seems to be somewhat stronger in absolute terms for female students.

As a quality check, we compare the coefficients for regression models with and without control variables. We find coefficient estimates to be very similar. This is what we expect when applying entropy-balancing weights and may also be taken as a sign that the entropy balancing works well (Oster 2019). With controls, confidence intervals are slightly smaller.

Figure 4: Satisfaction with mentoring – by subject (Coefficient plots from linear regression)



Source: Nacaps 2018, first wave. Own calculations. N = 15,333.
Note: Plot of regression coefficients for main effects of gender, gender match and interaction effect of models for five groups of subjects. Model specification: with entropy balancing and controls. For control variables see Table 2 above. Table with full regression coefficients is provided in the appendix 2 in Table A2.

In Figure A1 in the appendix 1, we compare coefficients with and without entropy balancing yielding a methodologically interesting result: While point estimates do not differ strongly, confidence intervals are clearly smaller when applying entropy balancing weights. The latter lead to more efficient estimates and in fact, without the entropy balancing we would not have accepted the coefficient of the gender-match dummy as statistically significant.

Looking at subject-specific differences, the picture becomes less clear (see Figure 4). Except for the conditional main effect of female doctoral students in arts and the interaction effect between female doctoral candidates in medicine and with a gender match, all coefficient estimates are statistically insignificant. Considerably larger confidence intervals indicate uncertainty in estimation, even though numbers of respondents are not particularly small, ranging from 1,415 in biology to 5,978 in the STEM fields. Above, we formulated two conflicting subject-specific expectations. Hypothesis 5a suggested that the positive effect of a gender match would be particularly strong in male-dominated fields while hypotheses 5b suggested a particularly strong positive effect in fields with relatively low proportions of men. Our results confirm neither hypothesis 5a nor hypothesis 5b. Rather, for doctoral students in Germany the subject as a context does not seem to make a major difference for the effect of a gender-matching supervisor on satisfaction with mentoring.

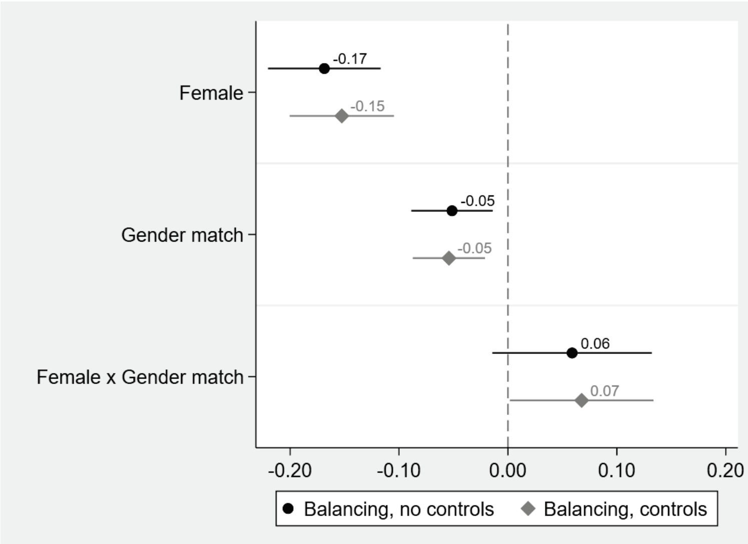
5.2.2 Belief in own research abilities

The belief in one's own research abilities is likely to be an important resource for successfully traveling the sometimes rocky road of a doctorate and an academic career in general. As Figure 5 shows, female doctoral students are significantly less well equipped with this resource and are more skeptical about their research abilities than their male peers. Does a gender-matching supervisor help to boost academic self-efficacy?

Results in Figure 5 resemble the pattern already observed for satisfaction with mentoring. There is no general positive effect of a gender match between students and supervisors. The main effect is negative, i.e., male doctoral students with a male supervisor believe somewhat less in their research abilities. For female students, though, we observe a positive interaction effect. With respect to hypothesis 3 the result is therefore mixed again and depends on the gender of doctoral students. A gender match helps only if the student is female. Putting it differently, female supervisors strengthen the academic self-efficacy of their doctoral students as compared to male supervisors. This effect does not fully compensate the lower academic self-efficacy of female doctoral students but helps to mitigate it.

Comparing estimates with and without controls we again find point estimates and confidence intervals to be quite similar. However, estimates are slightly more efficient with control variables and reveal a statistically significant interaction effect. Figure A2 in the appendix 1 provides the results for models without the entropy-balancing weights. Again, it is interesting to see that we would have overlooked several statistically significant point estimates without the entropy balancing.

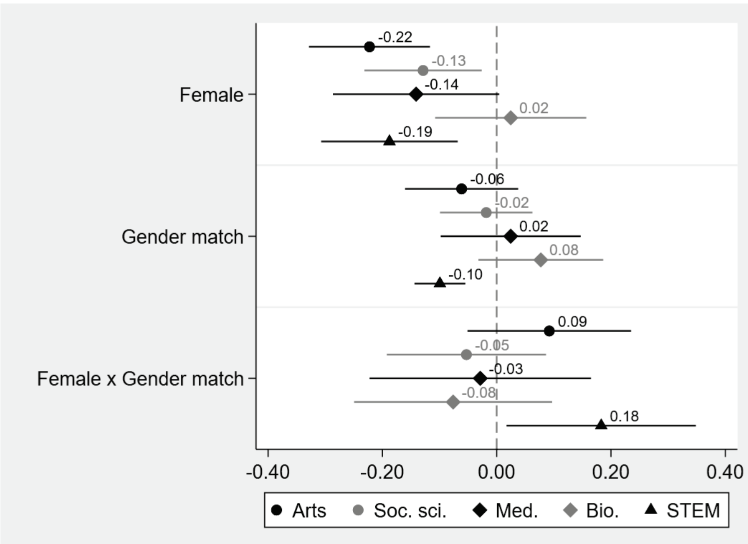
Figure 5: Belief in own research abilities (Coefficient plots from linear regression)



Source: Nacaps 2018, first wave. Own calculations. N = 15,280.
Note: Plot of regression coefficients for main effects of gender, gender match and interaction effect of models without control variables and with control variables. For control variables see Table 2 above. Table with full regression coefficients is provided in the appendix 2 in Table A1, models 2a and 2b.

Findings of subject-specific models show a more complex picture (see Figure 6). For three groups of subjects (arts, social sciences, and STEM) we find that female doctoral students have significantly lower levels of academic self-efficacy—as in the overall analysis. For the main effect of the gender match and the interaction, significant effects are only observed for the largest field of study, i.e., STEM. For the latter, beliefs in own research abilities are negatively affected by a gender matching, i.e., male doctoral students are less confident in their research abilities if supervised by a male mentor. This negative effect turns into the opposite if female doctoral candidates are supervised by women in STEM fields, which is in line with previous findings (Bettinger/Long 2005). For all other subjects, neither the main effects of a gender match nor the interaction terms are statistically significant. Thus the overall picture seems to be dominated by the pattern to be observed for the STEM fields. The pattern for arts is very similar, even though the main effect of a gender match and the interaction effect are not statistically significant with the given statistical power. Remarkably, these results do not support theoretical considerations about the share of female doctoral students as a relevant context condition as similar patterns are observed for the subject groups with the lowest and with the highest shares of female doctoral students and supervisors. The relatively large positive interaction-effect in the STEM fields could be seen as supporting hypothesis 5, that suggested a relatively strong effect for male-dominated fields. But as coefficients of the different subjects overlap, the results support neither hypothesis 5a nor hypothesis 5b.

Figure 6: Belief in own research abilities – by subject (Coefficient plots from linear regression)



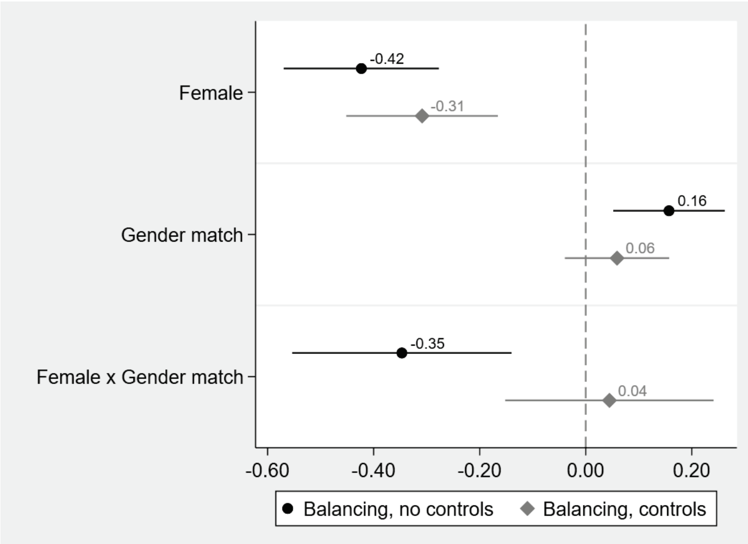
Source: Nacaps 2018, first wave. Own calculations. N = 15,280.
Note: Plot of regression coefficients for main effects of gender, gender match and interaction effect of models for five groups of subjects. Model specification: with entropy balancing and controls. For control variables see Table 2 above. Table with full regression coefficients is provided in the appendix 2 in Table A3.

5.2.3 Prospects for postdoc position

With respect to the perceived career prospects, we first need to acknowledge that results differ for the models with and without controls (see Figure A3 in the appendix 1). In either case, compared to their male peers, women are less optimistic about their chances of obtaining a post-doc position in academia. However, when applying controls, neither the main effect of a gender match in general nor the interaction effect significantly affects the perceived prospects for a postdoc position.

Interestingly enough, the results without controls seem to suggest the obverse gender match and interaction effect as for the satisfaction with mentoring and academic self-efficacy, i.e., a generally positive effect of a *male* supervisor for doctoral students of both genders. However, with controls, both effects are insignificant and thus we need to reject hypothesis 4a and hypothesis 4b.

Figure 7: Prospects for postdoc position (Coefficient plots from linear regression)

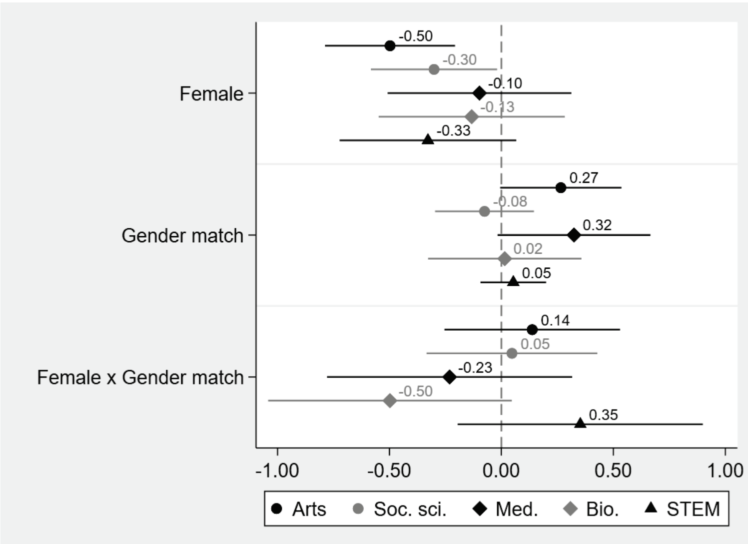


Source: Nacaps 2018, first wave. Own calculations. N = 14,915.
Note: Plot of regression coefficients for main effects of gender, gender match and interaction effect of models without control variables and with control variables. For control variables see Table 2 above. Table with full regression coefficients is provided in the appendix 2 in Table A1, models 3a and 3b.

As noted, we found relatively large differences in results with and without control variables (see Figure A3 in the appendix 1). The main gender effect and specifically the interaction term become insignificant when the control variables are included in the model. By stepwise regressions it was found that the interaction term becomes insignificant when the subjects are controlled for. With a good entropy-balancing model such differences between models with and without controls should not occur. While we must acknowledge that with the data at hand there is little we could do to improve the model, this may hint at weaknesses of the entropy-balancing model with regard to prospects for a postdoc position as dependent variable, i.e., results for this dependent variable should be interpreted with caution.

Subject-specific analyses show almost no significant effects (see Figure 8): As with the overall results, female doctoral students in arts and social sciences are less optimistic regarding their academic outlook. In line with the results for all subjects together, none of the conditional main effects of a gender match or of the interaction effects is statistically significant. Thus, again our results confirm neither hypothesis 5a nor hypothesis 5b.

Figure 8: Prospects for postdoc position – by subject (Coefficient plots from linear regression)



Source: Nacaps 2018, first wave. Own calculations. N = 14,915.
Note: Plot of regression coefficients for main effects of gender, gender match and interaction effect of models for five groups of subjects. Model specification: with entropy balancing and controls. For control variables see Table 2 above. Table with full regression coefficients is provided in the appendix 2 in Table A4.

6 Summary and discussion

In light of the 'leaky pipeline' phenomenon in the German science system, our contribution investigates (i) how widespread a gender match between doctoral student and supervisor is in Germany and (ii) whether a gender match of doctoral student and supervisor is beneficial for the doctorate and academic career prospects thereafter. To answer our two research questions, we draw on recent data from the 'German National Academics Panel Study (Nacaps)'.

Firstly, our analyses confirm a clear prevalence of gender-matching combinations between doctoral students and supervisors for both genders. This prevalence can be observed across all subject groups and is in line with previous findings mainly from the United States. Interestingly, even in subjects with a comparatively high proportion of female supervisors, the share is far from reflecting gender parity. Based on tokenism theory we suspected an especially strong overrepresentation of gender matches for female doctoral students in male-dominated fields; in such fields of study, female doctoral students could be exposed to discrimination particularly strongly and seek to find a female supervisor to avoid this. However, this hypothesis is not confirmed.

Secondly, results show that female supervisors have the expected positive effect on satisfaction with mentoring and academic self-concept for female doctoral students. This result was suggested by theory and it seems intuitive that supervisors of the same gender are somewhat beneficial. Surprisingly and challenging to our intuition, female supervisors have this positive effect on male doctoral students as well. To some extent, the effect therefore seems to be rooted in the supervisors' gender rather than in the match between doctoral students' and supervisors' gender. Thus, our hypotheses 2 and 3 on the beneficial effect of a gender match are only confirmed for female doctoral students but not for their male peers.

Thirdly, we find no significant effect of a gender match regarding the perceived prospects for a postdoc position. Thus, our results confirm neither hypothesis 4a regarding a general positive effect of a gender-match nor hypothesis 4b regarding a negative effect for women.

Fourthly, no clear pattern can be identified with respect to differences between doctoral subjects. Applying tokenism theory and the identity-based motivation theory we suspected a specifically strong beneficial effect of the gender match in male-dominated fields, such as STEM (hypothesis 5a). Considering arguments of network theory, in contrast, it seems plausible to expect specifically strong beneficial effects of the gender match in fields with relatively high proportions of women. In other words, we assumed the proportion of women in the field to be an important moderating context variable. But coefficients differed by subjects only very rarely. An exception that could be mentioned is that for STEM fields we do find a significant positive effect of the gender match on academic self-efficacy but not for the other fields of study. This might indicate that the mechanisms suggested by tokenism theory and the identity-based motivation theory are at work but again the gender-match effect for women does not differ significantly across subjects. All in all, our results therefore confirm neither the systematic differences between fields of study suggested by tokenism theory nor the systematic differences between fields of study suggested by network theory. This finding may be somewhat unsatisfactory, but it also fits with the results for bachelor students in Ohio (Bettinger/Long 2005).

Finally, from a methodological point of view it is interesting that by applying entropy-balancing weights we arrive at more accurate and thus statistically significant estimates which would otherwise have been overlooked (see Figure A1 in the appendix). Our estimation strategy helps in dealing with the endogeneity problem and strengthens the claim made in the reviewed literature of interpreting findings in a causal way. However, we cannot be sure whether we fully solved this obvious endogeneity problem with our entropy-balancing model. There may be heterogeneities between treatment and control group that are not observed and therefore cannot be controlled for. The Nacaps data provides a huge set of observed characteristics (see Table 2). This leads us to be fairly confident about our results and their interpretation. As mentioned above, however, results on prospects for a postdoc position should be treated with some caution.

To the best of our knowledge, our contribution provides results for doctoral students in Germany for the first time. It uses recent available data and applies a sophisticated estimation strategy. Still a couple of limitations should be mentioned. These limitations offer potential for future research.

First of all, our data contains only doctoral students at an early stage of their academic careers. Even though our outcome variables are directed to further academic careers, we do not know who stays in academia after graduation from doctoral studies and which of those graduates will finally go on to a successful academic career. To answer these and similar questions for long-term effects of a gender-matching supervisor relationship during doctoral studies, we need longitudinal data capturing a time span of several years. Future waves of Nacaps offer an opportunity for longitudinal analyses.

With respect to theoretical explanations, *secondly*, the findings partly conflict with our assumptions and probably also with our intuition. Our results suggest that effects on the outcome variables are rather driven by the supervisor's gender than the gender match between doctoral students and their supervisors. Ultimately, the core question of *why* same-gender supervisors are beneficial for academic careers still remains open. For identifying the social mechanisms behind the gender-match effect (or the supervisor-gender effect), we need more information on supervisors than just gender. For example, to test whether male supervisors provide better access to influential academic networks, as proposed in hypothesis 4b, we need appropriate measures for network size and density or supervisor's reputation within the scientific community. As a forecast, some of these indicators are measured in subsequent waves of Nacaps.

A *third* point is directed to alternative estimation strategies. Instead of using entropy-balancing as a reweighting method to build a synthetic control group, one could think of matching procedures on the individual level like Coarsened Exact Matching (CEM, Blackwell et al. 2009, Iacus et al. 2012) or propensity score matching (Caliendo/Kopeinig 2008, Gangl 2010) to build statistical twins. However, as Hainmüller (2012) shows, entropy-balancing is not only easier to apply than propensity score matching and similar techniques but also yields better results. Generally, the problem with selection on unobservable variables is by design not solved with either of these estimation strategies.

Concerning possible implications of our findings for higher education policies, we would like to highlight that despite all limitations we have clear indications that 'women are helping women', as Hilmer and Hilmer (2007) had put it; i.e., policies striving to bring more women into leading academic positions and thus to further boost the prospects of women in academic careers seem to be on the right track.

Doctoral students with female advisors are more satisfied with mentoring and have are more confident in their academic abilities.

Interestingly enough, male doctoral students also seem to benefit from female supervisors. We are not fully sure how to interpret this finding. It could be that women differ in their mentoring intensity and style which could lead to more satisfaction and academic self-esteem among doctoral students. To some extent these findings seem to confirm gender stereotypes of more 'caring' female supervisors. While we cannot exclude that this is the case, there are alternative interpretations, e.g., in all likelihood, female supervisors are on average younger and at an earlier stage in their academic careers than male supervisors. This could impact on mentoring intensity and style as well, in that younger professors, whose doctoral studies were completed relatively recently, might better understand and be more open to the needs of doctoral students. Moreover, they might have more available time to care about their doctoral students and lower 'opportunity costs' due to having fewer doctoral students and fewer other obligations (and opportunities) in which to invest their time. These alternative explanations are linked to the question, who chooses whom? Are students choosing supervisors or are supervisors choosing students and what are the reasons for such decisions? In this sense, the gender match could also be an interesting outcome variable to be investigated.

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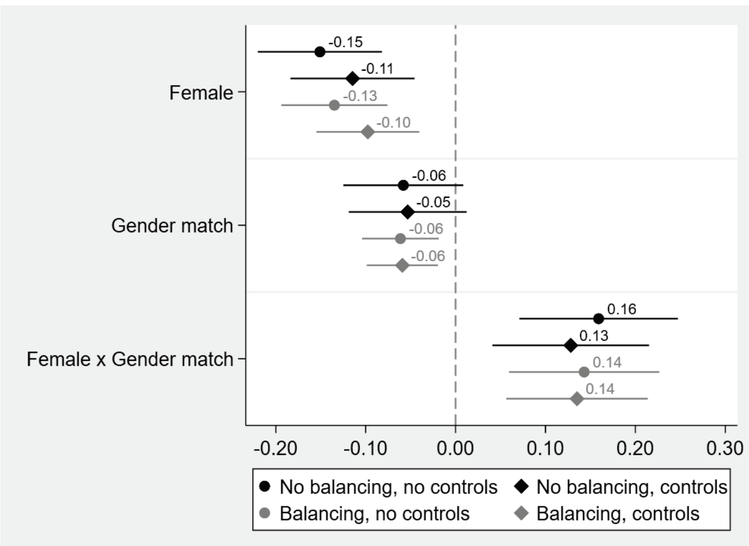
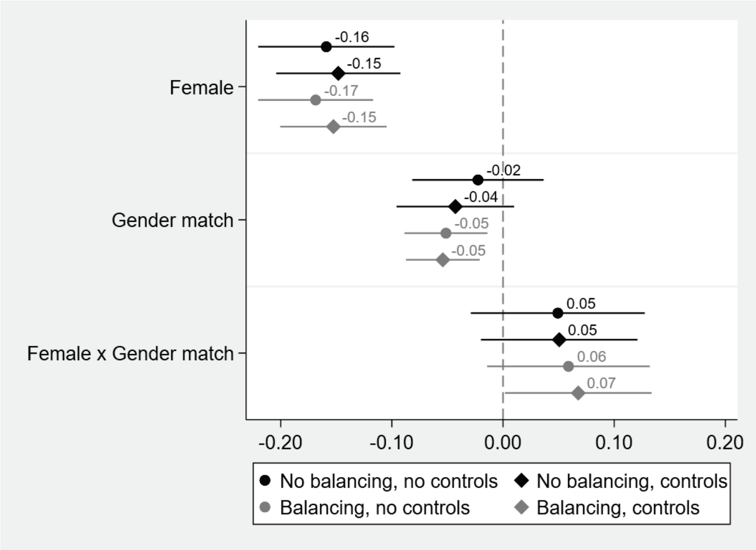
Appendix 1: Comparing estimation strategies

Figure A1: Satisfaction with mentoring – by estimation strategy



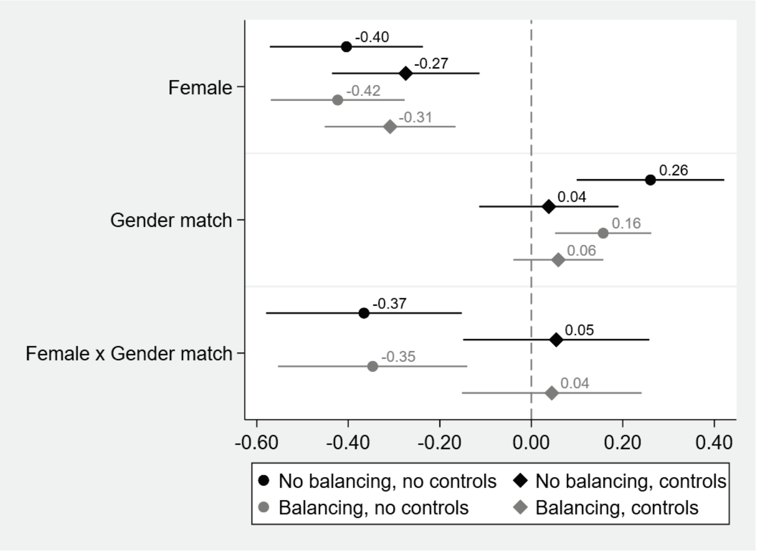
Source: Nacaps 2018, first wave. Own calculations. N = 15,333.
Note: Plot of regression coefficients for main effects of gender, gender match and interaction effect of model without entropy balancing weights and without control variables, without entropy balancing weights and with control variables, with entropy balancing weights and without control variables and with entropy balancing weights and with control variables. For control variables see Table 2 above.

Figure A2: Belief in own research abilities – by estimation strategy



Source: Nacaps 2018, first wave. Own calculations. N = 15,280.
Note: Plot of regression coefficients for main effects of gender, gender match and interaction effect of model without entropy balancing weights and without control variables, without entropy balancing weights and with control variables, with entropy balancing weights and without control variables and with entropy balancing weights and with control variables. For control variables see Table 2 above.

Figure A3: Prospects for postdoc position – by estimation strategy



Source: Nacaps 2018, first wave. Own calculations. N = 14,915.
Note: Plot of regression coefficients for main effects of gender, gender match and interaction effect of model without entropy-balancing weights and without control variables, without entropy-balancing weights and with control variables, with entropy-balancing weights and without control variables and with entropy-balancing weights and with control variables. For control variables see Table 2 above.

Appendix 2: Full regression models

Table A1: Satisfaction with mentoring, belief in own research abilities and prospects for postdoc position (Unstandardized coefficients from linear regression models)

	Satisfaction with mentoring		**Belief in own research abilities**		**Prospects for post-doc position**	
	M1a: Entropy balancing without controls	M1b: Entropy balancing with controls	M2a: Entropy balancing without controls	M2b: Entropy balancing with controls	M3a: Entropy balancing without controls	M3b: Entropy balancing with controls
Female (ref.: Male)	-0.13*** (0.03)	-0.10*** (0.03)	-0.17*** (0.03)	-0.15*** (0.02)	-0.42*** (0.07)	-0.31*** (0.07)
Gender match (ref.: No gender match)	-0.06** (0.02)	-0.06** (0.02)	-0.05** (0.02)	-0.05** (0.02)	0.16** (0.05)	0.06 (0.05)
Interaction: Female x gender match	0.14*** (0.04)	0.14*** (0.04)	0.06 (0.04)	0.07* (0.03)	-0.35** (0.11)	0.04 (0.10)
Ascribed and socio-demographic characteristics and characteristics of doctorate						
Age		-0.01*** (0.00)		0.00* (0.00)		-0.03*** (0.01)
Father: Higher education degree (ref.: Father: No higher education degree)		-0.07*** (0.02)		-0.04* (0.02)		0.08 (0.05)
Father: Doctoral degree		-0.05 (0.03)		-0.03 (0.03)		0.10 (0.08)
Mother: Higher Education degree (ref.: Mother: No higher education degree)		0.03 (0.02)		-0.02 (0.02)		0.13* (0.05)
Mother: Doctoral degree		0.04 (0.05)		0.04 (0.04)		0.00 (0.12)
Born abroad (ref.: Born in Germany)		0.08 (0.04)		0.03 (0.04)		-0.08 (0.11)
Father: Born abroad (ref.: Born in Germany)		-0.00 (0.04)		0.01 (0.03)		0.19 (0.10)
Mother: Born abroad (ref.: Born in Germany)		-0.03 (0.04)		0.05 (0.03)		-0.12 (0.10)
Arts & humanities (ref.: Social and behavioral sciences)		0.10** (0.03)		0.28*** (0.03)		-0.85*** (0.08)
Biology (ref.: Social and behavioral sciences)		-0.03 (0.04)		0.28*** (0.03)		0.94*** (0.10)

	Satisfaction with mentoring		Belief in own research abilities		Prospects for post-doc position	
	M1a: Entropy balancing without controls	M1b: Entropy balancing with controls	M2a: Entropy balancing without controls	M2b: Entropy balancing with controls	M3a: Entropy balancing without controls	M3b: Entropy balancing with controls
Medicine (ref.: Social and behavioral sciences)		0.07 (0.04)		-0.08** (0.03)		0.73*** (0.09)
STEM (ref.: Social and behavioral sciences)		-0.07** (0.03)		0.14*** (0.02)		0.74*** (0.06)
Other subjects (ref.: Social and behavioral sciences)		0.06 (0.05)		0.09* (0.04)		0.65*** (0.13)
Program/scholarship (ref.: Appointment		0.07*** (0.02)		-0.10*** (0.02)		-0.02 (0.05)
‘Free’ doctorate (ref.: Appointment)		-0.06* (0.03)		-0.37*** (0.02)		-0.80*** (0.07)
Final grade HE degree		-0.00 (0.02)		-0.21*** (0.02)		-0.58*** (0.05)
Child/children (ref.: No child/children)		0.05 (0.03)		0.01 (0.02)		0.01 (0.07)
Partner (ref.: No partner)		-0.18*** (0.03)		-0.01 (0.03)		0.26** (0.08)
Partner: Vocational training (ref.: Partner with higher education degree)		0.00 (0.03)		0.07** (0.02)		-0.06 (0.07)
Partner: Doctoral degree (ref.: Partner with higher education degree)		0.03 (0.03)		0.08** (0.03)		0.12 (0.09)
Partner: Part-time employed (ref.: Partner full-time employed)		0.09*** (0.03)		0.08*** (0.02)		-0.23*** (0.07)
Partner: In training or parental leave (ref.: Partner full-time employed)		0.03 (0.03)		-0.02 (0.03)		0.05 (0.08)
Partner: Not employed (ref.: Partner full-time employed)		0.20*** (0.04)		0.03 (0.03)		-0.23* (0.10)
Partner: Not in academia (ref.: Partner in academia)		0.07* (0.03)		-0.07** (0.02)		-0.19** (0.07)

	Satisfaction with mentoring		**Belief in own research abilities**		**Prospects for post-doc position**	
	M1a: Entropy balancing without controls	M1b: Entropy balancing with controls	M2a: Entropy balancing without controls	M2b: Entropy balancing with controls	M3a: Entropy balancing without controls	M3b: Entropy balancing with controls
Health and personality traits						
Health		0.08*** (0.01)		-0.04*** (0.01)		-0.04 (0.03)
Big5: Extraversion		-0.02 (0.01)		-0.04*** (0.01)		0.00 (0.03)
Big5: Neuroticism		-0.06*** (0.01)		-0.10*** (0.01)		-0.18*** (0.03)
Big5: Openness		-0.01 (0.01)		0.09*** (0.01)		0.12*** (0.03)
Big5: Conscientiousness		0.01 (0.01)		0.17*** (0.01)		0.01 (0.03)
Big5: Agreeableness		0.01 (0.01)		-0.04*** (0.01)		-0.06* (0.03)
Risk-taking		-0.02* (0.01)		-0.01 (0.01)		0.01 (0.02)
Control beliefs		0.16*** (0.01)		-0.00 (0.01)		0.21*** (0.03)
Self-efficacy		0.04** (0.01)		0.15*** (0.01)		0.22*** (0.03)
Individual attitudes						
Interested in the issue		0.10*** (0.01)		0.02* (0.01)		-0.06* (0.03)
Contribution to scientific progress		0.05*** (0.01)		0.13*** (0.01)		0.11*** (0.03)
Common in my discipline		0.02** (0.01)		0.05*** (0.01)		0.19*** (0.02)
Personal environment expects it		-0.01 (0.01)		-0.02** (0.01)		0.05* (0.02)
Nothing else came about		-0.02* (0.01)		0.01 (0.01)		-0.04 (0.02)
Contribute to solving societal problems		-0.01 (0.01)		0.05*** (0.01)		0.07*** (0.02)

	Satisfaction with mentoring		Belief in own research abilities		Prospects for post-doc position	
	M1a: Entropy balancing without controls	M1b: Entropy balancing with controls	M2a: Entropy balancing without controls	M2b: Entropy balancing with controls	M3a: Entropy balancing without controls	M3b: Entropy balancing with controls
Increase my reputation		0.00 (0.01)		-0.01 (0.01)		-0.01 (0.02)
Improve career opportunities outside academia		-0.02** (0.01)		-0.01* (0.01)		-0.07*** (0.02)
Managerial responsibility		-0.04*** (0.01)		-0.01 (0.01)		-0.04 (0.02)
Compatibility of work and family		0.04*** (0.01)		0.01 (0.01)		0.05* (0.03)
Availability of resources		0.02 (0.01)		0.01 (0.01)		0.01 (0.03)
Good opportunities for advancement		-0.02 (0.01)		0.04*** (0.01)		0.01 (0.03)
Societal recognition		-0.01 (0.01)		-0.04*** (0.01)		0.03 (0.02)
Job security		0.02 (0.01)		0.03** (0.01)		-0.06* (0.03)
Societal benefits of work		-0.01 (0.01)		-0.04*** (0.01)		-0.07** (0.02)
Salary level		0.03* (0.01)		0.01 (0.01)		0.01 (0.03)
Autonomy in decision-making		0.01 (0.01)		0.06*** (0.01)		0.11*** (0.03)
Working in a team		-0.03** (0.01)		-0.03*** (0.01)		-0.01 (0.02)
Intellectual challenge		0.06*** (0.01)		0.08*** (0.01)		0.06 (0.03)
Location		-0.05* (0.02)		-0.05** (0.02)		-0.09 (0.05)
Good research conditions in my discipline		0.15*** (0.02)		0.03 (0.02)		0.17** (0.05)
Supervisor		0.62*** (0.02)		-0.00 (0.02)		0.07 (0.06)

	Satisfaction with mentoring		**Belief in own research abilities**		**Prospects for post-doc position**	
	M1a: Entropy balancing without controls	M1b: Entropy balancing with controls	M2a: Entropy balancing without controls	M2b: Entropy balancing with controls	M3a: Entropy balancing without controls	M3b: Entropy balancing with controls
Good reputation of the university		-0.04 (0.02)		-0.00 (0.02)		0.04 (0.06)
Attractive services for doctoral candidates		0.09* (0.04)		-0.00 (0.03)		0.01 (0.10)
It just came about that way		0.11*** (0.03)		-0.02 (0.03)		-0.14 (0.08)
Other reasons		-0.01 (0.03)		0.04 (0.02)		-0.12 (0.06)
Constant	3.80*** (0.02)	2.59*** (0.14)	3.82*** (0.01)	2.83*** (0.12)	5.09*** (0.04)	5.50*** (0.35)
N	15333	15333	15280	15280	14915	14915
R^2	0.001	0.154	0.004	0.227	0.009	0.146

Source: Nacaps 2018, first wave. Own calculations. Standard errors in parentheses.
Level of significance: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table A2: Satisfaction with mentoring – by subject (Unstandardized coefficients from linear regression models)

	Satisfaction with mentoring				
	Art & humanities	Social & behavioral sciences	Medicine	Biology	STEM
Female (ref.: Male)	-0.18** (0.06)	-0.07 (0.06)	-0.16 (0.09)	-0.17 (0.09)	-0.06 (0.07)
Gender match (ref.: No gender match)	-0.05 (0.06)	-0.08 (0.05)	-0.10 (0.08)	-0.10 (0.08)	-0.02 (0.03)
Interaction: Female x gender match	0.17 (0.09)	0.07 (0.08)	0.31* (0.12)	0.09 (0.12)	0.14 (0.10)
Ascribed and socio-demographic characteristics and characteristics of doctorate					
Age	0.00 (0.00)	-0.00 (0.00)	-0.01* (0.01)	-0.02* (0.01)	-0.03*** (0.00)
Father: Higher education degree (ref.: Father: No higher education degree)	-0.11* (0.05)	-0.19*** (0.05)	0.05 (0.08)	-0.14* (0.07)	-0.06* (0.03)
Father: Doctoral degree (ref.: Father: No higher education degree)	-0.13 (0.08)	-0.11 (0.07)	-0.09 (0.09)	0.07 (0.12)	-0.03 (0.05)
Mother: Higher education degree (ref.: Mother: No higher education degree)	-0.03 (0.05)	0.04 (0.05)	-0.05 (0.07)	0.11 (0.07)	0.14*** (0.03)
Mother: Doctoral degree (ref.: Mother: No higher education degree)	-0.21 (0.11)	0.21* (0.10)	-0.00 (0.12)	0.01 (0.16)	0.12 (0.08)
Born abroad (ref.: Born in Germany)	0.16 (0.10)	0.36*** (0.10)	-0.03 (0.14)	-0.18 (0.15)	-0.01 (0.07)
Father: Born abroad (ref.: Born in Germany)	-0.18* (0.09)	-0.13 (0.08)	0.11 (0.13)	0.32* (0.13)	-0.00 (0.07)
Mother: Born abroad (ref.: Born in Germany)	-0.01 (0.09)	-0.07 (0.08)	-0.20 (0.13)	-0.19 (0.15)	0.05 (0.07)
Program/scholarship (ref.: Appointment)	0.08 (0.05)	-0.01 (0.05)	-0.13 (0.08)	0.11 (0.06)	0.11*** (0.03)

	Satisfaction with mentoring				
	Art & humanities	Social & behavioral sciences	Medicine	Biology	STEM
'Free' doctorate (ref.: Appointment)	-0.03 (0.06)	-0.06 (0.05)	-0.07 (0.08)	0.02 (0.13)	-0.15** (0.06)
Final grade HE degree	0.01 (0.06)	-0.00 (0.04)	0.08 (0.06)	0.08 (0.08)	0.00 (0.04)
Child/children (ref.: No child/children)	-0.08 (0.06)	0.12* (0.06)	0.05 (0.10)	0.23 (0.12)	0.14** (0.05)
Partner (ref.: No partner)	-0.23** (0.09)	-0.34*** (0.08)	-0.40*** (0.11)	-0.08 (0.10)	-0.05 (0.05)
Partner: Vocational training (ref.: Partner with higher education degree)	-0.06 (0.07)	-0.06 (0.06)	0.03 (0.09)	0.11 (0.09)	0.06 (0.04)
Partner: Doctoral degree (ref.: Partner with higher education degree)	0.06 (0.08)	0.04 (0.08)	0.22* (0.10)	0.02 (0.10)	0.04 (0.06)
Partner: Part-time employed (ref.: Partner full-time employed)	0.07 (0.06)	0.15** (0.06)	0.21* (0.10)	0.04 (0.10)	-0.02 (0.04)
Partner: In training or parental leave (ref.: Partner full-time employed)	0.10 (0.09)	-0.04 (0.07)	0.17 (0.11)	-0.11 (0.13)	-0.03 (0.05)
Partner: Not employed (ref.: Partner full-time employed)	0.20 (0.11)	0.38*** (0.10)	0.35* (0.14)	-0.09 (0.13)	0.17** (0.06)
Partner: Not in academia (ref.: Partner in academia)	0.11 (0.07)	0.22*** (0.06)	0.05 (0.09)	-0.13 (0.09)	-0.02 (0.04)

	Satisfaction with mentoring				
	Art & humanities	Social & behavioral sciences	Medicine	Biology	STEM
Health and personality traits					
Health	0.08** (0.03)	0.07* (0.03)	0.07 (0.04)	0.11** (0.04)	0.07*** (0.02)
Big5: Extraversion	-0.05 (0.03)	-0.05 (0.03)	0.11* (0.04)	-0.08 (0.04)	0.01 (0.02)
Big5: Neuroticism	-0.01 (0.03)	-0.06* (0.03)	0.03 (0.04)	-0.11** (0.04)	-0.10*** (0.02)
Big5: Openness	0.04 (0.03)	0.02 (0.03)	-0.02 (0.04)	-0.08 (0.05)	-0.04 (0.02)
Big5: Conscientiousness	0.10** (0.03)	0.00 (0.03)	-0.03 (0.05)	-0.03 (0.05)	0.00 (0.02)
Big5: Agreeableness	-0.01 (0.03)	0.03 (0.02)	-0.00 (0.04)	0.02 (0.04)	0.01 (0.02)
Risk-taking	0.02 (0.02)	-0.04* (0.02)	0.00 (0.03)	-0.05 (0.03)	-0.02 (0.01)
Control beliefs	0.18*** (0.03)	0.21*** (0.03)	0.16*** (0.05)	0.12** (0.05)	0.11*** (0.02)
Self-efficacy	0.01 (0.03)	0.01 (0.03)	-0.02 (0.04)	0.07 (0.04)	0.06** (0.02)
Individual attitudes					
Interested in the issue	0.03 (0.03)	0.12*** (0.02)	0.06 (0.04)	0.13** (0.04)	0.11*** (0.02)
Contribution to scientific progress	0.09*** (0.03)	0.05* (0.02)	0.00 (0.04)	0.03 (0.04)	0.07*** (0.02)
Common in my discipline	-0.02 (0.02)	0.02 (0.02)	0.08** (0.03)	0.02 (0.03)	0.02 (0.01)
Personal environment expects it	0.02 (0.02)	-0.04 (0.02)	-0.03 (0.03)	0.00 (0.03)	-0.02 (0.02)
Nothing else came about	-0.05* (0.02)	0.01 (0.02)	-0.10** (0.03)	0.00 (0.03)	0.00 (0.01)
Contribute to solving societal problems	0.01 (0.02)	-0.02 (0.02)	0.01 (0.03)	0.01 (0.03)	-0.00 (0.01)
Increase my reputation	-0.02 (0.02)	-0.01 (0.02)	-0.04 (0.03)	-0.01 (0.03)	0.02 (0.01)

	Satisfaction with mentoring				
	Art & humanities	Social & behavioral sciences	Medicine	Biology	STEM
Improve career opportunities outside	-0.03 (0.02)	0.00 (0.02)	-0.04 (0.03)	-0.04 (0.03)	-0.03* (0.01)
Managerial responsibility	-0.06** (0.02)	-0.03 (0.02)	-0.09** (0.03)	-0.04 (0.03)	-0.03* (0.01)
Compatibility of work and family	0.05* (0.02)	0.03 (0.02)	0.06 (0.04)	-0.02 (0.04)	0.02 (0.02)
Availability of resources	0.03 (0.03)	0.01 (0.02)	0.06 (0.04)	-0.05 (0.04)	0.02 (0.02)
Good opportunities for advancement	0.01 (0.03)	-0.07* (0.03)	-0.02 (0.04)	0.06 (0.05)	0.00 (0.02)
Societal recognition	0.05* (0.03)	-0.02 (0.02)	-0.04 (0.04)	-0.05 (0.04)	-0.01 (0.02)
Job security	-0.01 (0.03)	0.01 (0.02)	0.00 (0.04)	0.03 (0.04)	0.04* (0.02)
Societal benefits of work	-0.03 (0.03)	-0.02 (0.02)	0.01 (0.04)	0.02 (0.04)	-0.01 (0.02)
Salary level	-0.00 (0.03)	0.06* (0.03)	0.01 (0.04)	0.00 (0.04)	0.00 (0.02)
Autonomy in decision-making	0.00 (0.03)	0.06* (0.03)	0.09* (0.04)	0.04 (0.04)	-0.02 (0.02)
Working in a team	0.01 (0.02)	-0.03 (0.02)	-0.08* (0.04)	-0.04 (0.04)	-0.03* (0.02)
Intellectual challenge	-0.03 (0.03)	0.05 (0.03)	0.04 (0.05)	0.04 (0.05)	0.10*** (0.02)
Location	-0.03 (0.05)	-0.04 (0.04)	-0.14 (0.08)	0.06 (0.07)	-0.07* (0.03)
Good research conditions in my discipline	0.21*** (0.05)	0.19*** (0.05)	0.16 (0.09)	0.08 (0.08)	0.10** (0.03)
Supervisor	0.56*** (0.07)	0.63*** (0.05)	0.49*** (0.08)	0.62*** (0.07)	0.70*** (0.03)
Good reputation of the university	-0.04 (0.06)	-0.00 (0.05)	-0.17 (0.10)	-0.08 (0.08)	-0.00 (0.04)
Attractive services for doctoral candidates	0.09 (0.09)	0.17* (0.08)	0.01 (0.15)	-0.12 (0.12)	0.01 (0.07)

	Satisfaction with mentoring				
	Art & humanities	Social & behavioral sciences	Medicine	Biology	STEM
It just came about that way	-0.00 (0.10)	0.14 (0.08)	-0.04 (0.11)	0.19 (0.11)	0.19*** (0.05)
Other reasons	0.06 (0.06)	-0.01 (0.05)	-0.17 (0.09)	0.06 (0.09)	-0.02 (0.04)
Constant	2.79*** (0.34)	2.66*** (0.31)	3.58*** (0.47)	3.18*** (0.55)	2.68*** (0.24)
N	2420	3286	1625	1415	5973
R^2	0.173	0.170	0.133	0.168	0.195

Source: Nacaps 2018, first wave. Own calculations. Standard errors in parentheses.
Level of significance: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table A3: Belief in own research abilities – by subject (Unstandardized coefficients from linear regression models)

	Belief in own research abilities				
	Art & humanities	Social & behavioral sciences	Medicine	Biology	STEM
Female (Ref.: male)	-0.22*** (0.05)	-0.13* (0.05)	-0.14 (0.07)	0.02 (0.07)	-0.19** (0.06)
Gender match (ref.: No gender match)	-0.06 (0.05)	-0.02 (0.04)	0.02 (0.06)	0.08 (0.06)	-0.10*** (0.02)
Interaction: Female x gender match	0.09 (0.07)	-0.05 (0.07)	-0.03 (0.10)	-0.08 (0.09)	0.18* (0.08)
Ascribed and socio-demographic characteristics and characteristics of doctorate					
Age	0.00 (0.00)	-0.00 (0.00)	-0.00 (0.01)	0.02* (0.01)	0.00 (0.00)
Father: Higher education degree (ref.: Father: No higher education degree)	0.02 (0.04)	-0.10* (0.04)	-0.13* (0.06)	-0.13** (0.05)	-0.01 (0.03)
Father: Doctoral degree (ref.: Father: No higher education degree)	0.05 (0.07)	-0.05 (0.06)	-0.11 (0.07)	-0.09 (0.09)	-0.00 (0.04)
Mother: Higher education degree (ref.: Mother: No higher education degree)	-0.02 (0.04)	0.04 (0.04)	-0.04 (0.06)	0.10 (0.05)	-0.04 (0.03)
Mother: Doctoral degree (ref.: Mother: No higher education degree)	0.02 (0.09)	0.18* (0.08)	-0.13 (0.10)	0.11 (0.11)	0.04 (0.07)
Born abroad (ref.: Born in Germany)	0.03 (0.09)	0.16 (0.09)	0.04 (0.11)	-0.11 (0.11)	-0.01 (0.05)
Father: Born abroad (ref.: Born in Germany)	-0.02 (0.08)	-0.06 (0.07)	-0.08 (0.11)	0.15 (0.10)	0.04 (0.06)
Mother: Born abroad (ref.: Born in Germany)	0.03 (0.08)	0.06 (0.07)	0.11 (0.11)	0.11 (0.11)	0.03 (0.05)
Program/scholarship (ref.: Appointment)	-0.12** (0.04)	-0.14*** (0.04)	-0.39*** (0.06)	-0.12* (0.05)	-0.03 (0.02)

	Belief in own research abilities				
	Art & humanities	Social & behavioral sciences	Medicine	Biology	STEM
'Free' doctorate (ref.: Appointment)	-0.35*** (0.05)	-0.40*** (0.05)	-0.56*** (0.06)	-0.19* (0.09)	-0.27*** (0.05)
Final grade HE degree	-0.21*** (0.05)	-0.31*** (0.04)	-0.18*** (0.04)	-0.18** (0.06)	-0.14*** (0.03)
Child/children (ref.: No child/children)	-0.09 (0.05)	0.13* (0.05)	0.04 (0.08)	-0.01 (0.09)	0.01 (0.04)
Partner (ref. No Partner)	-0.13 (0.07)	0.15* (0.07)	-0.04 (0.09)	0.02 (0.08)	-0.03 (0.04)
Partner: Vocational training (ref.: Partner with higher education degree)	0.04 (0.06)	0.15** (0.05)	0.04 (0.07)	0.03 (0.07)	0.13*** (0.03)
Partner: Doctoral degree[j] (ref.: Partner with higher education degree)	0.13 (0.07)	-0.06 (0.07)	0.19* (0.08)	0.17* (0.08)	0.07 (0.05)
Partner: Part-time employed (ref.: Partner full-time employed)	0.07 (0.05)	0.01 (0.05)	0.07 (0.08)	0.04 (0.07)	0.10** (0.04)
Partner: In training or parental leave (ref.: Partner full-time employed)	0.00 (0.07)	-0.14* (0.06)	0.05 (0.09)	0.07 (0.09)	0.04 (0.04)
Partner: Not employed (ref.: Partner full-time employed)	0.20* (0.09)	-0.06 (0.08)	0.00 (0.11)	-0.02 (0.09)	0.01 (0.05)
Partner: Not in academia (ref.: Partner in academia)	0.11 (0.06)	-0.14* (0.06)	-0.09 (0.08)	-0.02 (0.07)	-0.16*** (0.04)

	Belief in own research abilities				
	Art & humanities	Social & behavioral sciences	Medicine	Biology	STEM
Health and personality traits					
Health	-0.02 (0.03)	-0.12*** (0.02)	-0.05 (0.04)	-0.02 (0.03)	-0.01 (0.02)
Big5: Extraversion	-0.05 (0.03)	0.02 (0.02)	-0.10** (0.03)	-0.04 (0.03)	-0.04* (0.02)
Big5: Neuroticism	-0.10*** (0.03)	-0.06** (0.02)	-0.06 (0.04)	-0.13*** (0.03)	-0.09*** (0.02)
Big5: Openness	0.12*** (0.03)	0.08** (0.02)	0.15*** (0.03)	0.01 (0.03)	0.09*** (0.02)
Big5: Conscientiousness	0.24*** (0.03)	0.15*** (0.03)	0.04 (0.04)	0.11** (0.04)	0.18*** (0.02)
Big5: Agreeableness	-0.06** (0.02)	-0.02 (0.02)	-0.01 (0.03)	0.03 (0.03)	-0.05*** (0.01)
Risk-taking	-0.05*** (0.02)	0.00 (0.01)	-0.04 (0.02)	-0.00 (0.02)	0.02 (0.01)
Control beliefs	-0.04 (0.03)	0.03 (0.03)	-0.08* (0.04)	0.02 (0.03)	0.00 (0.02)
Self-efficacy	0.08*** (0.02)	0.16*** (0.02)	0.19*** (0.03)	0.17*** (0.03)	0.16*** (0.02)
Individual attitudes					
Interested in the issue	-0.02 (0.03)	-0.01 (0.02)	0.04 (0.03)	-0.04 (0.03)	0.03* (0.01)
Contribution to scientific progress	0.19*** (0.02)	0.17*** (0.02)	0.10*** (0.03)	0.09** (0.03)	0.11*** (0.01)
Common in my discipline	0.07*** (0.02)	0.07*** (0.02)	0.03 (0.02)	0.02 (0.02)	0.04*** (0.01)
Personal environment expects it	-0.01 (0.02)	-0.07*** (0.02)	-0.05* (0.02)	-0.05* (0.02)	0.03* (0.01)
Nothing else came about	0.02 (0.02)	0.03 (0.02)	0.02 (0.03)	-0.03 (0.02)	-0.01 (0.01)
Contribute to solving societal problems	0.03 (0.02)	0.03 (0.02)	0.09*** (0.02)	0.01 (0.02)	0.06*** (0.01)
Increase my reputation	0.01 (0.02)	-0.06** (0.02)	0.02 (0.03)	-0.00 (0.02)	-0.03* (0.01)

	Belief in own research abilities				
	Art & humanities	Social & behavioral sciences	Medicine	Biology	STEM
Improve career opportunities outside academia	-0.05*** (0.01)	0.00 (0.02)	0.05* (0.02)	-0.03 (0.02)	-0.01 (0.01)
Managerial responsibility	0.03 (0.02)	-0.03 (0.02)	0.02 (0.03)	-0.01 (0.02)	-0.01 (0.01)
Compatibility of work and family	0.03 (0.02)	-0.03 (0.02)	0.03 (0.03)	0.02 (0.03)	0.03* (0.01)
Availability of resources	-0.02 (0.02)	0.05* (0.02)	0.05 (0.03)	0.04 (0.03)	0.01 (0.02)
Good opportunities for advancement	0.04 (0.02)	0.01 (0.02)	0.11*** (0.03)	0.03 (0.03)	0.05** (0.02)
Societal recognition	-0.06** (0.02)	-0.01 (0.02)	-0.13*** (0.03)	-0.03 (0.03)	-0.03** (0.01)
Job security	0.03 (0.02)	0.04* (0.02)	-0.04 (0.03)	-0.02 (0.03)	0.04** (0.01)
Societal benefits of work	-0.07*** (0.02)	-0.02 (0.02)	-0.02 (0.03)	-0.06* (0.03)	-0.05*** (0.01)
Salary level	0.05 (0.02)	0.01 (0.02)	-0.01 (0.03)	-0.02 (0.03)	-0.00 (0.02)
Autonomy in decision-making	0.10*** (0.03)	0.08** (0.03)	0.12*** (0.03)	0.11*** (0.03)	0.06*** (0.02)
Working in a team	-0.03 (0.02)	-0.04* (0.02)	-0.07* (0.03)	-0.03 (0.03)	-0.02 (0.01)
Intellectual challenge	0.12*** (0.03)	0.10*** (0.03)	0.00 (0.04)	0.13*** (0.04)	0.02 (0.02)
Location	-0.03 (0.04)	-0.08* (0.04)	-0.07 (0.06)	-0.02 (0.05)	-0.05 (0.03)
Good research conditions in my discipline	-0.01 (0.05)	-0.09 (0.05)	0.16* (0.07)	0.05 (0.06)	0.05 (0.03)
Supervisor	0.04 (0.06)	0.03 (0.05)	0.06 (0.06)	-0.04 (0.05)	-0.09** (0.03)
Good reputation of the university	-0.01 (0.05)	-0.05 (0.05)	-0.13 (0.08)	0.04 (0.06)	0.06* (0.03)
Attractive services for doctoral candidates	0.06 (0.08)	-0.04 (0.07)	0.04 (0.12)	0.17 (0.09)	-0.04 (0.05)

	Belief in own research abilities				
	Art & humanities	Social & behavioral sciences	Medicine	Biology	STEM
It just came about that way	-0.04 (0.09)	-0.04 (0.07)	-0.13 (0.09)	0.01 (0.08)	0.00 (0.04)
Other reasons	0.06 (0.05)	0.07 (0.05)	-0.10 (0.07)	-0.01 (0.06)	0.09* (0.03)
Constant	2.77*** (0.28)	3.65*** (0.27)	3.24*** (0.38)	3.13*** (0.40)	2.90*** (0.19)
N	2412	3269	1613	1413	5962
R^2	0.266	0.215	0.335	0.233	0.200

Source: Nacaps 2018, first wave. Own calculations. Standard errors in parentheses.
Level of significance: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table A4: Prospects for postdoc position – by subject (Unstandardised coefficients from linear regression models)

	Prospects for postdoc position				
	Art & humanities	Social & behavioral sciences	Medicine	Biology	STEM
Female (ref.: Male)	-0.50*** (0.15)	-0.30* (0.14)	-0.10 (0.21)	-0.13 (0.21)	-0.33 (0.20)
Gender match (ref.: No gender match)	0.27 (0.14)	-0.08 (0.11)	0.32 (0.17)	0.02 (0.17)	0.05 (0.07)
Interaction: Female x gender match	0.14 (0.20)	0.05 (0.19)	-0.23 (0.28)	-0.50 (0.28)	0.35 (0.28)
Ascribed and socio-demographic characteristics and characteristics of doctorate					
Age	-0.03** (0.01)	-0.03* (0.01)	-0.04** (0.02)	0.01 (0.02)	-0.06*** (0.01)
Father: Higher education degree (ref.: Father: No higher education degree)	-0.16 (0.12)	0.29** (0.11)	-0.23 (0.17)	-0.27 (0.16)	0.26** (0.09)
Father: Doctoral degree (ref.: Father: No higher education degree)	0.01 (0.19)	0.10 (0.16)	-0.06 (0.20)	0.12 (0.27)	0.25 (0.13)
Mother: Higher education degree (ref.: Mother: No higher education degree)	0.18 (0.12)	0.11 (0.11)	-0.02 (0.16)	0.40* (0.17)	0.17 (0.09)
Mother: Doctoral degree (ref.: Mother: No higher education degree)	0.47 (0.25)	0.26 (0.23)	0.15 (0.28)	-0.12 (0.36)	-0.33 (0.22)
Born abroad[e] (ref.: Born in Germany)	0.80*** (0.24)	0.14 (0.23)	-1.18*** (0.31)	-0.23 (0.35)	-0.40* (0.18)
Father: Born abroad (ref.: Born in Germany)	-0.41* (0.21)	0.03 (0.20)	0.08 (0.29)	0.69* (0.30)	0.24 (0.18)
Mother: Born abroad[e] (ref.: Born in Germany)	0.25 (0.22)	-0.22 (0.21)	0.34 (0.30)	-0.39 (0.33)	-0.10 (0.18)
Program/scholarship (ref.: Appointment)	-0.47*** (0.12)	-0.22* (0.11)	-0.54** (0.18)	0.05 (0.15)	0.18* (0.08)

	Prospects for postdoc position				
	Art & humanities	Social & behavioral sciences	Medicine	Biology	STEM
'Free' doctorate (ref.: Appointment)	-1.15*** (0.13)	-0.75*** (0.13)	-0.85*** (0.18)	-1.27*** (0.30)	-0.63*** (0.15)
Final grade HE degree	-0.18 (0.13)	-0.70*** (0.11)	-0.25* (0.13)	-0.44* (0.18)	-0.92*** (0.10)
Child/children	-0.16 (0.14)	-0.03 (0.14)	-0.31 (0.22)	-0.38 (0.28)	0.24 (0.13)
Partner (ref.: No Partner)	0.13 (0.20)	-0.12 (0.19)	-0.20 (0.26)	0.39 (0.24)	0.48*** (0.14)
Partner: Vocational training (ref.: Partner with higher education degree)	0.02 (0.17)	0.04 (0.14)	0.14 (0.20)	-0.33 (0.22)	-0.28* (0.11)
Partner: Doctoral degree (ref.: Partner with higher education degree)	0.12 (0.20)	-0.08 (0.18)	0.05 (0.23)	0.01 (0.24)	0.37* (0.16)
Partner: Part-time employed (ref.: Partner full-time employed)	-0.06 (0.15)	0.01 (0.13)	-0.29 (0.22)	-0.07 (0.22)	-0.52*** (0.12)
Partner: In training or parental leave (ref.: Partner full-time employed)	0.27 (0.21)	-0.21 (0.16)	0.16 (0.25)	0.11 (0.29)	0.23 (0.13)
Partner: Not employed (ref.: Partner full-time employed)	-0.16 (0.25)	0.21 (0.23)	0.27 (0.32)	-0.38 (0.29)	-0.33* (0.17)
Partner: Not in academia (ref.: Partner in academia)	-0.16 (0.17)	0.14 (0.16)	0.20 (0.22)	-0.08 (0.21)	-0.39** (0.12)

	Prospects for postdoc position				
	Art & humanities	Social & behavioral sciences	Medicine	Biology	STEM
	Health and personality traits				
Health	-0.04 (0.07)	-0.05 (0.06)	-0.06 (0.10)	0.11 (0.09)	-0.07 (0.05)
Big5: Extraversion	-0.08 (0.07)	0.04 (0.07)	0.04 (0.10)	0.09 (0.09)	0.03 (0.05)
Big5: Neuroticism	-0.17* (0.07)	-0.14* (0.06)	-0.09 (0.10)	-0.10 (0.10)	-0.18*** (0.05)
Big5: Openness	0.05 (0.08)	0.09 (0.07)	0.11 (0.10)	-0.17 (0.10)	0.21*** (0.06)
Big5: Conscientious-ness	-0.13 (0.08)	0.02 (0.07)	0.26* (0.10)	-0.03 (0.11)	-0.02 (0.06)
Big5: Agreeableness	-0.14* (0.06)	-0.05 (0.06)	-0.24** (0.09)	0.03 (0.09)	0.01 (0.04)
Risk-taking	0.03 (0.04)	0.05 (0.04)	-0.00 (0.06)	-0.06 (0.06)	-0.02 (0.03)
Control beliefs	0.29*** (0.07)	0.33*** (0.07)	0.14 (0.11)	-0.03 (0.10)	0.11 (0.06)
Self-efficacy	0.09 (0.07)	0.17* (0.07)	0.23* (0.10)	0.50*** (0.10)	0.28*** (0.05)
	Individual attitudes				
Interested in the issue	-0.07 (0.07)	-0.17** (0.06)	0.15 (0.08)	0.13 (0.09)	-0.09* (0.04)
Contribution to scientific progress	0.19** (0.06)	0.20*** (0.06)	0.11 (0.08)	0.02 (0.10)	0.01 (0.05)
Common in my discipline	0.07 (0.04)	0.09 (0.05)	0.14* (0.06)	0.22*** (0.06)	0.24*** (0.03)
Personal environment expects it	0.18** (0.05)	0.05 (0.05)	0.09 (0.06)	-0.07 (0.07)	-0.03 (0.04)
Nothing else came about	-0.20*** (0.05)	0.03 (0.05)	0.08 (0.07)	0.02 (0.06)	-0.08* (0.04)
Contribute to solving societal problems	0.09 (0.05)	-0.01 (0.05)	-0.01 (0.07)	-0.08 (0.07)	0.14*** (0.04)
Increase my reputation	-0.08 (0.05)	-0.10 (0.05)	0.04 (0.07)	0.09 (0.07)	0.01 (0.04)

	Prospects for postdoc position				
	Art & humanities	Social & behavioral sciences	Medicine	Biology	STEM
Improve career opportunities outside academia	-0.10* (0.04)	-0.07 (0.04)	0.06 (0.06)	-0.01 (0.07)	-0.13*** (0.03)
Managerial responsibility	-0.06 (0.05)	-0.10 (0.05)	0.04 (0.07)	0.11 (0.07)	-0.03 (0.04)
Compatibility of work and family	0.08 (0.06)	0.10 (0.06)	-0.20* (0.09)	-0.00 (0.08)	0.02 (0.05)
Availability of resources	-0.07 (0.06)	0.01 (0.06)	0.14 (0.10)	0.21* (0.10)	0.00 (0.05)
Good opportunities for advancement	0.10 (0.07)	0.01 (0.07)	-0.16 (0.10)	-0.08 (0.10)	0.07 (0.05)
societal recognition	0.08 (0.06)	0.01 (0.05)	0.01 (0.08)	-0.12 (0.08)	0.06 (0.04)
Job security	-0.21** (0.06)	-0.07 (0.05)	-0.37*** (0.09)	-0.29** (0.10)	0.09* (0.04)
Societal benefits of work	-0.07 (0.06)	-0.02 (0.05)	0.18* (0.08)	0.08 (0.08)	-0.13*** (0.04)
Salary level	-0.03 (0.07)	0.08 (0.07)	0.08 (0.09)	0.08 (0.10)	-0.00 (0.05)
Autonomy in decision-making	0.09 (0.07)	0.07 (0.07)	0.04 (0.10)	0.30** (0.10)	0.10 (0.05)
Working in a team	0.03 (0.05)	-0.10 (0.05)	-0.08 (0.08)	-0.03 (0.08)	0.01 (0.04)
Intellectual challenge	-0.03 (0.08)	0.08 (0.07)	0.01 (0.10)	0.12 (0.11)	0.05 (0.05)
Location	-0.10 (0.11)	-0.19 (0.11)	-0.43* (0.17)	-0.31 (0.16)	-0.00 (0.09)
Good research conditions in my discipline	0.20 (0.13)	0.19 (0.12)	0.76*** (0.20)	0.29 (0.17)	0.01 (0.09)
Supervisor	-0.01 (0.15)	0.10 (0.13)	-0.14 (0.17)	-0.41* (0.16)	0.21* (0.09)
Good reputation of the university	0.09 (0.15)	0.17 (0.13)	0.09 (0.21)	0.13 (0.19)	-0.25* (0.10)
Attractive services for doctoral candidates	-0.01 (0.21)	0.02 (0.19)	0.61 (0.35)	-0.43 (0.28)	0.09 (0.18)

	Prospects for postdoc position				
	Art & humanities	Social & behavioral sciences	Medicine	Biology	STEM
It just came about that way	0.10 (0.23)	0.12 (0.18)	-0.46 (0.24)	-0.44 (0.25)	-0.22 (0.14)
Other reasons	0.15 (0.14)	-0.16 (0.13)	-0.33 (0.20)	-0.25 (0.20)	-0.29** (0.11)
Constant	5.16*** (0.78)	6.25*** (0.74)	7.34*** (1.06)	3.49** (1.25)	7.61*** (0.63)
N	2376	3194	1555	1393	5809
R^2	0.153	0.093	0.165	0.164	0.108

Source: Nacaps 2018, first wave. Own calculations. Standard errors in parentheses.
Level of significance: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

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Navigating treacherous waters

Exploring the dual career experiences of European Research Council applicants******

Abstract: Careers of scientists do not unfold in a social vacuum. According to the concept of linked lives (Moen, 2003), the career of one partner has implications for the career of the other. Using a quantitative survey and qualitative interviews we explore the experiences of navigating dual careers for a sample of scientists who applied for a European Research Council (ERC) grant. While the notion of an ideal scientist is built on an individualistic model of unrestricted international mobility and dedication, our quantitative analysis shows that the majority of ERC applicants have an employed partner, who is often also a scientist, and children. The majority of ERC applicants with an employed partner say both careers are equally important, but the proportion is higher among women ERC applicants. These scientists experience difficulties in coordinating and combining dual careers, even if their own career is considered more important. This is evident for established scientists as well as for scientists who are in the 'rush hour' of life. From the scientists' lived experiences it becomes evident that the ERC applicants want to comply with the notion of the 'ideal' scientist but face limitations, especially when mobility opportunities are constrained by the portability of the partners' careers. Dual-career cycling dilemmas are raised by mobility events, often resulting in priority shifts through a competing rather than synchronic process. These dilemmas arise for both men and women scientists, but some of the consequences–where and with whom the children live and who has primary care responsibilities–are quite gendered. We conclude with recommendations for employers and funders in supporting dual careers in science.

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Keywords: linked lives; dual career couples; scientific career paths; international mobility; academic couples; Europe

Durch tückische Gewässer navigieren

Die Erfahrungen mit Doppelkarrieren von Antragsteller_innen beim European Research Council

Zusammenfassung: Die Karrieren von Wissenschaftler_innen entwickeln sich nicht in einem sozialen Vakuum. Nach dem Konzept der „linked lives“ (Moen 2003) hat der Karriereverlauf eines Partners Auswirkungen auf die Karriere des anderen Partners. Wir untersuchen die Doppelkarrieren von Wissenschaftler_innen, die sich auf eine Förderung durch den European Research Council (ERC) beworben haben, auf Basis einer quantitativen Befragung und von qualitativen Interviews. Während das idealtypische Bild von Wissenschaftler_innen auf einem individualistischen Karrieremodell mit uneingeschränkter internationaler Mobilität und Karriereengagement beruht, zeigt sich quantitativ, dass die Mehrheit der Antragsteller_innen beim ERC erwerbstätige Partner_innen, häufig ebenfalls Wissenschaftler_innen, und Kinder haben. Das Gros der ERC-Antragsteller_innen mit berufstätigen Partner_innen bewertet, dass beide Karrieren in der Partnerschaft gleich wichtig sind. Bei den Antragstellerinnen ist der Anteil jedoch höher. Selbst wenn die eigene Karriere wichtiger erscheint, erleben die Wissenschaftler_innen die Koordination zweier Karrieren als nicht einfach. Dies gilt sowohl für ältere etablierte Wissenschaftler_innen als auch für Wissenschaftler_innen, die sich noch in der "Rushhour" des Lebens befinden. In den erlebten Erfahrungen der ERC-Antragsteller_innen zeigt sich, dass sie dem vorherrschenden Idealbild in der Wissenschaft entsprechen wollen, aber an Grenzen stoßen, insbesondere wenn Mobilitätsanforderungen durch fehlende Übertragbarkeit des Job der Partner_innen eingeschränkt ist. Vor diesem Hintergrund stellt sich die Frage, wie sie zwei Karrieren koordinieren, für sie immer wieder neu. Diese Anforderungen bestehen sowohl für Wissenschaftler als auch Wissenschaftlerinnen, aber einige der Konsequenzen – etwa bei wem die Kinder sind und wer vorrangig die Betreuung übernimmt – sind geschlechtsspezifisch. Wir ziehen Schlussfolgerungen zur Förderung dualer Karrieren in der Wissenschaft für Arbeitgeber_innen und Forschungsförderung.

Stichworte: Doppelkarrierepaare; Wissenschaftskarriere; Internationale Mobilität; Akademikerpaare; Europa; dual career

1. Introduction

If contemporary career paths in science are like "braided rivers" (Batchelor et al. 2021), trying to coordinate dual careers may be like navigating treacherous waters. A successful career in science is often assumed to require absolute dedication, high productivity, and unrestricted international mobility. As the lives of partners in dual-career couples are closely linked (Moen 2003), meeting these career requirements has to be continuously coordinated between them (Livingston/Ryu 2020). The effort needed to sustain dual careers can be demanding, particularly when couples have children. Early-career scientists in the so-called 'rush hour' of life, the period from about age 30 through to mid-40s, may thus find it hard to reconcile career requirements with family obligations. In addition, dual careers pose challenges to universities in hiring and retaining scientists (Baker 2004; Rivera 2017; Tzanakou 2017). Yet, evidence on the experience of dual careers in science is scarce (Baker 2004; Rusconi/Solga 2011).

Pathways to career success in science have been elaborated previously, typically with a focus on gender differences. Career gaps between men and women emerge, with mothers likely to progress more slowly, to hold less prestigious jobs than men, or to leave science altogether (e.g., Baker 2010; Buber et al. 2011; European Commission 2021; Joecks et al. 2014; Xie/Shauman 2003). Among the selective group that stays in science, career similarities between men and women are often stronger than the differences (Joecks et al. 2014; Jungbauer-Gans/Gross 2013; Vinkenburg et al. 2020).

In this contribution, we explore the experiences of scientists with an employed partner in navigating dual careers. We make use of quantitative and qualitative data to examine the following questions: Whose career has been/is more important, and how easy has it been to combine dual careers? How do scientists reflect on and make sense of navigating dual careers given demanding career requirements?

Our analysis is based on survey data and interviews collected in 2013 from scientists who applied for a grant from the European Research Council (ERC), source of the most prestigious research grants available in Europe. This population is a select sample of scientists, not only because they have embarked upon a career in science following their PhD, but also because ERC grant applicants, due to the elite nature of the funding scheme, are unique among scientists in general with regard to ambition and excellence. In this context, we describe the dual-career situation of the ERC applicants at the time of application and examine their reflections on their lived experiences up to that point as a potential area of conflict that has to be navigated between career norms and family requirements. The goal of the original project in which the data was collected was to explore gendered career paths in science (Vinkenburg et al. 2020), and in doing so, dual careers emerged as a highly salient theme for ERC applicants. Dual-career couples are often distinguished from dual-earner couples, assuming that coordinating work and family spheres is easier when at least one partner ‘only’ has a job to earn money (Rapoport/Rapoport 1969; Rusconi/Solga 2007). Focusing on scientists, we prefer the term ‘dual careers’, and we let the data speak to the coordination of a career in science for those with employed partners.

2. Dual careers in science

Associated with the rise of women in academia (European Commission 2021) is a significant increase in the number of dual-career couples with two highly-educated, often academic, partners (Connolly et al. 2011; Ferber/Loeb 1997; Schiebinger et al. 2008). Dual-career couples have to navigate and coordinate individual career goals and ideals and reconcile these with work-family requirements. Among academics, those who pursue a career in science face very particular career requirements in addition to these dual-career challenges, for example shared beliefs that a successful career in science is indicated by their output (e.g., publications, funding), assessed through rigorous peer review, often focusing on early achievements (European Commission 2004). Absolute dedication is demanded and the early stages of successful careers involve very few promotions along the status hierarchy. Mobility is generally expected (in terms of longer stays or positions abroad), ideally including employment with distinguished scholars at elite institutions (Morano-Foadi 2005), preferably in the United States (Uhly et al. 2017; Zippel 2017). Scientists must turn professional and institutional demands to their advantage (Herschberg et al. 2014). Fitting the implicit but normative image of the ideal scientist is important (van Veelen/Derks 2022) for being hired or promoted or securing a permanent position (Herschberg et al. 2018; O’Laughlin/Bischoff 2005).

The expectations of individual performance for scientists are built on particular partnership and family arrangements (Rusconi et al. 2013). Historically, ideal scientists were “free standing individuals that have in fact been male heads of households with relatively mobile family units” (Schiebinger 2011: 163). Emphasizing the challenge of deviating from the ideal, Brouns and Addis (2004: 28) concluded that “the dominant image of the excellent scientist is more or less grounded in a male career pattern with an absolute dedication to science. Many people – especially those with family responsibilities – find it hard to live up to this image”.

In her work on linked lives, Moen (2003: 238f.) states that contemporary career development is a conjoint process between partners, embedded in institutional arrangements. Findings on patterns in couples’ career biographies are key to understanding couples’ reflections. From a conceptual perspective on the dual-careers interface, Moen distinguishes between competing, synchronic, and independent processes (ibid.). Other scholars describe similar relative constellations within dual-career couples (Rusconi/Solga 2007). It is often assumed that if partners agree on whether one partner’s career is more important, at least temporarily, this can make it easier to coordinate the two careers. However, when couples face changing demands, especially when job opportunities require relocation or there are other changes in family arrangements (Rusconi et al. 2013), dual-career cycling dilemmas arise in navigating the demands of two careers (Rapoport/Rapoport 1969).

Different theoretical models are used to explain how couples arrive at dual-career coordination. While relative differences in economic resources and bargaining power explain couple decisions in general (e.g., Steiber/Haas 2012), this is less evident among those with highly-educated partners with similar resources and bargaining power (Abele/Volmer 2011). Disparities in position and career prospects may still make a difference within the couple, such as career advancement at the beginning of the partnership, and different opportunities according to the partner's profession or discipline (Rusconi/Solga 2007). An offer for one partner may shift priorities so that the other's career must take a back seat, at least temporarily, especially if this involves relocation. In many couples the man is one career step ahead, which results in gender-specific patterns where men are hired first and women follow (Schiebinger et al. 2008). However, having a partner who is also a scientist might also come with advantages (Astin/Milem 1997; Uhly et al. 2017), such as providing mutual understanding of requirements, support, and networks (Rusconi/Solga 2007).

Navigating dual careers becomes even more complicated when the available time for a career becomes limited by care responsibilities for children. Becoming parents is often referred to as a 'traditionalizing push' in couples (Grunow et al. 2012) and a pivotal point for early-career scientists (Vohlídalová 2017). At this point small disparities in career opportunities as well as traditional gender norms of behavior become crystalized (Livingston/Ryu 2020) and affect decisions even in situations when resources are equally distributed in couples or to the woman's advantage (e.g., Rusconi/Solga 2007; Steiber/Haas 2012). Couples' negotiations may be influenced by the adoption of traditional gender roles, reflecting the prevailing model in the social context, or matching statutory rights (e.g., existence of paid parental leave) (Krüger/Levy 2001). Women in dual-career couples are more likely than men to give priority to the career of their partner (Abele/Volmer 2011), at least temporarily, to accommodate partnership and family (Becker/Moen 1999). As a consequence, women scientists might find it more difficult to navigate dual careers than men scientists.

External conditions play a decisive role, especially when it comes to the choice of a joint place of work. Whilst mobility in the form of commuting may provide an opportunity to pursue careers individually (Kilpatrick 1982), many prefer two jobs nearby or at the same institution (Wolf-Wendel et al. 2003). This is especially challenging for scientist couples, because finding even one permanent position is already difficult (Rivera 2017). When couples have children, the question of mobility and choice of workplace can be posed anew. Couples may move closer to other family members or to institutions where support of dual-career couples is available. Dual-career programs in academia aim to provide joint job arrangements (Tzanakou 2017), which, if found, benefit both partners (Moen/Sweet 2002).

Employers' recruitment procedures are critical in the formation of gender differences. The decisions of selection committees are often framed according to gendered perceptions of the ideal scientist (Herschberg et al. 2018). Mothers (or perceived potential mothers) are believed to be less dedicated to their careers (Herschberg et al. 2018; Nikunen 2012; van Veelen/Derks 2022), and moreover, there are assumptions regarding mobility, portability, and 'trailing' spouses (Ferber/Loeb 1997; Rivera 2017). Recruiters may believe that women scientists will be less mobile than men, resulting in their job applications being taken less seriously (Rusconi/Solga 2007). However, if women are mobile, they are often penalized for leaving their families behind, again resulting in lower chances of being hired. While the portability of men's partners and children is rarely discussed, the portability of women's partners and children is a doubt raiser (Rivera 2017). The extent to which gender differences emerge varies by discipline (e.g., life sciences, see Lockhart 2021), the number of positions available, and also by requirements on research outputs and international mobility (Jungbauer-Gans/Gross 2013; Zippel 2017).

In conclusion, the course of dual careers is shaped by a multi-layered environment–the individual, the partnership, and the institutional level (Abele/Volmer 2011). There is a lack of knowledge on how scientists navigate these complexities. With so many scientists with partners also in science, and because of the very particular requirements of scientific careers, they form a specific subgroup of dual-career couples. Although others have addressed the dilemmas that men and women face in dual careers per se (Rapoport/Rapoport 1969; Rusconi et al. 2013) and dual-careers in academia in particular (Ferber/Loeb 1997; Schiebinger et al. 2008), we contribute specific insights from scientists in Europe providing empirical evidence for a select sample of scientists who are (working to be) the future leaders in science by showing how they reflect on the process of navigating dual careers.

We proceed in two steps: We first draw a quantitative picture of prevailing dual careers among ERC grant applicants in terms of relative career importance and perceptions of how difficult it is to combine two careers. We show how they are framed by career and partnership characteristics. Here, we look at early career scientists applying for an ERC Starting Grant (StG)[1] and established scientists applying for an ERC Advanced Grant (AdG). Second, we present narratives on dual-career cycling based on qualitative interviews. We show how ERC applicants reflect on their lived experiences of difficulties in navigating dual careers posed by career norms and the partner's career. We focus on the lived experiences amongst the StG applicants as a specific reflection of the 'rush hour' of life.

1 At the time of our study, the ERC provided a track for 'starters' (within 7 years of the PhD) and 'consolidators' (8–12 years after the PhD). The two grant programs have been separated since 2013, after our data collection.

3. Data and Methods

The data we use in this paper stem from a research project commissioned by the Gender Balance Working Group of the ERC that aimed to explore careers of men and women applying for research grants. Quantitative and qualitative data were collected from the same group of ERC applicants. Whilst careers in science are relatively stable in structure, where behavior and perceptions can be captured by a quantitative survey among individual scientists, dual careers are non-stable entities. They involve complex navigational issues that are more often than not multi-faceted, layered, and emotional. This calls for a qualitative research approach. We believe that a mixed methods approach applied here adds value by bridging the gap between structure and meaning.

A data-based strategy for integrated data analysis is applied (Baur et al. 2017; Kuckartz 2017). We also applied a parallel design that involves quantitative and qualitative analyses at every stage, with multiple points of integration of the two approaches (see also Figure A1 in the appendix; see also Kuckartz 2017: 166); for example, a document analysis of CVs and written applications for funding by the ERC generated questions for the survey. From the survey results an overview emerged on the prevalence and structure of dual careers in the sample. This information in turn was used in the qualitative analysis of how dual careers are lived, coordinated and, quite literally, worked on–meaning and knowledge that could not be inferred in-depth from the survey alone. In our study, we deliver inferences, for example, with regards to opportunities scientists have taken but also about the many scientifically attractive offers that they have not accepted because of their dual-career situations.

3.1 Quantitative survey and analysis

We conducted retrospective online surveys with samples of StG and AdG applicants in three disciplinary domains of Life Sciences (LS), Physical Sciences and Engineering (PE), and Social Sciences and Humanities (SH) (see Vinkenburg et al. 2020 for more details). A personalized email invitation with a link to the online survey was circulated to those StG applicants (the 2012 application cohort) and AdG applicants (who applied between 2007 and 2012) who had given consent to the ERC for the use of their data for research (33 percent of StG applicants, n= 1,588; 39 percent of AdG applicants, n=4,088). The response rate in the survey was 20 percent in the StG sample and 18 percent in the AdG sample. The sample for the following analysis consists of all survey participants who fully completed the questionnaire (322 StG applicants, 737 AdG applicants). Comparing the samples with their respective population, we find no selectivity in terms of discipline. However, funded grantees and women are overrepresented. We therefore use probability weights relating the sample population with the ERC applicant population based on gender, discipline and grant success.

The surveys included retrospective questions on job positions, institutional affiliations, career breaks after the PhD,[2] questions on employment at time of the application to the ERC and future career expectations. Information on children, partnership status, employment of partner, and combination of careers was also collected. Both surveys were supplemented with information from the ERC on host institution, domain, and application outcome.

In the survey, the ERC StG and AdG applicants where asked whether they have a partner at present. Those with partners were asked whether the partner is employed. For those with an employed partner questions on career *importance* and dual-career *difficulty* were also posed. Self-reported career *importance* was measured with the question "During your relationship, whose career has been/is more important?". The possible responses were: "mine", "mostly mine", "both equally", "my partner's", and "mostly my partner's". For the following analysis, responses on career importance are grouped as "both equally", "mine" ("mine" and "mostly mine") or "partner" ("my partner's" and "mostly my partner's"). *Difficulty* in combining careers was captured with the question "How easy has is it been over the years to combine dual careers?". The possible answers were: "very difficult", "difficult", "neither difficult nor easy", "easy", and "very easy".[3] Here, the analysis groups categories as "difficult" ("very difficult" and "difficult"), and "easy" ("very easy" and "easy") respectively.

We take a more in-depth look at the career and life stage of the StG applicants. We explore career stage by whether or not the StG applicants have completed their PhDs in the previous seven years. We allow for career logics to vary across domains (LS, SH, PE). We use two indicators for international mobility, whether the host institution for the ERC application is outside the applicant's home country and whether the applicant has spent any part of their career in the United States.[4]

3.2 Qualitative data collection and analysis

3.2.1 Data collection

Semi-structured interviews were conducted with 26 ERC applicants (5 AdG, 21 StG) from the Life Sciences.[5] This ERC domain historically shows the largest discrepancy between the share of women applicants and women grantees (European Research Council 2012). From the ERC database, more than 420 applicant CVs were manually extracted. Of those, 140 applicants had requested an exemption. Based on an analysis of these CVs, we purposively selected applicants from seven

2 The survey design for StG and AdG applicants was slightly different, to reflect the relative career stage.

3 For both questions, respondents could choose the option "not applicable". Given this answer, we excluded five respondents from the analysis.

4 Syntax files of the descriptive analysis are available under https://doi.org/10.7802/2543.

5 By CH, SC, CJV.

countries (UK, NL, DE, FR, ES, SE, AT), to ensure dispersion across the European continent, grantees and non-grantees. As a selection method we used a number of items such as (international) mobility, care responsibilities, dual-career issues, institutional support, career conventions and career steps. Nineteen women and 7 men agreed to participate in an interview between July and October 2013. All interview respondents had partners, and were facing dual-career issues at the time of the interview.

The interviews provided rich data for understanding the lived experiences behind the careers of the ERC applicants. We used an interview topic guide (Bryman 2003) around three themes: 1) retrospective career experiences, 2) science, ERC, and career conventions, and 3) work-life and dual-career issues. The interviews were conducted in English. They were recorded with respondents' permission and transcribed verbatim. These transcripts were analyzed and a coding tree was developed in 2013/4 in Atlas.TI with multiple codes and sub-codes, including (among others) dual career*, mobile*, and parent*.[6]

3.2.2 Analysis

We started this analysis by reviewing the relevant quotes collected in Atlas.TI, starting with the "dual career*" code. We proceeded by rereading the complete interview transcripts. While reading, we highlighted excerpts related to career decisions, mobility events, and dual-career experiences. At the same time, we made notes of our first thoughts. We then used results from the quantitative analysis on difficulty and importance to categorize the interviews. We selected interviews from participants where we concluded from their words (sometimes implicit, often explicit) how difficult they had found combining two careers and whether their own career had been most important or both careers had been equally important. We did not look for evidence where the partner's career had been most important, because this category is very small among the survey respondents, and almost non-existent among the interview participants.

We directed our analysis to the respondents who had applied for a StG rather than an AdG because at the time of the interview they were in situations where dual-career decisions and difficulties were more prominent. Our aim was to present the variety in the stories among women and men scientists across Europe rather than 'typical' examples. We use a subsample of eight interviews with six women and two men basing the selection on the dual-career experiences that the respondents reflected upon. In the process of selecting and bracketing relevant quotes, we returned to the original transcripts in an iterative process of analysis, sense-making, and reflection.

In giving voice to the participants, we give them a fictitious first name. We describe their dual-career situation and the presence of children. Because of confidentiality,

6 by CJV, CH.

we omit names of institutions, research groups or laboratories, and physical locations (country, city), even if this information is sometimes crucial to the story in terms of statutory rights, economic situation, and (absent) institutional support.

4. Results

4.1 The dual careers of ERC applicants

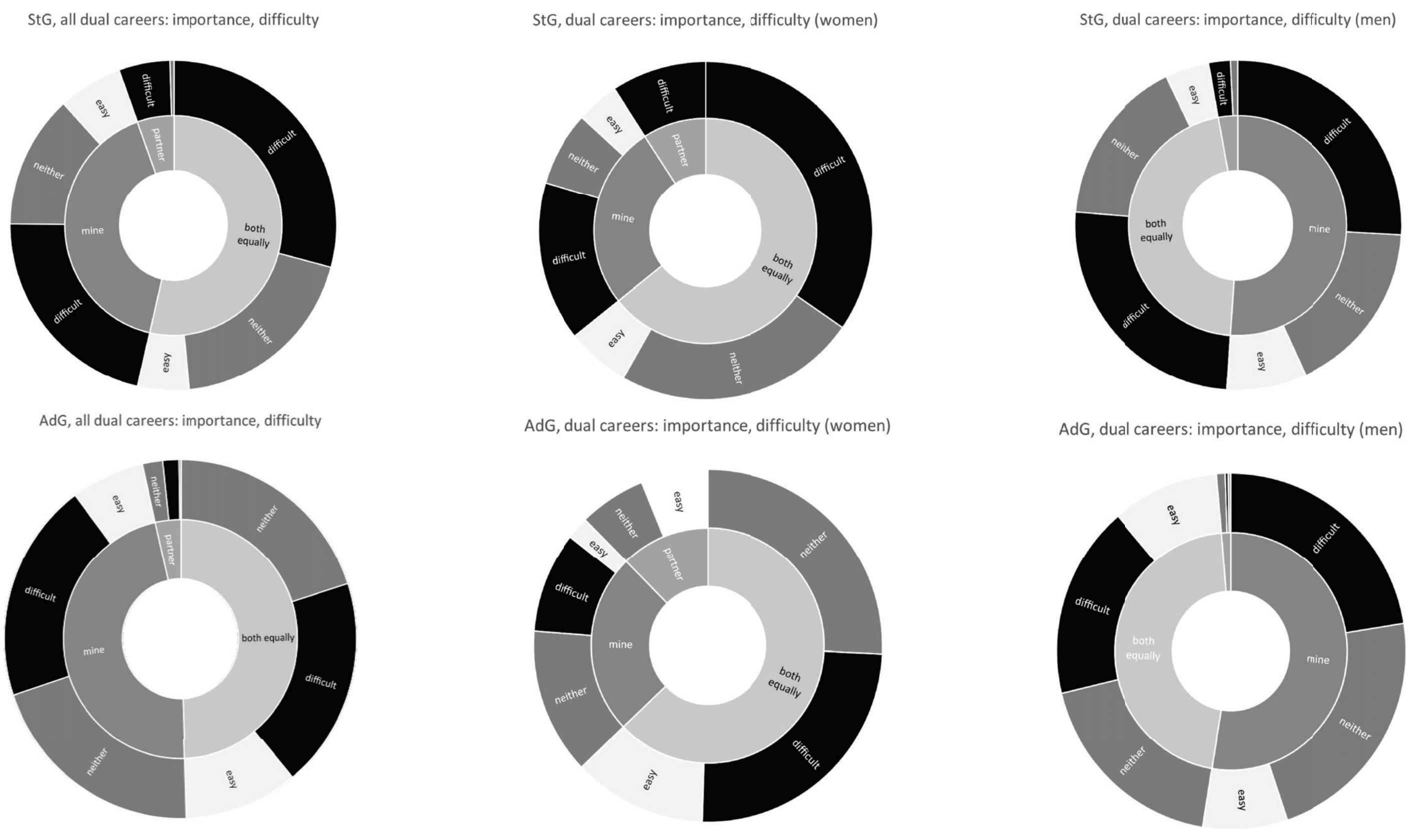
Amongst the ERC applicants, 88 percent of the StG and 90 percent of the AdG applicants have partners at the time of the interview, 76 percent (StG) and 68 percent (AdG) respectively have employed partners. Of those with employed partners, 85 percent (StG) and 76 percent (AdG) have partners working 30 hours or more per week, 50 percent (StG) and 52 percent (AdG) have partners who are also in science, with 25 percent (StG) and 28 percent (AdG) working in the same institution. The figures illustrate that dual careers predominate among both StG and AdG applicants, and dual careers in science are also common.

Of those with an employed partner, 51 percent of the men scientists reported that their career has been *more important*, and a slightly smaller share (46 percent) reports that both careers have been *equally important*. In contrast, most women scientists report that both careers have been *equally important* (64 percent) and 27 percent reported that their career has been *more important*. In both groups, there are very few scientists who report that the partner's career was more important (3 percent of the men StG applicants, 9 percent of the women StG applicants). As with the StG applicants, the majority of men AdG applicants (60 percent) report that their career has been most important, and most women scientists report that both careers have been equally important (56 percent). Again, relatively few AdG applicants report that the partner's career has been more important (1 percent of the men, 12 percent of the women).

The majority of the StG applicants report that it has been difficult or very difficult to combine dual careers (52 percent of men, 60 percent of women). Slightly smaller shares state that the combination of both careers has been neither difficult nor easy (35 percent of the men, 30 percent of the women) and a small proportion that it has been easy to combine dual careers (13 percent of the men and 10 percent of the women). Compared to the StG applicants, a lower share of the AdG applicants report that the experience of combining dual careers has been difficult (39 percent of men, 42 percent of women). A slightly larger share reports that it has been neither difficult nor easy (42 percent of men, 44 percent of women) or easy (19 percent of men, 14 percent of women). In contrast to the statements about the importance of careers, gender differences in the evaluation of difficulties are not obvious.

Figure 1 illustrates the intersection of self-reported career importance and difficulty in combining careers. Answers to the question on career importance are presented

Figure 1: Dual career arrangements, circle diagram, StG and AdG applicants with working partners, by gender



237 StG applicants, 139 men, 98 women; 497 AdG applicants, 395 men, 102 women;
Answers to questions: “During your relationship, whose career has been more important?” “How easy has it been to combine dual careers?”

in the inner ring of each circle and those on difficulty in combining careers are shown in the outer ring. The figures clearly show that high shares of scientists experience difficulties in coordinating two careers both when the ERC applicant's own career is more important and when both careers are equally important.

Having established the difficulties encountered in combining careers, we now investigate the dual careers of StG applicants (Table 1) more closely. Most StG applicants have *children* (72 percent). In terms of *career progression*, StG applicants are split evenly between those at more advanced (more than 7 years since their PhD) and those in relatively early career stages. In terms of *discipline* the largest shares of applications come from the Life Sciences, including medicine, and Physics and Engineering. Finally, regarding *international mobility,* a quarter of the StG applicants applied to the ERC with an institution outside of their home country, and 28 percent have spent time in the United States.

Next, we use the intersection of career importance and difficulty in combining careers to take a closer look at the sample and explore any potential relevance to navigating dual careers for women and men scientists.[7]

The men StG applicants who assign greater importance to their own careers (table 1, columns 1 and 2) are slightly more established in their careers in terms of time since PhD. Amongst those who say that their career is more important and who did not find the combination of dual careers difficult, there is a lower share of fathers–61 percent report having children as opposed to 83 percent of those reporting difficulties in combining two careers. We also observe less mobility in the group of men who report that both careers were equally important–about a quarter reports employment spells in the United States as opposed to a third among those who report that their career is more important. Turning to women StG applicants, more of those who report that combining careers has been difficult, especially when careers were equally important, are mothers–81 percent compared with 67 percent amongst those who reported that careers were equally important and that combining them had not been difficult. Women StG applicants who have applied to the ERC from an institution outside their home country are more likely to report that their career was more important and that combining two careers was difficult. Finally, both men and women StG applicants are more likely than AdG applicants to report that combining careers was difficult. Despite the heterogeneity of the sample, it can be seen that the partner's profession, the presence of children, career stage, and international mobility are to some extent related to the difference in experience of navigating dual careers, and this is largely similar for women and men scientists. In the next section, we supplement this descriptive account with insights drawn from the interviews on the lived experience of navigating dual careers.

7 The group of StG applicants who say that their partner's career has been more important is not included in the in-depth description due to the small number of cases.

Table 1: Characteristics of the men and women dual-career StG applicants, by career importance and difficulty (weighted %)

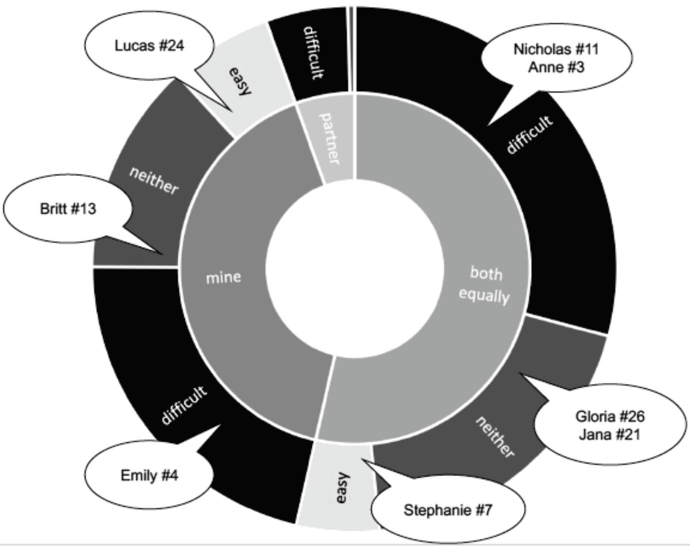
	Total sample	My career, not difficult	My career, difficult	Equal, not difficult	Equal, difficult
Partner academic	*45*	*40*	*38*	*40*	*58*
men	44	40	37	41	57
women	48	43	40	40	62
Children	*73*	*62*	*81*	*71*	*79*
men	73	61	83	72	77
women	73	69	73	67	81
More than 7 years since PhD	*52*	*56*	*58*	*42*	*54*
men	51	60	56	35	51
women	56	(36)	64	54	61
Domain					
LS	*39*	*28*	*40*	*44*	*43*
men	38	24	40	45	43
women	43	51	39	42	44
PE	*41*	*51*	*39*	*39*	*37*
men	46	55	47	49	34
women	29	(27)	(12)	23	43
SH	*20*	*21*	*21*	*17*	*20*
men	16	21	13	(6)	24
women	28	(22)	49	35	(13)
ERC host not in home country	*24*	*37*	*29*	*16*	*17*
men	22	36	23	16	15
women	28	40	50	16	23
Any spell in US	*28*	*32*	*36*	*26*	*22*
men	31	33	43	27	22
women	21	(25)	(9)	24	23
n	*224*	*46*	*51*	*58*	*69*
men	135	35	36	29	35
women	89	11	15	29	34

Cell frequencies n<5 in parentheses

4.2 *Reflections on lived experiences of ERC StG applicants*

In the interviews we have identified compelling stories on navigating dual careers in science. Informed by the quantitative results, we present the stories according to the prevailing impression of how difficult it was for the ERC applicants to combine two careers–although nuances and shifts may become apparent. We provide substantive excerpts that show these stories, combined with our own short reflections.

Figure 2: Dual-career arrangements of the selected interviewees



4.2.1 Difficulties in combining two careers

Nicholas speaks about the difficulties he and his partner experienced in navigating dual careers during the early stages of his career in science when he got a postdoc fellowship. At that time, they had two young children.

> Well I-I went before the family to the [United] States for um-for a few months and as I said I haven't been to the place. I was prepared to take my suitcase and go back. Um-but it turned out to be nice and-and I found a good house to rent and they came over, but in this um-period my-my wife got a job and she just couldn't resist. So here in [home country], and then um-so she moved back after a few months only and um-with the children. And um-well, being a [medical doctor] she couldn't easily be working in the States without doing numerous tests and um-. Yeah, it was really not worth the effort. And we had, the children were small. And um-well she was anyway not so um-happy just being there quite alone at home and so. So she moved back with her stuff. And um-. So um-during the [short silence] I still felt that it was so rewarding that-the the postdoc work was so I wanted to pursue and um-to enjoy this five-year postdoc fellowship I had to be abroad at least two years and um-. So that was somehow a minimum limit and um-Um-so I simply had to go back and forth. Well, not too frequent, but say every two to three months I went over for a week or two. And um-so after two years in the States I moved back. I probably would have stayed longer if-if the family situation was um-was different. But um-somehow we um-we managed to-to survive haha. And I realised also that um-my wife might have had a tougher time being alone with small children.

> I could bury my sorrow with work and you it is um-and then um-well [short silence] since then [short silence] well I-I have tried to-to um-um-quit work early enough to-to spent time with the kids and-and still do now they are teenagers. (#11, careers equally important)

The experience of Nicholas shows how combining a career in science with a career outside academic science can create an “obstacle”, as he referred to in their situation. Moving to the United States, a requirement of the fellowship he received, resulted in a dual career cycling dilemma for him and his partner. While Nicholas expresses some ambivalence before taking up the postdoc, having arrived in the United States, his experiences of his postdoctoral position there are very positive. His partner, in contrast, was unhappy because she could not pursue her own career in medicine in the United States without certification. After a few months in the United States, she moved back to their country of origin with their children because of a job opportunity that “she couldn’t resist”. Their solution was to live apart together, and for Nicholas to visit regularly while staying in the United States for the minimum possible period. However, he argues that he would have acted differently if the family could have stayed with him. Nicholas’ career has been influenced by his partner’s career decisions, reflecting a competing process (Moen 2003).

Nicholas explains how, due to these shifts in prioritization, the combination of a dual career with care responsibilities had been hard for him and his partner. He missed out on some of his children’s early years, but he plays down his own situation with the recognition that it was harder for his partner. Nicholas also indicates the strain on their relationship when he looks back at that time: “Somehow we managed to survive”.

We next listen to *Anne*, who tells us she has never lived in the same country as her partner, who is the father of their two children. She explains how structurally living apart together works for her and her partner, in navigating dual careers in science. However, a recent job offer has forced her to reconsider their situation.

> And-um… and-um... yeah, it’s a bit-we have a bit of a special arrangement, because actually since I went to the U.S. I’m with my, well we’re not married, but with the same-the father of my children..., but we never lived in the same country, so-um, he now still lives in [country x].and-um... and let’s say the job offer in [country z] would have a position for us both...... and-um, so [partner] um-um, comes in for weekends since we have children, and then he works four days, and so he’s three days here [in country y] and four days in [country x]... and-um, that works great. So-um... and-um... yeah, so it’s um-I waited with having my children ‘til I-‘til I got a permanent position... And that-that’s nice so it’s-it’s all going quite well, um-.. also with the children, they’re doing great, and-um... so-um... and the only-um drawback is that-but that’s basically because my husband lives abroad, is that it’s quite difficult for me to go to conferences... so I don’t do that often enough, because it basically means that-um he has to take a week of holiday, to be here... and-um, that’s not always possible. So I-I-I... I don’t go as often as my colleagues...
>
> […] *And at the time you had your first child, was your partner abroad as well?*
>
> So he was in [country x] also at the time. He actually missed the birth because it was qui- so early-um-it-it was two days after my maternity leave started, so it was four weeks early. And

> then-um… she was born within three hours or something… […] and then with the second it was also… because then, she was a th-threatened to start very early so I was in the hospital for a week to stop everything, delaying everything… and then he stayed with me, but then it… still took another three weeks so… [laughs]. And then they-he actually got into a bit of a conflict, with his boss over there… who thought that was not okay, to just stay here for so long. […]
>
> But the thing is, yeah I know, we are together for a long time already and it, it goes very-very well, but […] if we are there in [country–z – where the job offer is], and it wouldn't work out, and we would get separated…and our children wouldn't see their father often anymore, and I would be there on my own, for what? So I didn't wanna do that. I felt this is it, this is great as it's going now. (#3, careers equally important)

In talking about their "special arrangement", Anne explains how it is "great as it is going now". Through living apart together, a synchronic process has been achieved. However, there is evidence of a (possible) dual-career cycling dilemma. She recently received an attractive job offer in another country, where there would be a very good position for both partners. In talking about turning down the job offer, Anne mentions trying to avoid disrupting the current arrangement that works well for everybody, including the children. For Anne, the main drawback of their arrangement is not being able to fulfill the academic requirement of attending conferences as easily and often as her colleagues. Looking back, the most difficult time was when their children were born. The wait for a permanent contract, the absence of paternity leave, and the career expectations raised by the partner's supervisor and colleagues are part of this couple's dual-career navigating efforts.

The complexities around navigating two careers and possible consequences of a future mobility event are also evident in the story told by *Emily*. She will be moving with two children to the other side of the country for her new position, while her partner (who is training to become a medical doctor) stays behind:

> Everybody's situation is very different. I think that's the first thing that has to be understood… and when- we only got married in 20** and my husband was living in [country a], he's from [country c] originally, and when he first um moved here [to country b] he didn't have a job, he had to work for free […] as his qualifications are not recognized by the system so he had to do his training all over again. Um, and to get a foot even in the system he had to work for free for a year, which included, um- we were pregnant fairly quickly after we got married, so…um, that included after the first child was born, which contributed very much… a lot actually, to me choosing not to take much maternity leave. I'm not sure I would've done it differently anyway but I can't go back and do the experiment, and this organization only provides, at the time, it was only 12 weeks at full paid maternity leave, um, and if you took any longer than that, then um, you only got, can't remember, six weeks of full pay and then- it-it was ridiculous we never would've been able to survive, because we were only surviving on a single wage anyway. Um, so I took the twelve weeks plus four weeks holiday that I had accrued… and that's how I ended up having sixteen weeks off. Um, and because that actually worked… and wasn't so dreadful…that's what I did again with the second one. Cause it really was ok actually, to an extent that… to me, working was still the norm.

In the story about the time they started their family, Emily talks about how her partner had to restart his training after moving to her country of origin when first married because his medical qualifications were not recognized. During this time, they lived on a single income and she took relatively short maternity leave by local standards. It helped her that she felt like "working was still the norm"– which is why she decided to do the same with the second child. Mobility, absence of accreditation of international qualifications, and limited paid maternity leave resulted in a dual-career cycling dilemma manifesting as a competing rather than a synchronic process.

In their current situation, Emily finds that the complexities lie in trying to meet their career requirements with their ideals of sharing childcare:

> Right, so the biggest problems for us […], is I want, and he wants the childcare to be 50/50. We want it to be 50/50. What that actually translates to is that the weekends we're taking shifts rather than doing parenting together... and on a personal level that makes me extremely sad, 'cause we both need our down time, we need a little bit of rest, so we end up just not seeing each other, and I'll take the kids away at this point, you take them away at that point. But it's mu- it's much worse than that. He's on call two weekends a month, so that means every other week... I am simply childcare at the weekends, which is fine, I like being with the kids, but it's a bit exhausting, because I've also worked all week. […] Cause I actually felt that maybe- 'cause his job is more vocational than mine, nobody else can run the [her last name] lab except me... I did wonder if he, you know, might want to do four days a week for example... but he really didn't... he said that he didn't feel it would be conducive to his career progression at all, actually.

Again, there is evidence here of ongoing dual-career cycling dilemmas and a competing process. While Emily describes her partner's job as "more vocational" than hers, she also recognizes that "nobody else can run" her lab. However, her husband is regularly on call and does not want to work part time, as it might adversely affect his career. Trying to achieve a 50/50 split in responsibility for childcare whilst each meeting their career requirements leaves Emily sad and exhausted. Taking shifts in parenting and not seeing each other adds to the burden. She next talks about how she is moving across the country with the children, while her partner stays to complete his training:

> Yes, I'm moving, yes. Um, yeah I'm not looking forward to this bit. That's gonna be difficult. I'm really looking forward to the move, I'm really looking forward to working in [town]. I think it's going to be- I think I'm going to be much happier there actually. But-um, I'm not looking forward to the 10 months of being a single parent. I'm really not looking forward to that. […] He will move eventually, yeah. He can't- he tried to get a transfer, but it wouldn't been- it was never really gonna happen, he's only got a year left, so it will be next August…he's only got a year left on his training, over a six year training course. […] So, we did um… and ah… about leaving the kids here, although I felt physically sick actually at the thought of not being with the children... I know he's not unhappy about it but it's not as visceral with him, and I don't know if that's how it should be, or you know [laughs]. Um, but maybe 'cause they're still quite young, maybe if they were a bit older I wouldn't feel... quite the same..., but it made me feel like "Agh, no I really don't want that", so I also then rationalised it and thought "if I move and take them with me, it's disruptive, but they'll have their mum with them and then dad will join us..." Whereas if I move...and leave them here, then they're without their mum for a year, and then they still have to move and be disrupted anyway... 'cause we are moving and this is happening. So, you know? I think that's-um... [...], yeah, I wanted to go, to... I guess it's sort of my fault really [laughs]. I wanted to go and now is a good time. But it's-it's not an- like you-you have to, right? Because it...Yeah no it's been an awkward- it's been a difficult year. (#4, own career primary)

Emily mentions that whilst she is very much looking forward to working at this new place she is concerned about the year ahead. The decision to move with the children and to live apart was not easy but it will only disrupt the children's lives once instead of twice. She prefers for the children to be with their mother, even though this means she will have to be a single parent for the time being. The expected benefits of the move and shift in priorities and responsibilities outweigh the negatives.

The stories from Nicholas, Anne and Emily show how the mobility and dedication required in science, combined with the non-portability of a partner's career, can create difficulties and disruptions in the linked lives of dual-career couples. All three stories relate to sacrifice in trying to reconcile often competing career and family demands. An opportunity for one partner (whether it is taken or not) generates dual career cycling dilemmas and may necessitate shifting priorities. A synchronic process is difficult to achieve but taking parental leave or working part time (if possible and paid) can help navigation. These stories also reflect gendered expectations of who is the primary caretaker of children, internalized as well as voiced by supervisors. In these stories, the scientists have all spent (or will spend) some time living separately from their partner, during which time the children (will) stay primarily with their mothers. Therefore, also while living apart, mothers provide more childcare than fathers. Regardless of perceived career importance, structural factors such as the accreditation of professional qualifications and the length of parental leave add to the lived and voiced experiences of difficulty in navigating dual careers.

4.2.2 Difficulties and ease in combining two careers

Gloria lives with her partner, who is also a scientist, and two children, in their country of origin. When they were postdocs, they moved together to the United States. She reflects with great joy on their experiences abroad:

> My husband was waiting until I defended my PhD, because he was postdoc. So, he was a higher level than me at this moment, in [home country]. So, after that I proposed him, "Okay, uh, come on to the postdoc outside, abroad," and I wanted to go to a very, very good university. And I started to write to different universities, and he was making the same as me. In order to try to go to very close universities. We had to combine our family, and our personal situation with work. So, we know a lot of couples that, uh, was happening the same, and they are making the same things, so trying to combine, and in California we found, finally, this […].I decided after the interview that it was fine, and that they were interested in me, and in the same time, my husband was, uh, looking for another laboratory in this place, no? […] We wanted to go to California. [Laughter] And the – the West Coast than the East Coast. [Laughter] And because there is a level – a very high level on science, and there are a lot of universities in which you can go.
>
> […] So, we just married one week before – before going to [town z]. […] I went with a D1, and he coming with me; he was coming with me with a H1, like a dependent on me. Uh, he got – he got a contract with [A] before, but uh, he was to wait for the documents. He needs to take the documents from [A], come back to [home country], change the visa, and then come back again to – to [town z] […] So, uh – initially it was a little difficult just for this detail, but – but after that we were working in both universities- and it was really great. So, we like it, and – yeah. […] He was a doing

a postdoc in [A], so we were living in the – initially we were living in [small town y]. It was a little, uh, silent for us [compared to] – living in [city in home country]. [Laughter] So, after six months we decided to move to the center of [town z], and uh, in the mornings, my husband – I usually drove my husband to the [train], and he took the [train] […] to [A] every day – every morning. It's morning, and then I was driving to [C] in one hour each morning, and this was our life – From 9:00 a.m. to 9:00 or later – later – uh, the laboratory working — making science, – and after that, uh, we decided to come back. […] Yeah. It was – it really was a – we had to make this decision, and um, for me it was very, very difficult, because I didn't want to come back. No. I didn't want to come back. I wanted to stay there […], but my husband wanted to come back. He was happy because, um, he was very, very happy with the laboratory, and with the research. He got, uh, publications, and it was fine. But sometimes you miss the family; you miss your – Yeah, much or more, you usually miss your country, and I am really much more happy than him, and – [laughter] – he was happy, but, uh, he had clear – a clear idea that he wanted to come back.

Despite the initial difficulties with her partner's visa, seeing other couples doing the same was a source of inspiration for Gloria, and we hear a sense of achievement that it worked out. Moving to the United States shifted priorities but also resulted in a synchronic process about which Gloria reflects positively. Moving back to their country of origin was not what Gloria wanted, but her partner was homesick. Following the move (and presumably after the children were born), Gloria felt it was necessary and possible to invest more time in her family:

And this is because I started to invest much more time in my family, and less time on science, […] and when you have children you have to invest to them – in them these hours, no? So, usually you have less time to write, less time to read. You have like emergency – emergency situations, like suddenly you're in the middle of experiments, and you have to go to attend the child at school, or things like that, no? And in my case I used to combine with my husband, so 50/50. So, it's, uh, 50 percent my husband, and 50 percent for me. My husband being a scientist, too. So, we used to try. […] I mean the kind of experiments that we are making that usually are different, so we try to combine the experiments of the mother and the father with the family hours, and the schedule of the times, no? And I believe – I have a lot of – I'm very lucky with that. Because I mean women, that have a husband working in an enterprise, that they have less flexibility in the schedules. (#26, careers equally important)

Gloria and her partner appear to have resolved the dual-career cycling dilemma that followed from their return to their home country. Feeling the need to invest more time in her family, and with both partners trying to balance their lab experiments, Gloria perceives herself as "very lucky" because as a couple they manage a 50/50 task distribution and can deal with emergencies. She sees this as a consequence of both being life scientists, which provides more flexibility than other lines of work. Both the move to the United States and the return home generated some difficulties but the lived experience shows enjoyment, relative ease, and mutual support.

Jana and her partner are also both scientists who have two children. They do not live and work in their country of origin. At the time of the interview, they both work in the same research group. Jana tells about the path that led to their current position.

Um-so my boss at [city Jana is currently working] she wanted to um-to have such a lab like the method which I knew and um she called me haha in [city in the same country Jana was previously

> working]. This is how I moved. So actually my husband is also in science so we looked together for positions. We have a dual group now so haha to make careers parallel. And we had like um-shortlist choices between [city in the U.S.] and [current city]. And then somehow we decided for kids and [current city]. Haha and that is how we moved there. [...]
>
> *Okay. And was it um-the lab that made you decide for [previous city]?*
>
> Yeah, it was first it was the lab and second um-because they had two positions also for my husband and um-that um-we um-like in the end we also had the choice between [other city in the same country] and [previous city]. And we also thought of practical reasons haha.
>
> […] *when you had to make that decision a long time ago between the U.S. and-and [current country], what was the reason for you to…*
>
> Pure social reasons. It was kids and citizenship […]
>
> *Haha. Yeah. So um-and did your husband also apply for the [other European country]?*
>
> Yes. First applied for the [other European country] and I think [a second European country] also. He had an interview in [this second European country] and then he also started applying for [current country] and um-finally we found the optimal um-position. And end in [current country]. [...]
>
> *You already said you and your husband have both a career, … you have dual careers. How do you experience that-that combination?*
>
> Um-we never tried different way, so it is difficult to compare. um-I think it is not easy. I-I um-I wish we would have sort of I don't know mentoring or training or whatever, there are only few such couples. For now another four couples altogether and we know several hundred scientists. For couples that have this sort of career. um-but yeah of course we have some struggle for power haha so like this but um-yeah it works in some at some stages it is really optimal because I can ask him to do something and I do something else. Or if I am concentrating on grants then he can supervise students or vice versa. So we um-can combine and also in terms of collaborations it is easier to me for me to work with some particular people and for him with other people, but it works so haha it is also sort of easy in a sense. (#21, careers equally important)

Jana explains how she and her husband navigated their dual career simultaneously in terms of timing and location. They had applied in various countries and had been invited for job interviews. Because they were both pursuing scientific careers, finding two positions in the same area or institution was the decisive element in choosing from multiple options. Their children and obtaining citizenship informed their decision to stay in the country where they currently live.

According to Jana, they have found the "optimal position" for both. At the same time, Jana says that combining her career and that of her partner is "not easy"; there are also "struggles for power". Moreover, she speaks about the lack of role models, due to the very few couples she knows that "have this sort of career". This motivates her desire for external support like "mentoring or training" to learn how to cope with the difficulties of combining two scientific careers. Still, working in the same research group has multiple benefits and she refers to their situation as "sort of easy in a sense". When reflecting on their situation, Jana addresses both the ease and the difficulties of navigating dual careers. In searching for and deciding on these positions as well as in establishing a dual lab group, they escaped the dual-career cycling dilemma inherent with one partner relocating. However, their lived experiences reflect some difficulties and power struggles on a day-to-day basis. Zooming in on the apparent synchronic process reveals evidence of competition. From Jana's story we learn that a "lab" is important in determining the place of work, but the (future) benefits for children and citizenship also influence the decisions of a dual-career couple in science. Next to job opportunities, social and practical factors are considered in navigating dual careers in science.

Britt's story also shows how career decisions are intertwined with factors that are not related to science. Her story starts when they were living in her partner's country of origin with a very young child, and she reflects on the next step in her career:

> Um, I had been offered, um... two postdocs. One in [European city], and one in [the U.S.]. But [city] was not do-able for my husband because it's too expensive to live there on one income... So... he couldn't-we couldn't afford living there on one postdoc salary, and he wouldn't be able to find a job there [because of the language]. And the same with [U.S.], he wouldn't be able to get a green card. [...] So when I got a fellowship, I moved.

When asked whether she moved by herself, Britt explains that they relocated together, as a family, back to her home country and the institution where she had also obtained her PhD.

> So my husband's a plumber, so- and he's been incredibly supportive so he's come with me wherever I wanted to move. And-um... when- like I said, when I turned down my postdoc grants, that's because we couldn't afford it, not because he said "no". So we decided it was too expensive. And-um being a plumber he can work anywhere they speak English. I mean, it takes him four days to get a job and it takes me four years.

Financial aspects and existing (in)formal support played a considerable role in their decision-making. When their child was born in her partner's country of origin, she had extensive maternity leave but there was no statutory paternity leave.

> My husband was not allowed to take paternity leave, because that doesn't exist there. So, he had to negotiate a lot with his company to be able to work, he also worked four days a week, so he could counterbalance, like shuffle around, [the caring] between us.

Since their move to her country of origin, her husband has been taking on most of the care responsibilities for their child.

> My husband's taken most of it- which is great. Um, because he doesn't want a career, he works to get money and nothing else. So he's almost taken all the sick days, he's taken like- he's used a lot of paternity leave to extend holidays, and so he's taken the... yeah, more than me. So he's been... it's been very-very good. That he- because he wanted to be more involved. Um, and it took him a while, because I'd been the main carer before then… [It was made possible] because of the support by the... by the government, because we had the financial support to do it, and because it was- because-um... I guess because of legislation... because you can't... legally dads are as much parents as moms here. [...] When female undergraduates ask me for career advice I said "choose your husband wisely!" It's like- it's-it's the biggest- if you look at people who are successful in science, you have to have a supportive husband. Like if he's not, if he's not supportive, you just not- it's gonna be impossible. (#13, own career primary)

Britt's story shows how her career has been primary. She explains that her partner has become the primary caregiver since relocating because he does not "want a career". Even though it took a while to get used to this shift, Britt elaborates on how his involvement has been "great" for her career. She says having a supportive partner is necessary to be "successful in science", and even "impossible" without one. However, there is a dual-career cycling dilemma evident in their decision on where to move, because of language barriers and work permits. Even if she says his profession is not a "career", deciding between her postdoc offers was largely based on the likelihood of a job for him. Additionally, navigation is made easy (or difficult) because of the availability (or lack of) financial support from the government for parents, paid leave, and informal support. Living on one income would not have been possible, so it was necessary for them to find a location where they both have an income and/or generous financial support for care. The local norms tied to statutory rights around care help, when "dads are as much parents as moms".

From the stories of Gloria, Jana and Britt we learn that combining dual careers can be both easy at times and difficult at other times. Mobility, and especially international mobility, complicated the navigation of dual careers for Gloria, Jana and Britt, resulting in dual-career cycling dilemmas, shifting priorities, and intense decision-making between partners. A synchronic process is sometimes achieved or alluded to, but competition may still occur. These stories show us how working on precarious, temporary contracts creates difficulties, forcing scientists to find new positions. However, they also give us an insight into times when navigating dual careers is easy and joyful, and how statutory rights (e.g., paid leave) and relative flexibility can help. Working in similar places, finding an optimal place for both, and shifting who is the primary caretaker can ease the navigation of dual careers.

4.2.3 Ease in combining two careers

Lucas is supported by his partner in pursuing his career ambitions. At the time of the interview, Lucas and his partner live with their three children in their country of origin. His partner also has a PhD and did a postdoc. Their careers started off quite similarly. The timing of their positions abroad and their return to their home country is interwoven with the birth of the children.

> And she didn't start to work in-um-in [foreign country], because we had the baby and then-um... we-we-we said, "ok, for a year there is a break". And-um, and she found a postdoc in the second year while we were there. So we said, "ok, I will postpone my return on this position I was just awarded, um for a year. So that's why we s-stayed three years. Basically after two years and a few months I could've come back in [home country] with this [institutional] position but we delayed that a bit. That's why we came back only in January the-um-the-um... the year after". "She did a PhD, um... and then postdoc, and then after she found a position-um in-um -as-um a manager of-um scientific platform – technical platform when we came back to [country]. Then she stopped again to...work um for three years because we had another kid in um... while we were [abroad], and when we came back to [home country] we had the third one. So she stopped for three years, and now actually she starts again. But, well I must say that what was also very easy is that my wife was not-um driven by her career, you know. Um, her career was not her main lead- is not her main lead in her-in her life. So this made...really the-um- all the path very easy. Because-um if we had to... find a way

> to accommodate her scientific career and my scientific- this would have been more challenging, but-but in her case it was like, less pressure on that side. That-um... So I could be leading my-um, my-my-um career-um very ambitiously, and-um, and she was-um... supporting me a lot...... for that. So this is great. I mean you've seen we moved and then I could start the postdoc and-um my wife was looking after the-the kids and-um this was really helpful. (#24, own career primary)

Before returning to their country of origin, Lucas explains, he and his partner both worked as scientists and took each other's careers into consideration when deciding between opportunities. This resulted, for example, in a longer stay abroad than anticipated because of her postdoc position. Yet, it was Lucas' partner who stepped back when each of their children were born. Relocation and having children resulted in multiple dual-career cycling dilemmas. While this started off as a competing process, the return to their country of origin and the birth of their third child resulted in a shift in the importance of the two careers.

When reflecting on this shift, Lucas says his partner being less career-driven made the "path very easy" for him. He believes that accommodating two scientific careers "would have been more challenging". In his experience, he could pursue his career "very ambitiously" because of the support from his partner.

Stephanie experiences support from her partner which helps in pursuing her career. They live with their three children in their country of origin. Stephanie explains how her career so far has unfolded "very smoothly" and how the support of her partner, a pediatrician, and the sharing of care responsibilities have facilitated her career.

> Yeah and that is also how I see, for-for me […] is the critical position in your career after your PhD for postdoc to group leader I think that is the um-the tricky point where a lot of people yeah. If you can past that point then um-that is the most critical point. And for me that went very smoothly. […]
>
> Yeah. And then um-after that [maternity leave of the first child] I um-started working again for four days a week. And that was what I continued after. And that is um-works fine although I realised the work you are doing is not fu-fitting four days. Because it is more a fulltime job, but yeah, that is how it is. But um-um-for-for me and also for our family it works fine to-to do it like this. Because I work four days a week. My husband is a paediatrician, he also works four days a week and nah that works…
>
> *That works out.*
>
> Yeah, that works out. And um-then also for the second um-child also the same pregnancy leave and the third. And what you realised that in the second pregnancy leave you continue some activities and for the third even more. […]
>
> *Do you have another network of support outside work or?*
>
> Yeah.Um.my parents and my parents in law take care of the children every Wednesday. And especially my parents um-are very helpful when I go to conferences or meetings and to be honest without them it would not be possible to do it like this. And my husband is a paediatrician so he doesn't have many um-conferences, but he also has night shifts so we can combine that very well and he is also very um-um-support that we really share the care. So when um-he is off on Monday and he does everything the children and bring them to school and to the swimming and um-swimming lessons and um-So he does really a lot. So we-we really…

> *Equally divided it.*
>
> Yeah. Yeah. And he also supports me in the um-in doing-doing this. So that is good. (#7, careers equally important)

Stephanie reflects on how she and her husband combine their careers and share the care responsibilities for their three children. In their country, it is increasingly common among educated parents to move from a five-day to a four-day work week following the birth of the first child. However, Stephanie explains how, for her, a job in science "is more a fulltime job", which she seems to accept because "that is how it is". Consequently, she continued working on tasks that she could do from home during the maternity leaves for her second and third child.

Stephanie experiences ease in combining two careers. She attributes this ease to sharing care responsibilities, to both working four days, to her partner's work (with night shifts but no conferences), and to the active role of the (grand)parents. There is little evidence of dual-career cycling dilemmas.

Lucas' and Stephanie's stories show how partners and (grand)parents play a vital role. The arrangement of Lucas and his wife is more traditional or gendered, but both show how support from their partner in combining work and family has been crucial to their own career. Also, shifts in priority can result in the perception of ease in navigating dual careers.

In conclusion, these six stories provide rich insights into the question of how dual careers are navigated, and how career opportunities, decision-making, sacrifice, and compromise all play a role in the pursuit of dual careers. The stories and lived experiences of the ERC StG applicants interviewed bring dual-career cycling dilemmas to the surface (Rapoport/Rapoport 1969). What may seem independent turns out to be deeply linked, especially when relocation decisions need to be made. While career commitment is rarely contested, both productivity and mobility including conference travel are said to be restricted due to the dual-career situation. The extent to which a synchronic process is achieved is related to opportunities but also to the availability of (in)formal support from (grand)parents, supervisors, institutions, and government (Moen 2003). While there are many tales of pressure and problems, knowing or seeing other couples successfully navigating dual careers and care responsibilities serves as a source of inspiration. When partners are both scientists and especially in the same discipline, they are better able to understand and support each other. This could be an advantage when it comes to joint mobility, but is also where individual norm-bending navigational strategies are found, such as living apart together.

5. Discussion

We explored the lived experiences of difficulties and ease in navigating dual careers in science by surveying and interviewing a unique select sample of European scientists; those who have applied for an ERC grant. Our study shows that scientists do not navigate their career in a vacuum. The majority of ERC applicants have a partner, most often an academic partner, and children, meaning that dual careers and parenthood are the norm among scientists. In the coordination of dual careers there is not, per se, a prevailing type of relative career importance. The numbers of men ERC applicants reporting that their career is more important than that of their partner and those reporting that both careers are equally important, are about the same. However, among the women ERC applicants, the majority reports that both careers are equally important. As the ERC grant applicants surveyed have already invested heavily in their career, and future career investments are needed, it is not surprising that only a few regard the career of their partner to be more important. However, giving priority to the partner's career may be the reality for scientists not in our sample who are in less demanding research positions or institutions, or who have left the research system altogether. In fact, some of the partners of those scientists interviewed for this study have left science following the birth of children. Navigating a career in science alongside the requirements of a partner's career and family life is not easy. Difficulties in combining careers are widely reported by the ERC applicants–amongst those who say that their career was more important as well those who give equal importance to both careers. This is not only the case for StG applicants who are emerging scientists in the so-called 'rush hour' of life but also for established scientists (AdG applicants). Thus, the dual-career experiences of the scientists seem to be relatively universal and are not limited to certain life stages.

The qualitative interviews with the StG applicants reflect the lived experiences of prioritization and difficulty in navigating dual careers. It becomes apparent that they want to comply with the ideal scientist norm, which is built on an individualistic model of unrestricted mobility and dedication, but experience this to be a myth. In dealing with dual-career cycling dilemmas that arise following a job offer and (potential) relocation, there is evidence of the conceptual competing and synchronic processes of the dual-career interface identified by Moen (2003). Interestingly, there is no evidence of an independent process, perhaps because all of our interviewees have care responsibilities. Striving for an equal distribution of care responsibilities is important to the ERC applicants, but it is also a constant struggle alongside a scientific career. While most people follow strategies that bend their personal lives to their professional career (Moen 2003), the dual-career cycling dilemmas and location decisions of the interviewees can also be viewed as evidence of bending careers to personal lives.

International mobility is one of the most important factors that makes continuing coordination necessary and difficult, challenged by restricted portability of the partner's career to another country. Against this background, the scientists' stories are not only about opportunities taken, but also about attractive offers that are not. As job offers can also enable new options, the search for an optimal position for both still requires effort and assessment of external factors. On top of considerations regarding working opportunities for the partner, considerations about what is best for the children also play a role. Children and partners can be a primary reason to stay in one place–often the home country–or to choose a specific place. Interviewees mention the opportunities that occur with specific funding and parental leave legislation, nationally regulated work opportunities as well as the restrictions imposed by their partners' employers. Against these complexities, the scientists' narratives are testimony to how navigation rests on their shoulders. It should be mentioned here that all scientists in dual-career couples struggle, even when the partner 'only earns money'. Finally, difficulty and ease go hand-in-hand in the scientists' lived experiences of navigating two careers, such as that when family life seems to run smoothly, the requirements of a scientific career may nevertheless still be perceived as difficult to meet–or coordination may be temporarily difficult or easier. Even scientists who report that the combination of two careers was easy for them, gradually nuance this in the interviews.

Our study also comes up with important issues with regard to gender. The requirements at the interface of family and work are similar for women and men scientists. The share is similar between men and women ERC applicants when it comes to having partners who are also scientists, and to having children. Hence, the importance of managing dual careers for both and the constraints set by the portability of the partner's job concern women and men scientists alike. However, gender differences become apparent in the quantitative data as more men and women scientists say that their career is equally important as that of the partner. With the data we have, we cannot comment on whether the responses to the survey or the interviews follow from egalitarian norms or (less or non-)egalitarian practices. Even if egalitarian ideals appear to be common in scientist couples, such as "50/50" models mentioned in the qualitative interviews (see also Daminger 2020), the scientists' stories about caretaking are quite gendered. Gender differences and gendered norms arise when (re)location decisions need to be made for the children. In the interviews, retrospective sensemaking occurs where parenting norms take center stage, such as when couples have to commute, or decide to live apart together. Gender norms exert significant pressure on scientists who are mothers. The prevailing argument that the children are better with the mother illustrates how the decision-making of the couple is framed by internalized gendered norms regarding work and family (Livingston 2014). Normative, gendered ways of behaving are hard to separate empirically from deliberate choice (Moen 2003). However, these non-egalitarian practices can turn into a disadvantage for women scientists, making it more difficult for them to meet career requirements and to fit ideal scientist norms. In some countries the statutory rights for mothers and fathers are equal and parenting norms are less gendered, which is clearly beneficial for the scientific careers of women.

Our study has limitations and offers points for future research. First, the findings represent a snapshot of the scientists' retrospective dual-career experiences. The stories from the interviews show that priorities and difficulties shift over time, and that there are even difficulties for those with a partner who "does not want a career", or for those without children. To explore dual career navigation over time, longitudinal data are needed that follow scientists over career transitions and family transitions. This is important in order to capture how two careers affect each other instantaneously, the temporality or so-called local interdependence of linked lives (Fan/Moen 2015). Second, as we do not have couple data, we cannot investigate whether partners have similar perceptions of importance and difficulty, and when discrepancies arise. Third, in our quantitative study, we could only capture that the scientists' experience of their dual careers has been neither difficult nor easy. Future questionnaire designs should, therefore, unravel perceptions and ask about what was hard, what was easy, and when. Finally, it is beyond the scope of our study to examine dual career arrangements in conjunction with scientific discipline and national context, which are important contextual factors. We limited our interviews to ERC applicants in the Life Sciences because they make up the largest share among the applications. Moreover, this allows us to control for the disciplinary background, in terms of working conditions and career logics. From the interviews, however, we can conclude that there exist marked differences already within this discipline.

The findings of this study contribute to the scarce literature on dual careers in science. Although this is a select sample of ERC applicants, our findings are relevant beyond this group. Regarding the high frequency of employed partners, academic partners, and importance of careers, our sample is very similar to scientists in other studies (e.g., Connolly et al. 2011; Jacobs 2004; Schiebinger et al. 2008). Moreover, ERC applicants are particularly important role models if we aim to support scientists in becoming the future leaders in European research. Thus, this study informs government, employers, and funders. While decisions for awarding jobs and funds may still be based on notions of the ideal scientist, interference with family is commonplace.

The COVID-19 pandemic has made it clear we need to reconsider linear career expectations and extreme work models in science, as these are incompatible with external shocks such as lockdowns, travel restrictions, and homeschooling. The same holds true for how the pandemic has changed how we view and live the mobility requirements in working in science. Offering remote work can alleviate strenuous commuting or living apart together. Collected well before the pandemic, our findings on ERC grant applicants can be used as a guide to build dual-career programs aligned with scientists' needs. Even if those needs are heterogeneous, employers and funders should recognize that applicants typically have employed partners and children, and act to facilitate the navigation of dual careers. This also means that there is a broader responsibility for dual-career support of the science system and its institutions.

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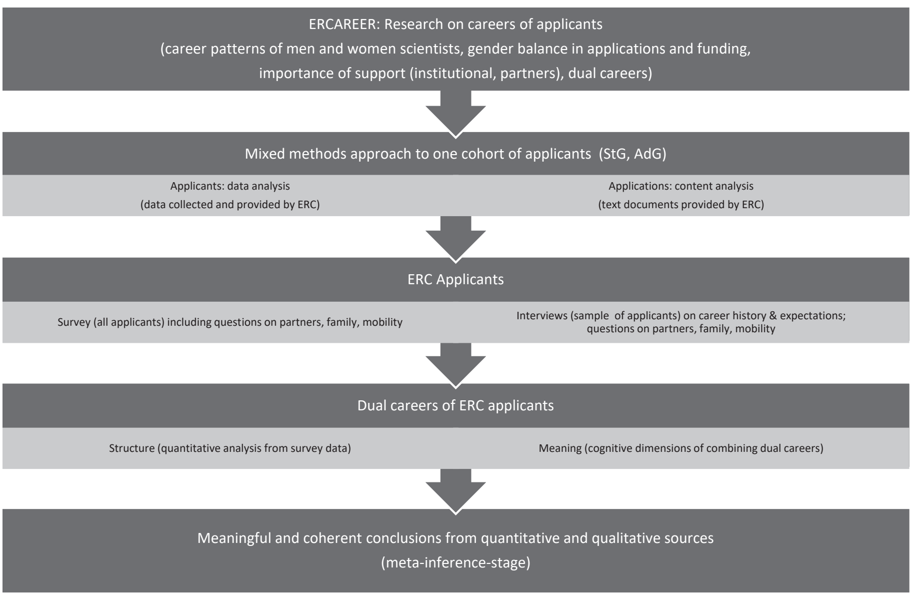
Figure A: ERCAREER Research Design



own illustration based on Kuckartz 2017: 166

Frerk Blome*

Mechanisms of Upward Social Mobility

A qualitative analysis of class-specific careers in law and educational science

Abstract: Higher education institutions are key to the (re)production and legitimation of social inequalities and have increasingly been studied at the level of students in this respect. However, little research has been devoted to academic careers in the context of class-specific inequalities. The few studies available suggest an underrepresentation of less privileged scholars and focus on explaining the reproduction of these inequalities. In contrast, this paper refers to theories of the social self, bringing into focus an interactionist perspective suitable for explaining social mobility. Drawing on a comparative analysis of 27 autobiographical narrative interviews with German law and education professors of different social origins, the article reveals two mechanisms of upward social mobility. First, through positive evaluations of student and academic performance—and the social comparison processes based on them—the confidence of socially mobile academics in their own abilities grows, and their self-concept changes. Second, social relationships and interactions with authoritative others also modify self-concepts. Both mechanisms are intertwined, in that performance indicators are closely linked to the formation of social relationships, positive evaluation, and encouragement by authoritative others. These findings contribute to scholarship on inequality research in higher education and social mobility research in general by providing comparative insights into class-specific academic careers and the mechanisms of social mobility within academia.

Keywords: academia, social inequality, intergenerational mobility, social comparison, social self, academic careers

Mechanismen der sozialen Aufstiegsmobilität

Eine qualitative Untersuchung klassenspezifischer Karrieremuster in Rechts- und Erziehungswissenschaft

Zusammenfassung: Hochschulen sind entscheidend für die (Re-)Produktion und Legitimation sozialer Ungleichheiten und wurden in diesem Zusammenhang vornehmlich mit Blick auf Studierende untersucht. Die Wissenschaftskarriere hinge-

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gen wurde vor dem Hintergrund klassenspezifischer Ungleichheiten bisher kaum erforscht. Die wenigen vorliegenden Studien verweisen auf eine Unterrepräsentation von weniger herkunftsprivilegierten Wissenschaftler:innen und konzentrieren sich in ihrer Erklärung auf die Reproduktion der Ungleichheiten. Dieser Beitrag hingegen bezieht sich auf die Erklärung sozialer Mobilität und stellt dafür mit der Theorie des sozialen Selbst eine interaktionistische Perspektive in den Mittelpunkt. Basierend auf einer vergleichenden Analyse von 27 autobiografisch-narrativen Interviews mit deutschen Rechts- und Erziehungswissenschaftler:innen unterschiedlicher sozialer Herkunft zeigt der Artikel zwei Mechanismen sozialer Aufstiegsmobilität auf. Erstens gewinnen die aufwärtsmobilen Wissenschaftlicher:innen durch positive Bewertungen ihrer studentischen wie akademischen Leistungen, und darauf basierenden sozialen Vergleichsprozesse, an Selbstvertrauen, wodurch sich ihre Selbstkonzepte verändern. Zweitens verändern auch soziale Beziehungen und Interaktionen mit autoritativen Anderen ihre Selbstkonzepte. Dabei sind diese beiden Mechanismen miteinander verwoben. So sind Leistungsindikatoren eng verbunden mit der Konstitution sozialer Beziehungen zu autoritativen Anderen sowie der positiven Bewertung und Förderung durch ebenjene. Die Ergebnisse des Aufsatzes tragen sowohl zur Ungleichheitsforschung im Hochschulbereich als auch zur Forschung über soziale Mobilität im Allgemeinen bei, indem sie vergleichende Einsichten in klassenspezifische Karrieremuster und Mechanismen sozialer Aufstiegsmobilität in der Wissenschaft bieten.

Stichworte: Wissenschaft; Wissenschaftskarrieren; soziale Ungleichheit; soziale Mobilität; soziales Selbst; soziale Vergleiche

Introduction

Universities play a central role in the (re)production and legitimation of social inequalities in “cognitive-cultural capitalism” (Reckwitz 2021: 73). Their growing social importance is reflected not only in the massive increase in the number of students worldwide in recent decades (Marginson 2016); university degrees are also an important social resource for individuals, as they enable access to privileged positions in the labor market and thus commensurate life chances. Against this backdrop, inequality scholars study universities from different perspectives, such as race, class, and gender, or in their intersectionality.

When it comes to class-specific inequalities, students are usually the focus of research, and studies address, for example, unequal access to higher education in general or to so-called elite educational institutions or prestigious degree programs. Nevertheless, while inequality research has devoted much attention to students in recent decades, far less attention has been paid to subsequent academic careers. As such, the extent to which class is relevant to participation in doctoral programs and the subsequent progression of academic careers has to date been less widely researched.

However, more attention should be devoted to these status trajectories, for several reasons. Firstly, enrolments in doctoral programs globally have increased rapidly, even dramatically in some cases (Shin et al. 2018). This is also the case for Germany, the country of interest for this paper (Jaksztat et al. 2021). A doctorate is not only a prerequisite for an academic career; it also has advantages in other professional fields. The title, once earned, is associated with higher employment rates, incomes, and occupational positions (Bloch et al. 2015; Konsortium Bundesbericht Wissenschaftlicher Nachwuchs 2021; Trennt/Euler 2019). Secondly, academics themselves—and professors especially—are involved in the education of students; by awarding educational degrees, they are directly involved in the (re)production of class-specific inequalities. Socially mobile faculty members might serve as role models for—or recognize and mentor—students from lower-class origins (Binns 2020; Lehmann 2014). Finally, class-specific inequalities challenge the universalistic covenant of science, namely that the recognition of scientific achievements should be independent of individual characteristics such as social origin, gender or race (Merton 1942).

Nevertheless, it is not only studies on postgraduate qualifications such as master's degrees and doctorates are comparatively rare (Wakeling 2018); apart from older studies (for France Bourdieu 1988; for Great Britain Halsey 1995; for Canada Nakhaie/Brym 1999), data on the social origin of faculty were until recently also rather rare. This has begun to change as there has been a recent engagement on academic careers in international research (for the scientific elite in the UK Bukodi et al. 2022; for Finland Helin et al. 2019; for tenure track faculty in the US Morgan et al. 2022). Admittedly, these studies pose difficulties in comparison, as they are based on different conceptualizations of social origin and refer to historically divergent societal settings. But what they have in common is that they indicate an underrepresentation of scholars from lower social classes and focus on the theoretical explanation of the reproduction of class-specific inequalities.

Contrary to the theoretical focus on the reproduction of inequalities, this article aims to explain processes of upward social mobility. It addresses how social origin influences academic careers, focusing especially on the comparatively rare cases of social mobility. These questions are addressed from a comparative perspective, based on 27 autobiographical narrative interviews with German law and education professors of different social origins. By referring to theories of the social self and social comparison theory, I present two mechanisms of upward social mobility. The first is that positive evaluations of student and academic performance—as well as the social comparison processes based on them—increase socially mobile academics' confidence in their abilities, changing their self-concept. The second is that social relationships and interactions with authoritative individuals also transform the self-concept. These two mechanisms are intertwined insofar as performance indicators are closely related to the constitution of social relationships, positive evaluation, and support by authoritative persons.

The paper is structured as follows. First, I briefly outline the German context with a particular focus on the disciplines studied and the state of the literature on class-specific inequalities in the German higher education system. In a second step, I describe the data my study draws on and how I went about analyzing this data. The theory of the social self underlying the two mechanisms, thus elaborated, is then outlined, before the empirical part is presented. The empirical part is subdivided into three further parts: First, I will focus on performance indicators as a mechanism of upward mobility; second, I refer to authoritative others as another mechanism of social mobility; third, I elaborate on the interconnectedness of both mechanisms. The paper concludes with a summary and contextualization of the results.

Context and literature on class-specific inequalities in the German higher education system

In Germany, educational inequalities determined by social origin[1] have come under increased scrutiny since the beginning of the 2000s. This was provoked by public discussion following the “PISA shock”, which was primarily concerned with school-level inequalities: After Germany’s poor performance in international comparative studies in the school sector (PISA, IGLU, TIMMS), following which a particularly strong correlation was established between social origin and educational success in Germany, the academic preoccupation with inequalities specifically deriving from differences in social origin increased (Dumont et al. 2014; Otte et al. 2021). Eventually, class-specific inequalities in higher education also became a popular object of research. However, as in international research, German scholars focused primarily on students, and examined career paths within academia much less frequently.

The findings on student-level behavior and academic success are well documented: Studies on class-specific inequalities in higher education show that students of privileged social backgrounds are more likely than peers with the same school grades to enter tertiary education in the first place (Watermann et al. 2014), to complete their study programs (Müller/Schneider 2013), and to opt for prestigious universities (Weiss et al. 2015) and prestigious fields of study (Lörz 2012). They also study abroad more often and for longer (Lörz et al. 2016; Netz/Finger 2016), are less likely to work during their studies, and, if they are employed, are more likely to be in skilled jobs (Staneva 2017). Finally, the more privileged their

1 In this article, the terms ‘class’ and ‘social origin’ are used as functional synonyms to refer to the socioeconomic status of the family of origin. In sociological research, there are a variety of categories for determining a person’s social origin, with parental education level being the most common indicator in the German studies reviewed.

socioeconomic background, the more likely students are to study at universities rather than universities of applied sciences (Reimer/Schindler 2010) and to follow a bachelor's degree with a master's degree (Auspurg/Hinz 2011; Lörz et al. 2015).

While comparatively little is known about postgraduate education and inequalities in subsequent academic careers, this has begun to change in recent years. In Germany, the doctorate is a necessary qualification for—and indeed often seen as the starting point of—an academic career, whether at universities or universities of applied sciences. Aside from the academic track, though, a doctorate is still associated with a higher lifetime income, a higher employment rate, and a higher professional position (Mertens/Röbken 2013; Trennt/Euler 2019). However, the relevance of the doctorate outside the academic field varies between disciplines, including those studied here. The different status of doctorates is reflected in their varying distribution. According to Jaksztat (2014: 293), whose study is based on a survey of university graduates, 31.9 percent of all graduates begin a doctorate in the first five years after graduation. The highest rate of doctorates is in medicine (96 percent), the lowest (8 percent) in education (and social work). For law graduates, it is 38.6 percent (for the doctoral rates of the different disciplines see also Konsortium Bundesbericht Wissenschaftlicher Nachwuchs 2021: 142). In law, the doctorate is regarded as a further professional qualification associated with increasing career (and especially high-income) opportunities (Heineck/Matthes 2012; Mertens/Röbken 2013). In education, by contrast, a doctorate is primarily regarded as an academic qualification. In many professional fields of education, a doctorate is considered insignificant, and sometimes even an obstacle to a career (Rauschenbach et al. 2005).

An increasing number of primarily quantitative studies on the German context shed light on class-specific inequalities in the distribution of doctorates by demonstrating an influence of social origin on the intention to participate in a doctoral program (Lörz/Seipelt 2019), doctoral admissions in general (Bachsleitner et al. 2020; Jaksztat 2014; Jaksztat/Lörz 2018; Radmann et al. 2017) or admissions to different forms of doctorates (de Vogel 2017).

The German academic system has been described as a winner-takes-all market (Berthoin Antal/Rogge 2020), and the career trajectory as an "Up or Out" model (Fitzenberger/Schulze 2014). In this Up or Out model, the doctorate is followed by a further qualification phase on the way to a professorship, in Germany typically habilitation,[2] but equivalent qualification paths have become established in recent

2 The following core principles characterize the specific German *Habilitationsmodell*: *Habilitation, Hausberufungsverbot, Lehrstuhlprinzip, Qualifizierungsstellen* (Berthoin Antal/Rogge 2020: 192). Qualification for a professorship requires a *Habilitation* or a habilitation-equivalent qualification. Postdoctoral researchers can spend up to six years on their habilitation, which concludes with a written examination (monograph or a cumulative work) and an oral defense. Due to the ban on internal appointments (*Hausberufungsverbot*), careers can only be continued by changing universities. Under the traditional and still predominant

years, such as junior professorships, junior research group leaders, and tenure-track professorships (see Kauffeld et al. 2019). Nevertheless, habilitation remains the dominant career path both in education and, to an even greater extent, in law (Gerecht et al. 2020: 140; Zimmer 2018).

The various postdoctoral status trajectories have also been researched only partially. These studies demonstrate the influence of socioeconomic origin on the transition from a doctoral to a postdoctoral position (Lörz/Schindler 2016) or from a postdoctoral position to a professorship (Jungbauer-Gans/Gross 2013; Zimmer 2018). In addition, and complementary to this, the social profile of those recently-established qualification paths (junior group leaders, junior professors) has also been examined (Burkhardt/Nickel 2015; Zimmer 2018), indicating an apparent underrepresentation of scientists with less privileged socioeconomic origins. The same applies to studies of professors in general (Möller 2013), and the scientific elite as a whole (Graf 2016). As it is primarily a professorship that enables permanent academic employment at universities, this article focuses on professors.

All these studies either demonstrate an influence of socioeconomic origin on career success or indicate an apparent underrepresentation of scientists of lower class origin. As such, quantitative research has proven increasingly useful in providing insights into career paths and status groups inside academia, albeit that these studies are primarily concerned with explaining the reproduction of class-specific inequalities and drawing on theories of social reproduction.

In the studies mentioned, references to Boudon's (1974) theory of rational choice and Bourdieu's (1992) theory of cultural reproduction dominate. Boudon explains inequalities in educational attainment with his model of primary and secondary effects. He refers to primary effects, thus describing class-specific disparities in family resources that would contribute to differences in the development of academic competencies and affect educational attainment. Secondary effects are described as the outcome of class-specific decision-making, resulting from different assessments of the rates of return to education, that is, the anticipated costs and the prospects of success associated with an educational path.

In research strands following Bourdieu, unequal capital endowments and habitus-field relations are used to explain (educational) inequalities. Quantitative studies often focus on capital endowments for reasons of operationalization, whereas qualitative studies often focus on habitus. In the competition over educational certificates, actors of higher classes are theorized as benefiting from a greater volume of economic, cultural, and social capital (Bourdieu 1986) and their habitus.

Lehrstuhlprinzip, professors preside over a chair (*Lehrstuhl*) and have budgetary resources with which they can employ staff (Hüther/Krücken 2013; Dobbins 2020). Academic staff is thus formally bound to professors, and the professors control the direction of research and teaching at their chair. Positions below the professorship are usually considered training positions (*Qualifizierungsstellen*).

Habitus is a internalized system of durable dispositions of "schemes of perception, appreciation and action" (Bourdieu 1984: 100). The homogeneity of the conditions of existence within classes leads to the internalization of comparable dispositional systems, i.e., class habitus (Bourdieu 1977: 80–81). Habitus influences the goals perceived to be desirable and reasonable, but also evinces differing levels of suitability to the requirements of a field e.g., the educational system. In this regard, habitus acquired in the lower classes would correspond less with those of the educational system, leading to lower levels of success and vice versa.

In addition to some of the cited quantitative studies, a number of German qualitative studies also draw on Bourdieu's theory. Engler (2001) states in her interview study with professors from different social classes that they construct their academic careers free of their social origin. Otherwise, she argues, they would risk breaking with the claim to scientific objectivity and thus the *illusio* of the field. While Engler suggests that socially mobile professors undergo a second socialization in their academic careers, she situates this finding outside her research interest. Keil (2020) draws on Bourdieu and argues, in the context of academic careers, that scholars of more privileged class origin benefit from their familial resources and are better adapted to academia due to their habitual dispositions. These studies may make reference to social reproduction in their explanations, but little is said about upward social mobility.

An exception is the interview study with socially mobile law professors by Böning, Blome, and Möller (2021), which analyzes the professors' narratives of upward social mobility. They argue that there is a change in biographical narratives over time: While professors of older cohorts ascribe a high relevance to structures of opportunity, it is professors of younger cohorts who emphasize the importance of talent and ambition for successful advancement. However, the analysis of narratives can be understood primarily as an engagement with biographical self-conceptions.

International qualitative research is also increasingly addressing issues of class-specific inequalities among scholars. Although these studies sometimes differ from the German studies in their theoretical references, they are also primarily concerned with questions of the reproduction of inequalities. Analyses of interview data or autobiographies reveal central themes used to explain inequalities. These include the lack of cultural and economic capital in the families of professors raised in working-class families (Haney 2015; Warnock 2016); the way in which negative aspects often accompany academic success, such as the loss of close relationships with (or alienation from) family and friends (Wakeling 2010; Warnock 2016); the stigmatization of US professors from less-privileged classes in academia by their middle-class peers (key terms here being discrimination or microaggressions) (Crew 2021; Lee 2017).

The current literature on class-specific inequalities in higher education focuses primarily on students but increasingly addresses later academic trajectories. Theoretically, research focuses on the reproduction of socioeconomic class-specific inequalities. Against this backdrop, this article sheds light on the scarcely-researched academic status trajectories, and examines how social origin influences careers. In contrast to theoretical explanations of social reproduction, the focus here is on explaining mobility. What social mechanisms can explain the comparatively rare cases of upward social mobility?

Methodological and theoretical framework

The organization of the research process for this article is anchored in grounded theory methodology (GTM), which emphasizes the abductive construction of theoretical concepts through iterative data analysis (Strauss 1987; Timmermans/Tavory 2012). GTM purports to generate hypotheses and middle-range theories in close engagement with the empirical material, an approach that is particularly appropriate given the largely unknown phenomenon, i.e., upward social mobility in academia. The research process is openly structured and follows an iterative approach and the associated "theoretical sampling". In this way, the collection and analysis of data intertwine, as does the construction of theories. Thus, data analysis leads, in engagement with theories and the empirical material, to the development of theoretically relevant criteria, which structure the further data collection and, in turn, drive theoretical development. While the GTM is a methodological framework suitable for organizing the research process, the GT as a method for data analysis reaches its limits when analyzing autobiographical narratives (Ruppel/Mey 2015), which is why the data analysis here is guided by narrative analysis.

The social self

In this article, I will draw on Mead's interactionist assumptions of a socially mediated self, whereby the self emanates from the dialectical relationship between the "I", as the impulsive and spontaneous side of the self, and the "Me" as the socialized component of the self (Mead 1934: 173–178). The "Me" is shaped by the interpretation of what others think of us ("reflected appraisal"), but varying relevance is attributed to different interaction partners. Referring to the concept of the significant other, coined by Harry Stack Sullivan (1940) but often attributed to George Herbert Mead (1934), authors distinguish the influence of different interaction partners. The concept of significant others is primarily used to describe and analyze processes of primary socialization, emphasizing the formative power of the internalization of social reality mediated by significant others (Berger/Luckmann 1991: 154).

However, some sociologists building on Mead still argue for the importance of primary socialization but conceptualize its continuing effects less rigorously (Gerth/Mills 1953; Strauss 1977). Gerth and Mills, the authors to whom I refer here, conceptualize the self as continuously changing and as "a reflection of the appraisals of others as modified by our previously developed self" (Gerth/Mills 1953: 85). The appraisals of significant and especially authoritative others are organized into a pattern in the "generalized other", which can be understood as the "internalized expectations of self" (Gerth/Mills 1953: 105); it changes "as new appraisals are added to older ones, and older ones are dropped or excluded from awareness" (Gerth/Mills 1953: 98). I follow Gerth and Mills in their definition of significant others as those to whom "the person pays attention and whose appraisals are reflected in his self-appraisals" (Gerth/Mills 1953: 85) and relate this to their notion of authoritative others. In reference to my empirical material, I understand as 'authoritative others' those significant others who are particularly important for the constitution of one specific (here: academic) element of the self, as authority is ascribed to them due to their expertise.

While the sociological tradition of social psychology emphasizes the interactional aspects of the self, the psychological emphasizes the complementary 'internal' views, including self-evaluation as one dimension of the self. In the context of the theory of the same name (Festinger 1954), social comparison serves an anthropological need to evaluate one's abilities and opinions and is thus another influential source of shaping the self. Comparing oneself on a given dimension to others reduces uncertainties regarding self-evaluation. In addition to self-evaluation, two other motives are attributed to social comparisons. One motive is self-improvement and is achieved through upward comparisons, and the other is self-enhancement and is, conversely, realized through downward comparisons. Social comparisons are sometimes assumed to be cognitively automatic (Gilbert et al. 1995), but unfamiliar, ambiguous, or unclear situations are thought to evoke explicit comparison processes (Festinger 1954).

Data collection

The paper draws on 27 autobiographical narrative interviews (Schütze 1983, 2016) conducted by me between 2017 and 2020 with professors in law and education. Two central arguments favor this form of interviewing: First, academic careers and intergenerational social mobility[3] are long-term processes, and secondly, the interview is characterized by a high degree of openness. Due to the temporal extension of academic careers and upward social mobility, these processes can neither be recorded in the research field nor directly observed. The autobiographical narrative interview, however, offers a possibility to approach them. The interview comprises two phases, beginning with an initial narrative question by the interviewer, initiating the interviewee's subsequent main narration. In the interviews at hand, I address

3 Regarding social mobility, a distinction is made between intra- and intergenerational mobility (Kalleberg/Mouw 2018). Intragenerational mobility describes mobility between relevant stratification dimensions of the same person over time. Intergenerational mobility refers to mobility between generations, with parents usually used as the reference. In what follows, I refer to social mobility as intergenerational mobility.

the whole life story with the initial narrative questions. In this way, hypothesis-driven data collection is dispensed with, and the respondents' relevance is followed. With this high degree of openness, the interview style is suitable for researching unknown phenomena in an explorative manner. Once the interviewee has finished their main narrative, the second phase continues with follow-up questions, in which I begin by elaborating on the themes of the main narratives. Only then do questions follow on topics that the interviewees themselves did not raise. I conducted the interviews face-to-face in German, then transcribed them completely. Their duration ranges from one to three hours. The transcripts are supplemented by field notes, which include information on the situational background, context, nonverbal cues, and pre- and post-interview discussion (Tessier 2012).

Sampling

Data were collected using theoretical sampling (Glaser/Strauss 2006) in terms of the characteristics of professors and the field of study. Based on the first interviews with socially mobile law professors, I decided to draw a contrast with those professors of higher social classes, thus reconstructing class-specific patterns of academic career paths using these contrasting cases as a basis.

For the classification of professors' social origins, the article draws on a model used between 1982 and 2009 in the *Sozialerhebung*,[4] which distinguishes four groups of origin (low, middle, upper, high), divided hierarchically according to the parents' professional positions and educational qualifications.[5] This model not only served for a long time to classify the social origin of students in the *Sozialerhebung*, but it also represents the most comprehensive study of the social origin of German professors (Möller 2015). In my study I categorized those originating in the low

4 The *Sozialerhebung* (1951–2016) surveyed students in Germany regarding their social and economic situation about every three years. In 2019 it was combined with the *Studierendensurvey*, EUROSTUDENT and *beeinträchtigt studieren* to form *Studierendenbefragung in Deutschland*. See https://www.die-studierendenbefragung.de/en/the-student-survey.

5 The 'low origin' group primarily includes students whose parents are, for example, manual workers or low-skilled employees, or entry-level civil servants without a university degree. In the middle group, the parents are master craftsmen, foremen, employees in mid-level positions, and civil servants without a university degree. The upper group includes, for example, employees and civil servants in higher positions, freelancers, and similar positions with and without a university degree. Finally, the high group of origin is composed mainly of employees with extensive management responsibilities, civil servants of higher service, managers of larger companies, and similar top professional positions with or (rarely) without a university degree (for a precise explication see Middendorff et al. 2009: 546). In 2012 the *Sozialerhebung* switched to a model of educational origin groups, which reduced the operationalization of social origin to the highest educational degrees attained by parents.

or middle groups as cases of upward social mobility, and those from the highest as reproductive cases.[6]

In addition to social origin, I identify three dimensions as particularly relevant in the analysis; they are taken into account in the sampling process: gender, age, and intra-disciplinary affiliation. Even the earliest interviewees addressed the massive underrepresentation of women. While recruiting female professors from higher social classes was not a problem, I was able to interview only one female upwardly mobile law professor. These recruitment issues might be explained first by the already low share of female law professors, which, to date, is only 18 percent (Sacksofsky/Stix 2018), and second, by the fact that female university professors as a whole come from privileged classes significantly more often than male professors (Möller 2015: 257). Table 1 shows in anonymized form the demographic characteristics of the 27 interviewed professors in the combination of social origin and gender on the one hand and social origin and disciplinary affiliation on the other.

Table 1: Interviewees demographic characteristics (n=27)

	Gender			Disciplines	
	Female	Male		Law	Education
Reproduction	2	5		5	2
Socially Mobile	6	14		11	9
Total	8	19		16	11

Furthermore, I interviewed professors from different age cohorts, as the interviewees addressed structural opportunities and barriers, such as educational expansion (Mitterle/Stock 2021) and the higher education restructuring process that followed German unification (John 2017), which affected them differently. In doing so, I identified specific opportunities and barriers within disciplines, such as the rise of empirical educational research and the concomitant demise of humanities-based German pedagogy (Zapp/Powell 2016), and, therefore, considered intra-disciplinary differences in the sampling process.

The interviewees were recruited through various strategies: personal and mediated contact, calls via relevant forums and networks, or direct contact based on publicly available biographical information. I ended the sampling when I reached theoretical saturation, i.e., when the collection of further interviews did not reveal any new aspects of the research question (Glaser/Strauss 2006: 61).

Law marked the study's starting point because it includes a very low proportion of socially mobile professors, and it is a discipline with many professors. The size of

6 With regard to people from the 'upper origin' group, one could also speak of upward social mobility when they attain a professorship, albeit a shorter one. However, such cases were not surveyed.

the discipline is significant both for the ease of recruitment of interviewees and the concomitant possibility of anonymization, which could prove difficult in a smaller field. Beginning with law, I sought a maximally contrasting comparison case, which involves establishing conceptual differences and, possibly, the rejection of previous assumptions (Glaser/Strauss 2006: 56).

Table 2: Socioeconomic profile of professors by disciplines studied based on Möller (2015), in %

	Low	Middle	Upper	High	Total
Law	2	19	28	51	100
(Special) Education/ Psychology[7]	19	27	26	28	100
All disciplines	11	28	27	34	100

In addition to the social homogeneity of law (see Table 2), two further contrasting criteria were derived from the iterative analysis: The importance of a candidate's academic supervisors and a strict and strongly hierarchizing culture of evaluation. Educational science was chosen as the comparative discipline, which contrasts strongly with regard to the social composition of the professoriate by being one of the more open disciplines for the socially mobile. Also, the individual influence of academic supervisors is less significant in education, and the grading culture is comparatively benevolent. Beyond these differences, one commonality is that both disciplines have many professors (Statistisches Bundesamt 2021: 109–110).

Analyzing autobiographical interviews

My analysis is based on Schütze's (see 1983, 1984, 2016) narrative theory. Following his methodological underpinnings, autobiographical interviewing aims to produce extempore autobiographical narratives, which he defines as unprepared accounts of personal experiences. One of his basic assumptions is that those accounts are structured around elementary communicative schemes; narratives, descriptions, and argumentations (Schütze 2016: 89–90). Narratives deal with personal experiences or specific events, having a chronological order with a beginning and an end. Descriptions recount the social frames in which the narrative is situated, such as recurring activities or social units, and are characterized by their static structure. Argumentations are abstract explanatory systems, consisting

7 Möller reports the data for a conglomerate of educational science, special education, and psychology and thus takes her cue from the Federal Statistical Office. Since 2015, however, educational science and special needs education have been merged. The aggregation of psychology and education is common but might pose a problem for the question of class-specific inequalities. At least among students, the 'low origin' group is underrepresented in psychology whereas the 'high origin' group is overrepresented. In educational science, on the other hand, the 'high origin' group is underrepresented among students—albeit less markedly (Middendorff et al. 2013: 100).

of, e.g., explanations for the course of events and the reasons for one's own actions. In analyzing interviews, Schütze focuses on extempore narratives as, "to a considerable extent, extempore narratives retrieve the actually ongoing experiences during past phases of life" (2014: 267). Argumentations, by contrast, are related to the current perspective of the interviewee, being affected by the interview situation and primarily representing secondary legitimations (Philipps/Mrowczynski 2021; Schütze 1977).

I began the analyses of the interviews by segmenting the main narratives in terms of their structure, whereas interview passages were segmented according to their communicative schemes and their content. I then compared, based on this segmentation, the cases at hand, and identified socioeconomic characteristics specific to the structural composition of the autobiographical main narrative. In conjunction with the structural analysis, I interpreted single narrative segments, occasionally in interpretive groups (Berli 2021), sequentially (Schütze 2008) as well as "microscopically" (Strauss 2004: 173), and then analyzed them from a case-comparative perspective. The segmentation of the extempore narratives enables the embedding or re-embedding of the single narrative segments and their analysis in and to the respective biographical "gestalt" (Schütze 2016: 91). The analysis is based on the fine-grained transcription of the German-language interviews. Only afterward were the interview transcripts translated and edited for presentation purposes.[8]

One of the analyses' central results is the reconstruction of class-specific divergent biographical schemes, which find expression in the structural composition of the main narrative and in specific narrative segments. Biographical schemes "consist of formulaic versions of obligatory or possible lives or parts of life, with some instructions as to how the parts are put together to form whole lives" (Luckmann 1991: 163). They "form the basis for individual projects of life, for the planning, evaluation, and interpretation of daily routines as well as of dramatic decisions and critical thresholds" (Luckmann 1991: 162). These schemes are transmitted in socialization and vary between societies and eras, but also between genders and social classes (Dausien 2018; Luckmann 1991).

The class-specific differences are essentially that the biographical schemes of the upwardly socially mobile respondents are typically oriented toward lower and middle educational qualifications and occupational positions. Their main narratives begin with primary education and describe the respective school and occupational transitions—from lower and upper secondary education and, if applicable, occupational activity—up to university entrance. Only in the process of education and career do their schemes modify, gradually moving vertically to higher education degrees and occupational positions. In contrast, the biographical schemes of the

8 The interview excerpts quoted have been edited for legibility, but the duration of longer pauses is indicated in brackets, e.g., (3s). A loud emphasis of individual syllables or words is highlighted via bold print.

social reproduction cases consist of higher educational degrees and—associated with this—higher occupational positions. Their main narratives only begin with the transition to tertiary education, more specifically the choice of a field of study, and merely imply their earlier school-leaving qualifications. This structural composition of autobiographical narratives of the reproduction cases can be interpreted as an indicator of their class-specific biographical scheme being oriented toward higher education.

In addition to the differences in the structural composition of the main narratives, the divergent class-specific schemes are reflected in the narrative segments. For example, the narrative segments of the upwardly mobile students typically deal explicitly with questions of financing and academic achievements. In the narrative segments on their academic progress, the reproduction cases address the completion of their studies, but do not explicitly address academic achievements (grades) or financing.

In this paper, I focus on the interview passages in which academic trajectories and career decisions were in the foreground—embedded in the context of the life history narratives. I limit the analysis to respondents' academic careers up to the first appointment as a full professor, i.e., the doctoral and postdoctoral phases are in the foreground. The focus here is on, for example, narrative segments about a respondent's studies and the doctoral intentions developed in this context, or, alternatively, on narrative segments about offers they had received for doctoral or habilitation positions. Analyzing these elements, I identify different social mechanisms (McAdam et al. 2001) constitutive for the modification of biographical schemes.

Mechanisms of upward social mobility in German academia

Performance indicators and social comparison as a mechanism of social mobility

The socially mobile respondents usually refer to various performance indicators in their main narratives. This applies to school grades, to the corresponding transitions (e.g., from primary to secondary school), and to university enrollment, as well as to academic careers. Focusing on academic careers, I distinguish between academic trajectories, the transition to the doctorate and postdoctorate, and the disciplines. Thus, interviewees in education typically highlight different performance indicators in their main narratives than those in law. And in narratives about doctoral entry, they highlight additional and/or different performance indicators than those discussed in the transition to postdoctoral positions. There are hardly any differences between cohorts or genders in the material at hand.

While the main narratives regarding the studies and the subsequent doctorate of the educational professors mostly emphasize their theses and final grades, the narratives of the law professors are dominated by their grades in the state examinations. When educationalists address the transition to the postdoctorate, there are no explicit references to grades, only references to their formal completion of the doctorate. Instead, they highlight other performance indicators such as third-party funding or publications. The absence of such references to doctoral grades marks a significant difference from legal scholars. When legal scholars talk about their transition to the postdoctorate, they continue to refer (comparatively) to their exam grades—especially the second *Staatsexamen* and their doctoral grades—and often also mention the time taken to complete the doctorate.

To exemplify the biographical relevance of such performance indicators, let me refer to a narrative segment of one upwardly socially mobile educational scholar: S begins this segment with a background description, contextualizing his first state examination, which he passed at a Bavarian university. The "Bavarian conditions", he argues, have been particularly tough. S continues:

> *From the first written exam onwards, I was off to a good start […] did the first two written exams with a one (1s) in history (1s) and came home and thought: 'Maybe you can do something after all.' And then I got a one and a two in German Studies. And even a two in Ancient History, to the amazement of the whole world. Because with (surname professors) four or five, that's all there was. (S, m, SM, Education)*

The influence of grades on self-concept as well as the comparisons associated with them can be vividly reconstructed in this excerpt. S derives his self-affirmation from his positive grading, as he underlines by recounting his inner monologue ("And came home and thought: Maybe you can do something after all"). However, S not only refers to his grades but also relates his positive performance via two social comparisons that give them additional emphasis. On the one hand, he relates his performance by describing the exams of the first state examination of his federal state as particularly difficult. And on the other hand, S underlines his examination performance ("to the amazement of the whole world") by comparing it with the other students through reference to his experiential knowledge of the strict grading practice of a specific professor.

The quoted excerpt refers both to a characteristic aspect of the interviewed educational professors, but also contains a distinctive feature. When discussing their entrance into their doctoral programs, the educational professors mainly make reference to specific numbers in isolation (Heintz 2010): They mention either their marks on the verbal grading scale[9] ("my homework and exams during my studies always got such excellent feedback [...] then I did very well in the exam" (R, m, SM, Education); "I got a 'very good' on the examination" (W, m, SM, Education) or their results ("I scored a 1.0 in the first examination" (V, m, SM, Education); "a grade average of 1.2" (Z, f, SM, Education)) and relate them mostly directly to the beginning of their doctoral studies. Unlike in the quoted segment from S, educa-

9 The German grading scale ranges between 1.0 as the best grade (equivalent to A+ on the US scale) and 4.0 as the worst grade (equivalent to D on the US scale). An exception to this is the grading scale for lawyers shown below.

tional scholars rarely compare their grades explicitly to other students' grades. Nevertheless, the reference to grades in the form of numbers lends itself naturally to comparisons and the hierarchies that go along with them: Numbers automatically imply relations, since they make no sense on their own (Heintz 2021).

The socially mobile law professors differ from the education professors in that, first, they refer exclusively to their state exams and, concomitantly, second, they characteristically make explicit comparisons. The social comparisons of legal scholars based on the grades of state examinations can be explained by the specifics of juridical performance indicators. These comparative criteria face the comparators as social facts since their relevance is constantly reproduced in law. In educational science, however, there is no comparative infrastructure corresponding to jurisprudence that would enable such social comparisons. Comparative criteria, it could be argued from a sociological perspective, are socially (re)produced.

In order to illustrate these differences by way of example, I will quote three shorter passages from the main narratives of socially mobile law professors:

> *Then I wrote the first exam in (state), and the oral exam was in (month and year). I passed the first state examination with 13.4 points. I think that puts me in the top 3 %. (N, m, SM, Law)*

> *And that [her first state examination] worked out well – it was the best state examination of the year in (state). (O, f, SM, Law)*

> *I don't know if you are familiar with the grading culture of lawyers, we have very strict grades and I got a 'very good' in the first exam, which is very, very rare and the two women [from his study group] both got a 'good', which was also extremely rare. Today it' s a bit more common, but back then only about 1 % got a 'good' or slightly more than 1 %, maybe 1,5 %. (J, m, SM, Law)*

The three interviewees have in common that they compare—albeit in different ways—their performance with that of other students. While O describes herself as the best in her year within her federal state without reference to a specific grade, N and J mention their marks and position them within the grade distribution (see table 4). In law, the grades[10] of the state examinations are perceived as an ostensibly objective indicator of performance, as they are strongly differentiated, and their grade point average is visible nationwide (Gaens/Müller-Benedict 2017). The biographical relevance of law exam grades is also a social fact for later law professors, not least in that it structures career options outside academia as well.

10 German legal education is structured as a two-stage model. The first training phase consists of at least four years of university studies, the second of two years of a legal traineeship. Both conclude with examinations covering the entire field of law (see Korioth 2006). Those exams include five to seven written tests and an oral exam lasting four to six hours. The state examination boards comprise mainly lawyers from the civil service (judges, public prosecutors, administrative jurists) and practicing lawyers, with only a small proportion of law professors among the examiners (Schultz et al. 2018: 216–217). The state examination was reformed in 2003, introducing a compulsory university component to the first examination, which accounts for 30 % of the overall grade. Since this university part is better evaluated, the state part is usually considered when evaluating graduates. Most of the professors interviewed, however, completed both exams as state exams.

The 'fully satisfactory' represents the entry threshold to the German judiciary and lucrative positions in the large and internationally-oriented law firms (Korioth 2006; Schultz et al. 2018).

Table 4: Grading scale of law and an exemplary nationwide grade distribution for first and second *Staatsexamen* in 2002 (Bundesamt für Justiz 2003).

Points	Grade (German)	Literal Translation	1st *Staatsexamen* (n=15.056)	2nd *Staatsexamen* (n=12.149)
14.00 – 18.00	*Sehr gut*	Very good	0.15 %	0.04 %
11.50 – 13.99	*Gut*	Good	2.67 %	1.72 %
9.00 – 11.49	*Vollbefriedigend*	Fully satisfactory	12.02 %	13.47 %
6.50 – 8.99	*Befriedigend*	Satisfactory	26.60 %	36.02 %
4.00 – 6.49	*Ausreichend*	Sufficient	30.55 %	33.77 %
0.00 – 3.99	*Nicht bestanden*	Failed	28.02 %	14.97 %

In addition to their strictness and transparency, the grades exhibit a strong geographical and historical constancy and, compared to other disciplines, are not affected by grade inflation (Gaens/Müller-Benedict 2017). Thus, social comparison processes based on these grades enable the interviewees to evaluate their performance in a supposedly objective way. And the relational positioning of one's own performance indicators within the performance elite enables the modification of the self-concept.

While the socially mobile professors fairly consistently refer to their performance indicators in their main narratives, I will argue that these positive evaluations and comparison are less significant for the self-concepts of the social reproduction cases. In their main narratives, they rarely mention their grades, and when they do, it is mostly implicit ("was very pleasing in terms of the result" (B, m, SR, Law); "was to my satisfaction" (C, m, SR, Law)). Thus, not only are there no concrete references to the grade, which can be found almost invariably in the socially mobile professors' main narratives, but explicit social comparisons are also entirely absent. However, they, too, must meet these formal requirements; but unlike the socially mobile, they are less likely to develop their biographical ambitions gradually based on the positive evaluation of performance indicators. Instead, their educational and career ambitions usually precede such evaluations, which will be exemplified by an interview passage from a law professor classified as a social reproduction case.

The passage is part of his main narrative and follows on from previous narrative segments on—in chronological order—family history, law studies, studies abroad, doctorate, habilitation, and first appointment. The interviewee ends the narrative extending to the first appointment with a narrative split coda (Schütze 1984: 102) before he continues with the following:

> *As I've just told you, I'd studied sociology in parallel to law.* ***It was always clear to me*** *that I would do a doctorate. My father held a doctorate, my grandfather held a doctorate. All my – not all my uncles, but many uncles held a doctorate, my mother holds a doctorate. And I always knew, with law, it's difficult to find a [doctoral position]. You have to have a 'fully satisfactory'.* ***One reason*** *I studied sociology at the same time was so that I could get a PhD in sociology (2s) in a pinch. (B, m, SR, Law)*

The excerpt illustrates the differences between the biographical schemes of different classes of origin in exemplary and contrasting form. B gives audible spoken emphasis to his almost ahistorical orientation toward the doctorate ("**It was always clear to me**") and explains it by referring to his family history. The fact that so many family members had a doctorate leads to him taking for granted that he, too, will earn a doctorate. This early biographical orientation towards the doctorate is already evident in the choice of the study subject. Knowing that it would be difficult to achieve the 'fully satisfactory', he also studied sociology, as he argues, so that he could earn a doctorate in this if necessary. Thus B also refers to the grades of the state examination, but exclusively to the 'fully satisfactory' as the minimum requirement for a doctoral position.

This illustrates the major difference in the relevance of performance indicators between social reproduction cases and socially mobile scholars. For the social reproduction cases, performance indicators appear to be relevant primarily insofar as they are the minimum prerequisite for access to doctoral studies. Thus, the early orientation of educational ambitions toward the highest possible educational degree, the doctorate, differs drastically from the gradual modification of the socially mobile, which is based repeatedly on positive evaluations at different academic stages. While the reproduction cases follow career paths that correspond to the biographical schemes of their social origins, there is higher biographical uncertainty for the socially mobile. Their uncertainty, it could be argued with regard to social comparison theory, evokes explicit or implicit—in the reference to grades—comparisons. Thus, the positive evaluations according to performance indicators are relevant to changing academic self-concepts and modifying biographical schemes. However, these performance indicators are not only relevant to the socially mobile themselves, but they also often provide the basis for the constitution of social relationships with their own academic supervisors.

Authoritative others as a mechanism of upward social mobility

Analyzing the narratives of upwardly socially mobile professors, I reconstructed the biographical relevance of significant and authoritative others (Gerth/Mills 1953) from higher social classes, identifying different groups of people, such as schoolteachers, classmates' parents, or academic supervisors. Focusing on academic careers, it is the supervising professors who are most relevant, although I distinguish between the various academic stages, between the transition to doctorate and postdoctorate, and between the disciplines. But while the *Lehrstuhlprinzip* assigns professors a key role in academic careers, as they act as "career gatekeepers"

(Hamann/Beljean 2021) and recruit personnel directly, interactions with them are nevertheless of particular relevance for socially mobile scholars, as they bear the potential to modify their self-concepts.

The importance of authoritative others diverges in the present material. I identify minor differences between disciplines and status transitions. In educational science, supervising professors are of particular relevance for the process of transition to the doctorate, although they are sometimes relevant to the transition to postdoctorate as well. In comparison, those who studied law emphasize the interactions with their authoritative others as highly relevant for both transitional periods.

These differences might be explained by the different status of academic supervisors in each discipline, as well as by disciplinary differences in the statuses of the doctorate. Law is a discipline fundamentally characterized by hierarchies. Furthermore, supervising professors—and the corresponding student-professor relationships—are considered essential (Schultz et al. 2018: 347; Schulze-Fielitz 2013). In addition, while a doctorate is regarded as a professional qualification in law, in education it is primarily considered an academic qualification. But when the doctorate is already seen as the beginning of an academic career, the subsequent transition to the postdoc phase may seem biographically more natural.

I will exemplify the relevance of academic supervisors to the pursuit of academic careers using an interview excerpt from the main narrative of a socially mobile professor of education. In her main narrative, she gives an account of her studies and describes, among other things, that she was offered a job as a student assistant in a seminar, which she accepted. She then talks about her upcoming university graduation and an associated decision-making situation. With Schütze, I interpret her depiction of that situation as a “situation or scene of biographical importance, in which there is a peak in the concatenation of events as well as in which the identity change of the narrator as former dramatis persona is experienced by her or himself and can be observed by others” (2016: 96). Schütze (1984: 100–102) thus describes those situations as consisting of four elements: first, an announcement of the scenic representation, second, the outline of the initial conditions, third, the execution of the core of the representation, and fourth, the representation of the outcome.

Regarding Z’s decision-making situation, I will focus on citing and interpreting the last two elements and briefly sketch the first two. She announces a scenic representation by stating that “at the end of my studies, there was an interesting situation”. Z then presents the relevant initial conditions for the interviewer and introduces the context of that decision-making situation. She had oriented her studies toward a double diploma to maintain job market opportunities in the business sector and as a teacher. Z thought that her chances in the business sector would increase with the business studies title *Diplomkaufmann*, which required a second diploma thesis, despite the creditability of the seminars she had otherwise completed.

Following this presentation of the initial conditions, she continues with the execution of the core of the representation:

> *And at that time, I talked about it with this professor, who I was also working for at the time. And I reflected on what was next, both the time frame and the topic, and that I was considering writing a second diploma thesis. And in that conversation, he asked me whether I wouldn't rather use the time to write a dissertation. Then I began to think about it more seriously, whether that* ***might*** *actually be something. Well, before that, sure, I'd thought about it a bit, like whether that would ever even come into consideration or not, because other people also ask you from time to time, don't you want to continue with it. Well, because my studies went very well, I'd finished my main studies with an average of 1.2. And then, of course, you think about it again. But it wasn't really a tangible goal for me – it wasn't really an option for me yet. (Z, f, SM, Education)*

Z depicts a situation in which she was talking to her former supervisor about the decision just presented. She narrates that in this conversation, he suggested she write a dissertation and argues that this made her think seriously about the doctorate. Before this conversation, her good grades and the resulting inquiries and suggestions from others had led her to vaguely consider a doctorate ("sure, I'd thought about it a bit"), albeit "it wasn't really a tangible goal" for her yet. Only her professor's suggestion of writing a dissertation contributed to a "serious" reflection on this option for action.

We can understand him as an authoritative other: The affective relational level with the professor is indicated by Z consulting him as a biographical advisor for her decision making. Simultaneously, his authority is shown in her reference to his status position ("this professor"), which is opposed to the demarcation from the unspecific "other people" and her higher valuation of his evaluation. Not only is there a lack of explicit elaboration on who these others were; it is only the professor's suggestion and the implicit assessment of her academic competencies contained therein which turn the vague notion into an earnest engagement with the idea of a Ph.D. Thus, her supervisor's suggestion of a doctorate led to a modification of her self-concept and thus to a modification of her biographical scheme. It is especially his assessment which she emphasizes in this regard as leading to her decision. Ultimately, though, the influence is cumulative: her good grades, the subsequent suggestions of a doctorate by "other people", and of course her supervising professor himself.

The detailed rendering of this situation of biographical importance in Z's main narrative suggests the significance of her supervisor's offer. Such an interpretation is in line with the Z's self-theoretical reflection in the concluding and evaluative part of the quotation:

> *But then, just with this conversation, I thought about it more seriously and eventually decided to do it. (Z, f, SM, Education)*

Z's main narrative is used here to exemplify the importance of authoritative others in modifying the self-concept of the socially mobile. During social relations and interactions with authoritative others the self-concept of the socially mobile internalizes the authoritative others' explicit and/or implicit evaluations. The biographical schemes of the socially mobile change through interaction with authoritative others, and they gradually develop academic career ambitions. The constitution of this social relationship is typically based on the performance indicators just outlined.

After describing the pattern for socially mobile professors, I will compare it with that found in the social reproduction cases, and argue that such positive evaluations through authoritative others and their biographical suggestions are less significant for these respondents' self-concepts: With one exception, in the main narratives of the present cases, academic supervisors are seldom ascribed much importance for the respondents' biographical decisions; equally, there are few similar "situations of biographical importance" referring to supervisors in the material. Nevertheless, supervising professors are also crucial to the social reproduction cases as career gatekeepers.

I will describe the social reproduction cases' pattern in the following by drawing on an excerpt from the main narrative of a law professor from that group. The quoted excerpt is taken from his narrative segment about his studies and follows remarks about exam preparation. He then continues:

> *And after the first Staatsexamen, which turned out to my satisfaction, I then turned to one of the professors with whom I had taken several seminars. And I approached him with a doctoral topic about [subject] which was not actually within his competence in the narrower sense. I had to expect that he would reject the topic and had thought of alternatives for this case. To my surprise, however, he reacted very generously. He said I should write about the topic that my heart desired – roughly his words. (C, m, SR, Law)*

C describes how he approached a professor he knew from seminars with his doctoral plans after receiving his grades for the first *Staatsexamen*. He does not mention his specific grade in his main narrative, noting merely that the exam "turned out to [his] satisfaction". However, in the follow-up section, he adds that "he was among the best 10 %" in his *Staatsexamen*, which corresponds to the 'fully satisfactory' grade and is also a requirement for admission to doctoral programs in law. That C also had considered alternatives in case the professors rejected his project suggests that his doctoral intention is less dependent on a specific professor.

This illustrates the major difference between the relevance of authoritative others for social reproduction cases and socially mobile scholars. Like C, social reproduction cases tend to pursue doctorate and postdoctoral positions more strongly on their own initiative and exhibit greater self-confidence. They are the ones who approach professors with their doctoral or postdoctoral projects. They, too, attribute an essential function to professors as career gatekeepers for jobs or fellowships, but consider them less significant for the development of biographical projects.

The interplay between authoritative others and performance indicators

Although I make an analytical distinction between objective performance indicators and the influence of supervisors as two social mechanisms, they are intimately intertwined. As such, the development of academic career ambitions and the modification of self-concepts among the socially mobile are closely linked both to the positive assessments of performance indicators that are considered to be meritocratic and also to the encouragement and support of academic supervisors. The grades thus referred to by the interviewees are relevant for, first, the changes in their academic self-concept and, second, the constitution of social relations with later academic supervisors. The latter, in turn, are constitutive of the change in the self-concept of the socially mobile as well as being important as career gatekeepers.

With regard to the interplay between performance indicators and authoritative others, differences between disciplines and their status trajectories can also be reconstructed in the material. The professors of educational science emphasize their overall grades and, in particular, their written theses as the starting point of doctoral programs offered by professors; in doing so, they emphasize the compatibility between the doctoral position and the course of studies or written thesis. This applies in a homologous manner—although without the explicit emphasis on doctoral grades—to the subsequent transfer to postdoctoral positions.

Thus, especially as far as doctoral offers are concerned, I identified major differences for the socially mobile in the field of law. In their case, relationships are occasionally constituted anonymously, in that students are approached by professors based on the examination results of the state examination. Professors consider the content of the degree program to be less relevant for doctoral programs. Instead, the exam grade dominates over the compatibility of the subject matter, which could also be explained by the model of the "*Einheitsjurist*" (roughly, "standardized lawyer") (Korioth 2006), in which only a small amount of subject specialization takes place when studying law. However, concerning postdoctoral transitions, the focus is on direct personal relationships with the academic supervisor or contacts with other professors mediated through the supervisor.[11] The relevant performance indicators are both the state examination grades and, in particular, the doctoral thesis, as graded by the academic supervisor.

I will depict the interconnectedness of performance indicators and authoritative others by using the main narrative of a socially mobile professor of law as an example. The quoted interview passage follows a narrative segment on the transition to doctorate, for which the law professor gives three reasons: First, a confidence in his abilities resulting from good grades in the state law examination; second,

11 In self-observation formats (Häberle 2010; Schulze-Fielitz 2013) in law, as well as in the interview material at hand, so-called 'teacher-pupil relationships' are mainly described as long-term social relationships that usually continue beyond the supervision of the doctoral thesis with the habilitation.

experiences of devaluation by colleagues during an internship due to the lack of a doctorate; and third, a doctoral offer from his "personable" (later-to-be) academic supervisor. He then goes on to elaborate on his career path as follows:

> *And, yeah, after two years, I was done with the doctorate. Well, it was – (1s) Anyway, I have to say, the second Staatsexamen was 'good', too. That is, 'good'* ***twice over****. Then you are – you're among the top one percent. So that's already something of a* ***royal accolade****. You know you've arrived, then. Then a* ***Ph.D.****, right, and this one was summa cum laude. And the professor thought it was pretty good [laughs]. And then I even got a prize, yes. (H, m, SR, Law)*

In the interview excerpt, H reports very briefly on his doctoral phase and then evaluates his legal career to date in the context of performance indicators, including the grades of both his *Staatsexamen* and his doctoral thesis (grade, award). This is another example of a comparative positioning through the performance indicators of the *Staatsexamen*. With the "'good' twice over"—i.e., a 'good' in the first and also the second *Staatsexamen*—one belongs, as he states, to the upper one percent of a graduating cohort. The interviewee emphasizes his excellent performance accordingly, even couching it in metaphorical terms of royalty.

After comparing himself via his exam grades, he mentions his doctoral grade ("summa cum laude"), its distinction ("got a prize"), and emphasizes, going beyond the mention of the grade, the favorable evaluation by his professor. Unlike the exam grades, in law, the doctoral grade represents both a crucial performance indicator and an evaluation by authoritative others. In this respect, one can firstly state an accumulation of positive evaluations, and also an interweaving of performance indicators and evaluations by authoritative others.

Taking these different evaluations as a starting point, in the following section he takes up the structural conditions he was confronted with after completing his doctorate, which I omit here for reasons of anonymity. With his formal qualification and the structural conditions at the time, he argues that he would have had various professional opportunities and even "quite good offers". Based on those initial conditions, he continues with the core of the representation of a situation of biographical importance (Schütze 2016) that follows.

> *Then [my supervisor] came to me and said, "Don't you want to do your habilitation with me?" And that's when I first started thinking about it, when I was [in my early 30s]. So, with the completion of the doctorate, I first started seriously considering it: "Yes, maybe you could consider university". For me, normally, I really have to say, university professors were a* ***long*** *way away for me. For me, they were – That group for me, at that time, not that I want to say now that I thought it was unattainable. But it was not, for me, at all part of my* ***horizon****. It wasn't something where I would have thought: "This is worth considering for you professionally". I really wouldn't have thought it possible. I kind of thought like: Nope, a* ***good*** *lawyer then, a lawyer* ***with a doctorate*** *in [field of work] maybe, or something along those lines, or a judge – that's what I had in mind at first. But a* ***university*** *professor?* ***Wow****, they're always so super educated, and so broadly educated. They know all kinds of things, speak lots of languages. You can just about halfway speak English, you're just playing at this. Somehow, I thought: "No, you're just not in that class". But that's what [supervisor] – and so I have to say:* ***[Supervisor]*** *was a great* ***encouragement****. He talked me out of all the doubts I had right from the start. He said, "You can do it". (H, m, SR, Law)*

H presents a situation in which his professor offered him habilitation, to his surprise. He recounts that with this offer, he seriously considered, for the first time, a university career ("maybe you could consider university"); he subsequently extensively recapitulates his concerns at the time. The interviewee expresses his concerns in multiple repetitions on a substantial level and emphasizes them through his intonation. For him, university professors were "a **long** way away"; they were not on his "**horizon**"; he "really wouldn't have thought it possible", and so on. He contrasts this social distance towards the professorship, first, with his professional perspectives at the time, considering working as a judge or an attorney and, second, by contrasting his reverential portrayal of professors as multilingual universal scholars ("**Wow**, they're always so super educated, and so broadly educated. They know all kinds of things, speak lots of languages") with his self-concept. Compared to the professors imagined in this way, he thinks he lacks "class" with his concerns indicating a social-structural dimension of biographical schemes. The concerns thus articulated are not refuted solely by the positive evaluations conveyed through performance indicators. It is the interactions with his academic supervisor which basically modify his biographical scheme. The supervisor eases his concerns by conveying confidence.

However, in addition to changing self-concept by implicitly or explicitly mirroring academic competencies, academic supervisors have another function, as illustrated in the following interview section. He continues:

> *And then I remember that he'd written a thesis of 800 pages. Such a **huge** thing. He spent eight years on it. And [the supervisor's own supervisor] had really held him to the highest standards. And then I said, "A text like that I – I wouldn't manage it. It's too much of a good thing." Then he said to me: "Whatever you do, don't make the mistake," he says, "of planning such a huge thing. It can be much leaner. Take a smaller timeframe. **Don't** take me as an example. You'll have to tackle it differently." So, yeah, he really **backed me up**. And then, we developed kind of battle plan, too, so, how could it be done in terms of time and so on. And then he told me directly: "Well, the best thing is to start after three years." So, it's like, two times three, it's still almost the same today, with junior professorships, it's still like that. And habilitation, the whole thing is still six years. So he said: "Well then, three years here with me for now, but in the third year, we'll try to get a DFG research grant somehow." And yes, that's how he did it. I really have to say that I found the right topic. Of course, I looked for it all myself, which ended up really grabbing me. And he went along with it all, didn't kind of talk me into having reservations, but said: "Go ahead, I have complete trust in you", and so on. It was important at the time that I had this **man** as a supporter, who made me feel like he **believes** in you. (H, m, SR, Law)*

In essence, I differentiate between two functions of authoritative others based on this interview excerpt. The first is the aforementioned modification of biographical schemes through the confirmation of academic competencies and the refutation of concerns. H emphasizes this again with regard to the requirements he anticipated for a possible habilitation thesis, in which his initial orientation was the comprehensive thesis of his academic supervisor.

Regarding the concerns of a habilitation thesis, however, a second function becomes apparent, consisting of H's supervisor's assistance in the practical planning and realization of the habilitation. It includes the conception of the habilitation thesis itself (scope, time planning) and its financing. To finance the six-year postdoctoral phase, his supervisor proposes a combination of a staff position and a DFG research grant,[12] with him taking the role of career gatekeeper (Hamann/Beljean 2021) in filling the staff position and supporting H with the grant's application process.

Concerning the staff position offered by the academic supervisor here, and his assistance in applying for a scholarship, I want to point out another aspect. Due to the *Lehrstuhlprinzip* (Berthoin Antal/Rogge 2020), German professors play a key role in recruiting and promoting young scientists, regardless of their social background. However, the relevance of economic security is emphasized in the interview material primarily by the socially mobile. Thus, with reference to biographical decisions to pursue doctoral or postdoctoral degrees, they mostly note the duration and scope of staff contracts and stress their influence on their decisions. They can rarely fall back on their family's economic capital, whereas parental economic support, at least until the completion of the doctorate, is quite typical among the social reproduction cases.

While social reproduction cases do not address economic considerations in the main narratives, nor refer to their contracts, they do occasionally address financial support in the follow-up section. For example, in a lengthy narrative segment in his follow-up section, B reflects on his social background and states:

> *But it was always clear that my parents would finance a doctorate for me. And in the same way, it was always clear to me that I would finance a doctorate for my daughter. And I have the money, so to speak. And that's another advantage when you come from a bourgeois background. (B, m, SR, Law)*

In this respect, academic supervisors not only have a relevance in the modification of self-concept that differs according to class origin. As career gatekeepers, they convey economic security through job offers, which becomes biographically relevant especially for those who have little economic capital.

Discussion

Academic careers have only been partially considered in the context of the sociology of inequality, and only a few studies deal with class-specific inequalities after the beginning of a doctorate, let alone look at later status trajectories. The few studies of academia point to an underrepresentation of professors from less privileged classes and focus on theoretical explanations. By examining academic careers from a class-specific perspective, this article contributes to and complements this field of research; it not only provides qualitative empirical insights, but also a theoretical

12 DFG refers to the *Deutsche Forschungsgemeinschaft* (German Research Foundation), the most important source of third-party funding for German universities (Hüther/Krücken 2018). In this context, the DFG offers various grants programs. It is thus similar to the National Science Foundation (NSF) in the US.

perspective that focuses on intergenerational transformation rather than reproduction.

Drawing on a comparative analysis of 27 autobiographical narrative interviews with German law and education professors from different social origins, I reconstructed *two basic social mechanisms,* which appear to be constitutive for modifying the self-concepts of the socially mobile. First, through *positive evaluations* of student and academic performance—and the *social comparisons processes* based on them—the confidence of the socially mobiles' professors in their academic abilities may grow, and their self-concepts may change. Second, *social relations and interactions with authoritative others* may be crucial in the modification of the self-concepts of the socially mobile respondents, as they may internalize their explicit and/or implicit evaluations and thus gradually develop academic career ambitions. However analytically differentiated, both mechanisms seem intertwined. The performance indicators seem relevant for the change in academic self-concepts and, consequently, the constitution of social relations with later academic supervisors. Academic supervisors, in turn, seem crucial in changing the self-concepts by evaluating the socially mobile professors' performances and mirroring academic competencies, and they seem relevant as career gatekeepers.

This contrasts with the social reproduction cases, for whom performance indicators—and the commensurate related social comparisons—and academic supervisors seem less relevant in terms of their self-concepts. Rather, for them, performance indicators appear to represent primarily formal entry requirements, from which less significance is derived for evaluating their academic competencies. The same applies to academic supervisors, who seem similarly relevant for the social reproduction cases as career gatekeepers, but less significant in modifying their self-concepts. Instead, these respondents tend to be the ones who approach professors with their doctoral or postdoctoral projects, and thus pursue academic careers more strongly on their own initiative and display greater self-confidence.

However, this study has its limitations concerning the methodological perspective and the scope of the results. The autobiographical interview allows us to focus primarily on the perspective of the interviewees. Structural opportunities or barriers can therefore only be considered to a limited extent. Moreover, this method does not enable us to adequately investigate either the evaluations of career gatekeepers or the reciprocity of building social relations as authoritative others with them. Regarding the constitution of social relations with professors, individual studies point to an indirect class-specific structuring of recruitment criteria through habitus, for example, among doctoral students (Kahlert 2016). With respect to the significant performance indicators, one of the questions that arises is what influence social origin has on the performance evaluation. While this has been researched for social origin's influence on teachers' assessment of pupils (Lorenz et al. 2016; Tobisch/Dresel 2017), for gender inequalities in the aforementioned state law examination (Glöckner et al. 2017) or academia (Nielsen 2018; Rivera/ Tilcsik 2019), such insights are lacking for social origin and academic careers. Consequently, one might rightfully question, for example, the extent to which ascriptive characteristics influence the assessment and recruitment of young scholars and the related biographical influences upon an academic career by authoritative others, as well as the appointment procedures that ultimately determine professional success.

Further limitations concern the scope of the results, especially in the light of disciplinary and national contexts. The study is limited to two disciplines, which could limit the scope of the results. For example: In law, but also in educational science, less importance is attributed to collaborative research in large teams than it is in natural science work contexts (Kagan 2009: 101). Does this reduce the relevance of authoritative others for the modification of biographical schemes? Furthermore, the German case has some peculiarities due to its prevailing *Lehrstuhlprinzip* (faculty chair principle) and the associated staff structure, which it shares with other countries where faculty chairs wield considerable influence (Dobbins 2020). In these cases, the career path to professorship requires many years of temporary and insecure employment with a high degree of dependence on the chair. The chairs' pronounced influence suggests that they are crucial as authoritative others and career gatekeepers, but this might differ in departmental academic systems. Regarding performance indicators perceived as significant, differences may arise from those contexts in which there is an established strong hierarchization between universities (for the US see Beyer 2021), and the associated differences shape self-concepts. The German system of higher education, and science in general, has been characterized by a low degree of hierarchization between universities, although this could be in the process of change due to excellence initiatives (Hartmann 2010).

Furthermore, quantitative studies dealing with class-specific inequalities in academic careers, especially in the later career phases, would be desirable. Such studies could also draw—with the intention of testing—on the assumptions derived from this study. Thereby, it would seem less problematic to look at performance indicators, even if their disciplinary specificities ought still to be considered. Operationalizing the concept of authoritative others seems to be more challenging.

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Female advantage in German sociology: Does accounting for the "leaky pipeline" effect in becoming a tenured university professor make a difference?

Abstract: Recent studies, controlling for publications and other observable career signals, suggest that women have a higher chance of becoming tenured sociology professors in German universities than men. In this paper, we replicate one such study using the same data, plus two follow-up waves, as well as new data on parenthood. This allows us to consider gender-specific leaving rates, which may have led to an overestimation of female advantage in the original study. However, the replication does not indicate a lower female advantage. On the contrary, Cox regressions show that women have a 48 percent higher chance of obtaining a tenured professorship once parenting is additionally controlled for. Further findings reveal that women leave academia predominantly at the predoc stage, while men leave academia more often at the postdoc stage. This, however, is not a relevant explanation for why women have a higher chance than men of obtaining tenure.

Keywords: gender bias; female advantage; academic careers; leaky pipeline; German sociology

Chancenvorteil für Frauen in der Soziologie: Berücksichtigung des „Leaky Pipeline"-Effekts bei der Erlangung einer Lebenszeitprofessur in Deutschland

Zusammenfassung: Aktuelle Studien, die Publikationen und weitere sichtbare Karrierefaktoren berücksichtigen, zeigen eine höhere Chance für Frauen, Soziologieprofessuren an deutschen Universitäten zu erhalten. In diesem Beitrag replizieren wir eine solche Studie und erweitern diese um zusätzliche Datenerhebungspunkte und Angaben zur Elternschaft. Dies ermöglicht Rückschlüsse auf geschlechtsspezifische Ausstiegsraten aus dem Wissenschaftssystem, die in der ursprünglichen Studie zu einer Überschätzung des Chancenvorteils von Frauen geführt haben könnten. Die Replikation deutet jedoch nicht auf eine Abschwächung des Effekts hin: Cox-Regressionen zeigen, dass Frauen eine um 48 Prozent höhere Chance auf eine

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Lebenszeitprofessur haben, wenn Elternschaft berücksichtigt wird. Weitere Ergebnisse zeigen, dass Frauen häufiger ohne Promotionsabschluss die Wissenschaft verlassen (Pre-Doc-Phase), während Männer häufiger in der Post-Doc-Phase die Wissenschaft verlassen. Diese geschlechtsspezifischen Ausstiegsraten tragen allerdings nicht zur Erklärung des Chancenvorteils von Frauen bei der Berufung auf eine Lebenszeitprofessur bei.

Stichworte: Geschlechter Bias; Chancenvorteil für Frauen; akademische Karrieren; Leaky Pipeline; Soziologie

Introduction

Recent studies on German academia suggest that female sociologists have a higher chance than male of becoming tenured as sociology professors (Lutter/Schröder 2016; Jungbauer-Gans/Groß 2013). Jungbauer-Gans and Groß (2013), based on a survey of academics who wrote their habilitation, find that women are 2.17 times as likely to be promoted to associate/full professors compared to men when publications and other observable career signals are controlled for. Lutter and Schröder (2016), based on manually coded Curriculum Vitae (CV) and publication data from German sociologists, show that female professors become tenured approximately two years earlier than men, having published 23–44 percent less than men. Overall, when controlling for the number and types of publications, as well as other career milestones, such as scholarly awards or international experience, female sociologists have a 44 percent higher chance of being appointed to a university professorship.

An important critique of these studies is that their documented female advantage might be a methodological artifact due to gender-specific survivorship bias. Both studies collected their data at one point in time. Lutter and Schröder's (2016) results are based on retrospective data, namely manually-collected information on career trajectories (CV and publication records) from websites of academics at all sociology departments in Germany in the year 2013. By design, academics who had already left academia when the data was collected were not included. It has been firmly established that women leave academia disproportionately compared to men (e.g., Blickenstaff, 2005; Hancock et al., 2013; Joecks et al., 2014; Leemann et al., 2009; Leemann et al., 2010; Pell, 1996). Due to this "leaky pipeline", only the most qualified or motivated women may remain in academia, while less career-orientated women may leave and consequently be unobservable in academia. This survivorship effect would lead to a gender-specific selection bias that could explain the female advantage effect found by both Lutter and Schröder (2016) and Jungbauer-Gans and Groß (2013). If this is true, their result would overestimate the female advantage in gaining tenure.

In this paper, we replicate Lutter and Schröder's (2016) study, using their original 2013 data plus two newly collected follow-up waves from the years 2016 and 2019. These two follow-up waves (1) add and update the new publication and CV data of academics in the original 2013 dataset, (2) identify who left academia since 2013, and (3) add the data of those academics who entered academia after 2013. This allows us to investigate whether women leaving academia disproportionately causes a survivorship bias that affects their chances of attaining tenure. Our hypothesis is that the female advantage should be less than in the original study, since taking into account the two additional waves reduces a potential survivorship bias. Improving upon the original study, we also examine the possibly gendered effect of having children on gaining tenure, as children may be one of the main reasons that women leave academia. We expected the female advantage to reduce further after controlling for parenthood. Our results show, however, that the advantage of women still occurs and even slightly increases after accounting for parenthood. None of the additional determinants explains women's significantly higher chances of becoming sociology professors.

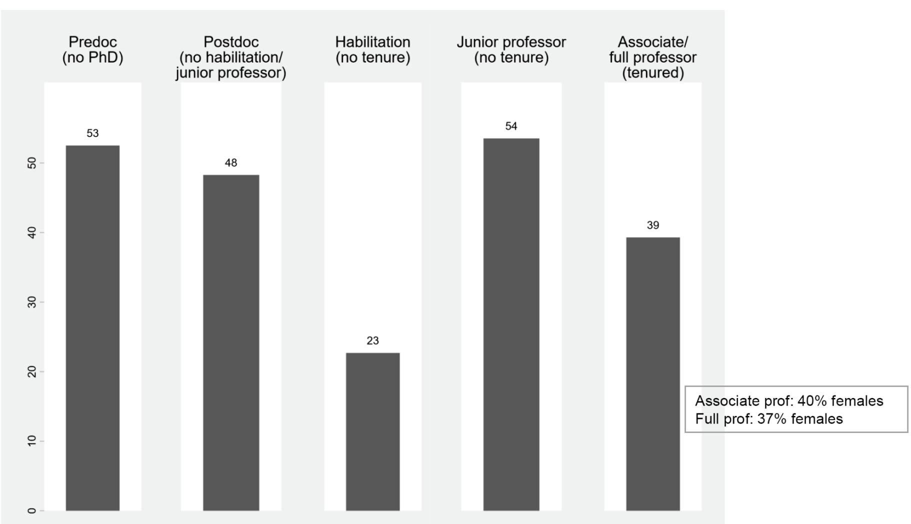
To become a tenured professor in Germany, academics are required to author a doctoral thesis, followed by a habilitation (comparable to a second thesis) or publications that are equivalent to a habilitation (such as several journal articles). In 2002, junior professorships (similar to assistant professorships in the US) were introduced.[1] Most junior professorships have no tenure track (this changed recently to some degree), which means that virtually all positions prior to tenured professorships are temporary. German legislation (*WissZeitVG*), however, prohibits the employment of academics on the basis of temporary contracts for longer than 12 years, after which they must either leave academia or have secured one of the few permanent positions, which is usually a tenured professorship. The effect is that qualified academics are forced to leave academia if they fail to obtain one of the few tenured positions. This becomes especially crucial for women, as the "race for tenure" takes place during the same period as starting a family typically also does, which is likely to impact women more than men (Dorenkamp/Weiß, 2018). Thus, if women are more likely to leave academia, this may have implications for the results of previous studies that observed only the remaining, and thus possibly the most committed women (e.g., Auspurg et al., 2017; Jungbauer-Gans/Gross, 2013; Lutter et al., 2022; Lutter/Schröder, 2016). The results of our study therefore have relevance for higher education and science policies. As previous studies might suffer from selectivity bias, their results are possibly misleading. Incorporating the leaky pipeline in our panel design enables us to show that this is not the case for the academic field of German sociology.

1 In Germany, a distinction has been made since 2002 between W1 junior professorships (assistant professorships), W2 tenured professorships (associate professorships) and W3 tenured professorships (full professorships), according to the salary scheme.

Survivorship bias in academia

To explain how survivorship bias can lead to an overestimation of female advantage, one must first understand how it occurs. Figure 1 illustrates that in 2019, fewer women than men remained in academia at successive career stages. The first bar shows the share of female sociologists among those who do not yet have a doctorate ("predocs"), the second bar indicates the share of female sociologists among those who have already obtained a doctorate ("postdocs"), and the third bar shows the percentage of female sociologists among those with a habilitation, followed by junior professors. The last bar shows the share of female sociologists among tenured associate/full professors. As one can see, the share of women decreases with each successive career stage up to tenured professorships; the only exception is that women are appointed more often as junior professors. Among professors, the share of women is slightly greater in the lower position (40 percent among associate professors vs. 37 percent among full professors). However, comparing these figures with the 2013 data from Lutter and Schröder (2016) shows that the proportion of women among associate professors fell slightly (from 46 percent in 2013) while the proportion of women among full professors almost doubled (it was 21 percent in 2013).

Figure 1. Share of female sociologists at each career stage in 2019 in Germany.



Note: Own data collection of sociologists at German universities. N = 2,290; $N_{pre\text{-}doc}$ = 699; $N_{post\text{-}doc}$ = 903; N_{habil} = 143; N_{junior} = 59; $N_{tenured}$ = 486.

Similar to sociology, research in the fields of psychology and political science in Germany has shown that fewer women hold professorships, while there is near parity at the beginning of academic careers (Lutter et al., 2022; Schröder et al., 2021). In 2019, 44 percent of predocs in political science were women but only 31 percent of tenured professorships were held by women (39 percent of those who obtained a PhD were women, as were 31 percent of those who obtained a habilitation or held a junior/assistant professorship). In the same year, 64 percent of predocs in psychology were women but only 37 percent of all tenured professorships were held by women (61 percent among those who obtained a PhD, 49 percent among those who obtained a habilitation or held a junior/assistant professorship).

The described self-selection of women in academia is plausible based on theories and empirical research: Studies agree that women leave academia disproportionately because of work-family conflicts (Goulden et al., 2011; Hancock et al., 2013, p. 524; Leemann et al., 2009; Mason et al., 2013), poorer integration in academic networks (Leemann et al., 2009; Leemann et al., 2010), or lower productivity (Cole/Zuckerman, 1984; Schubert/Engelage, 2011; Schucan Bird, 2011). If exits are systematic, then the remaining women may also share systematic characteristics; for example, women remaining in academia may be particularly committed to an academic career (Xie/Shauman, 2003, pp. 13, 135). Their higher career orientation may lead them to subordinate other goals, which increases their scientific output relative to their less-committed peers. Because scientific output is related to academic resources, such as research grants or access to academic networks (Habicht et al., 2021), it is likely that high-performing women also have above-average scientific capital, producing accumulative advantages throughout the career pipeline (DiPrete/Eirich, 2006). These selection processes may lead to overestimated female advantages in studies that address women's applications for higher positions (e.g., Auspurg et al., 2017; Jungbauer-Gans/Gross, 2013; Lutter/Schröder, 2016).

Self-selection processes matter at several levels. For instance, if less-committed women become parents and leave academia, this inversely leads to positively selected remaining female scholars. Career-oriented women are probably better able to handle both working on an academic career and having a family at the same time. Studies indeed show that high-performing mothers tend to stay in academia (Joecks et al., 2014), and that low-performing mothers face stronger motherhood penalties than high-performing mothers (Lutter/Schröder, 2020).

Apart from care work, other reasons may also help to explain women's lower levels of productivity. For example, women differ in their research styles (Fox/Mohapatra, 2007), so they might publish fewer but qualitatively better papers. Women also spend more time on teaching and/or service activities (for the US, see, e.g., Bird et al., 2004), which may impair their research. They exhibit less confidence in their academic performance than men (Buser et al., 2014), which could explain why they publish less. Women are also less productive at the beginning of their careers, which may lead to larger cumulative differences over time, as early success yields resources for later success (for political science in Germany, see, e.g., Habicht et al., 2021).

However, all these explanations refer to "remaining" scientists in academia. How, then, can we reduce survivorship bias in studies of academia? Problems of selectivity can only be reduced by observing the data of non-survivors and gathering data at multiple points in time over a sufficiently long period. We therefore supplement the career data of Lutter and Schröder (2016) with six more years of data. Our hypotheses are the following:

Hypothesis 1: If the assumption of the survivorship bias is true, i.e., if female advantage is artificial because Lutter and Schröder (2016) sampled a selective group of extraordinarily qualified and motivated women, then the effect of female advantage must be substantially lower if we use data that also includes non-survivors.

Hypothesis 2: If we further control for parenting dynamics (whether academics have children or not), the effect must be further reduced because we additionally control for a main factor of the leaky pipeline.

Data and methods

We used a dataset that covers career data on virtually all sociology scholars (doctoral students, postdocs, and tenured faculty) at German universities, based on all 75 sociology or social science departments that exist in German universities.[2] Lutter and Schröder's original study collected the CVs and publication lists of sociologists in 2013. We added two additional waves of data, collected three and six years later (in 2016 and 2019). Both waves updated the publication lists and career profiles of all those included in the original 2013 wave[3] and identified who had left academia since 2013 ("leavers")[4], while also adding publications and CV information for all who entered academia after 2013 ("new sociologists", for an overview, see Table A1). Sociologists, according to the study design, are academics currently working in a sociology department. If a university does not have an exclusive sociology department, it usually has a "social science" department that includes sociology, political science or related sub-disciplines. In this case, we searched the department for professors with "sociology" in their denomination and coded the professor's full team (only those with at least one publication to avoid coding administrative staff, etc.).

Using three waves of data collection, the complete dataset includes 2,290 sociologists (1,063 female, or 46 percent), of whom 486 are tenured professors (these of

2 In 2019, Germany had 112 universities (Statistisches Bundesamt 2020, p. 10). In addition, we used the websites of sociologists from two research institutes in Germany: Max Planck Institute for the Study of Societies and the WZB Berlin Social Science Center.

3 Even though (sur)names may have changed through marriage, we were able to identify the person through their publications (scientists usually also include their birth name in the CV, presumably because they are interested in being recognized by others).

4 We assumed this to be the case if they can no longer be found on the web at any university or research institute either in Germany or abroad.

whom 191 are female, or 39 percent) with 50,457 publication years. We use Cox regressions to capture influences throughout their career until being *tenured*, which is the outcome variable. By design, we only consider career data up till the first appointment to a tenured position. Due to the panel design, right-censoring occurs if someone left academia, retired, passed away, or until the observation period runs out (the year 2019).

For the second hypothesis, we examined whether *parenting* affects the chances of becoming a professor. Based on collected email addresses, we conducted two email surveys, asking whether academics had children and when their children were born (including biological, adopted and stepchildren). The first email survey took place in 2014, immediately after the first wave of data collection; a second survey took place in 2019 after the third wave. We gathered information on children for 70 percent of female and 67 percent of male scholars.

As independent variables, we use career information from CVs and control the same variables as Lutter and Schröder (2016). However, we added new variables not included in the original study to test the robustness of the results. First, we count *DFG funding* grants, as these may increase the chance of attaining tenure. We used the "Gepris" database of the German Research Foundation (DFG) to collect funding information for each academic in our dataset. We also considered sociologists' *entry cohorts*.[5] Due to labor market changes and the introduction of gender equality policies, effects may reflect the past but not be indicative of what happened to more recent cohorts of researchers. To account for this, we captured cohort effects by the years when sociologists entered academia through their first publication, measured in intervals of ten years (1980–1990, 1991–2000, 2001–2010 and 2011–2019). For a descriptive overview of all variables, see Table 1. If career information was not provided on CVs, we assumed it did not happen. For example, if no information about scientific awards could be found, we assumed that the person had not received any such awards.[6]

5 As an alternative to academic entry cohorts, we use a dummy variable for years after 2013 (*post 2013*). Because we assumed the group of women to be more heterogeneous after 2013 (when we tagged sociologists leaving academia, as well as sociologists who entered academia), we see in this reason to also assume that gender-specific leaving rates may have contributed to the positive female effect of the original study design. However, the results hardly change (see Table A4, Model 2b).

6 Replication files can be found at https://osf.io/vzych/ (DOI 10.17605/OSF.IO/VZYCH).

Table 1. Descriptive statistics of all variables used in this study.

Variable	N	Mean/Prop	SD	Min	Max	Operationalization	Variable type	
SSCI/SCIE articles	2290	1.86	3.02	0	31.68	# of SSCI/SCIE articles, co-author adjusted: *2/(number of authors+1)*	continuous	time-varying
Non-SSCI/SCIE articles	2290	3.21	5.07	0	79.80	# of Non-SSCI/SCIE articles (co-author adjusted)	continuous	time-varying
Books	2290	1.15	1.52	0	22.50	# of books (co-author adjusted)	continuous	time-varying
Edited volumes	2290	.70	1.41	0	15.40	# of edited volumes (co-author adjusted)	continuous	time-varying
Book chapters	2290	7.01	9.93	0	121.67	# of book chapters (co-author adjusted)	continuous	time-varying
Grey literature	2290	3.85	7.05	0	87.87	# of grey literature (co-author adjusted)	continuous	time-varying
Female	2290	.46		0	1	1=female, 0=male	dichotomous	time-constant
Prestige graduation	2290	.30		0	1	1=graduation at a German university of excellence, 0=graduation at other German university or abroad	dichotomous	time-constant
Prestige doctorate	2290	.20		0	1	1=doctorate at a German university of excellence, 0=doctorate at other German university or abroad	dichotomous	time-constant
Prestige habilitation	2290	.06		0	1	1=habilitation at a German university of excellence, 0=habilitation at other German university or abroad	dichotomous	time-constant
Awards	2290	.22	.66	0	9	# of scholarly awards	continuous	time-varying
Months abroad	2290	11.90	25.18	0	246	# months spent abroad	continuous	time-varying
Studied abroad	2290	.31		0	1	0=studied in Germany, 1=(parts of) studies spent abroad	dichotomous	time-constant
Doctorate abroad	2290	.09		0	1	0=doctorate in Germany, 1=doctorate abroad	dichotomous	time-constant
International publications	2290	5.49	8.75	0	92	0=published not in English (e.g., in German), 1=in English	continuous	time-varying
Mobility	2290	1.96	1.75	0	11	# of moves to another university	continuous	time-varying
Interim professor	2290	.31	.82	0	9	# of substituted professorships	continuous	time-varying
Department size	2290	9.77	7.39	1	37	# of tenured professors per department where the person was recently employed	continuous	time-constant
Incomplete[1]	2290	.12		0	1	1=only selected publications, 0=complete publication lists	dichotomous	time-constant
Co-authors	2290	18.30	27.49	0	390	# of co-authors per publication	continuous	time-varying

Variable	N	Mean/Prop	SD	Min	Max	Operationalization	Variable type	
Open positions	2290	18.36	7.93	4	34	# of tenured professors per year (vacant positions), lagged by one year	continuous	time-varying
Years since habilitation	2290	.86	2.62	0	27	Year(s) since habilitation was obtained	continuous	time-varying
Years since habilitation (sq.)	2290	7.62	38.11	0	729	Year(s) since habilitation was obtained (squared term)	continuous	time-varying
Years since assistant professor	2290	.23	1.07	0	12	Year(s) since assistant professorship	continuous	time-varying
Childless	2290	.35		0	1	Childless	categorical	time-varying
With children		.33		0	1	Having children		
No info on children		.31		0	1	Did not participate in our survey		
DFG funding	2290	.20	.56	0	6	# of DFG research grants acquired	continuous	time-varying
Entry cohort before 1990	2290	.08		0	1	Scientists who started their careers before 1990	categorical	time-constant
1990–1999		.15		0	1	Scientists who started their careers between 1990–1999		
2000–2009		.36		0	1	Scientists who started their careers between 2000–2009		
after 2009		.41		0	1	Scientists who started their careers after 2009		

Note: Based on 2.290 academics with 50,457 publications; sq = squared.
[1] The share of males/females with incomplete publication lists is almost equal (13 % of males and 11 % of females; chi-squared test not significant).

Results

We start by describing sociology professors who just got their first tenured position, including data from all three waves (2013, 2016 and 2019) and all variables (see Table 2). We then present a descriptive overview of those who left academia since 2013 and compare their characteristics (such as publications or children) with those who stayed in academia (see Tables 3.1 and 3.2). We then run Cox regressions on who becomes a sociology professor using three waves (Table 4) and present several robustness tests (Table 5 plus appendix).

Descriptive findings on who gains tenure

Table 2 presents descriptive statistics for all independent variables when sociologists receive their first tenured professorship. Different from the descriptive statistics of 2013 (Lutter/Schröder, 2016, p. 1005), women in sociology are no longer appointed significantly earlier than men. It now takes about 15 years from first publication to tenure for both women and men who actually received tenure.

Table 2. What characterizes male and female sociologists who just gained tenure (including waves 2013, 2016, 2019)?

	Overall		Men		Women		dif	sig.
	Mean/ Prop	SD	Mean/ Prop	SD	Mean/ Prop	SD		
Years to professorship	15.4	4.84	15.65	4.77	15.01	4.94	.64	
SSCI/SCIE articles	4.43	4.24	5.09	4.65	3.43	3.31	1.66	***
Non-SSCI/SCIE articles	7.25	7.18	8.46	8.13	5.41	4.91	3.05	***
Books	2.43	1.99	2.76	2.26	1.94	1.36	.82	***
Edited volumes	1.67	1.94	1.75	1.88	1.55	2.03	.20	
Book chapters	15.89	12.03	17.23	11.70	13.85	12.27	3.38	**
Grey literature	7.69	9.78	8.77	10.77	6.04	7.78	2.74	**
Prestige graduation	.31		.31		.31		.01	
Prestige doctorate	.30		.30		.29		.00	
Prestige habilitation	.19		.24		.11		.12	**
Awards	.39	.96	.35	1.01	.45	.87	-.10	
Months abroad	21.94	34.07	19.9	30.53	25.06	38.75	-5.16	
Studies abroad	.27		.23		.33		-.09	*
Doctorate abroad	.13		.11		.16		-.05	
International publications	11.10	12.89	11.30	13.07	10.80	12.65	.50	
Mobility	3.25	1.77	3.28	1.78	3.2	1.76	.08	
Interim professor	.83	1.04	.85	1.02	.81	1.07	.04	
Department size	10.87	8.99	11.01	9.21	10.66	8.66	.35	
Co-authors	31.96	32.94	34.34	33.03	28.34	32.59	6.00	+
Habilitation	.64		.70		.54		.16	**
Years since habilitation	2.02	2.63	2.46	2.85	1.35	2.09	1.11	***
Assistant professor	.17		.12		.25		-.13	***
Years since assistant professor	.78	1.92	.52	1.57	1.17	2.31	-.64	**

	Overall		Men		Women		dif	sig.
	Mean/ Prop	SD	Mean/ Prop	SD	Mean/ Prop	SD		
Childless	.26		.22		.31		-.09	*
With children	.48		.52		.43		.09	+
No info on children	.26		.26		.26		.00	
DFG funding	.56	.84	.53	.85	.60	.82	-.08	
Entry cohort before 1990	.29		.35		.19		.16	***
1990–1999	.40		.40		.41		-.02	
2000–2009	.29		.24		.36		-.12	*
after 2009	.03		.02		.04		-.02	

Notes: Cases with incomplete publication lists (n = 90) were dropped. N_{male} = 239, N_{female} = 157. SD = standard deviation.

Mean differences between men and women significant at + p <.1, * p <.05, ** p <.01, *** p <.001; two-sided tests).

Gender differences in publications mostly resemble the 2013 results. Men still publish significantly more when getting their first tenured professorship (except for a nonsignificant difference in edited volumes). Compared to female sociologists, men have 1.5 times as many articles appearing in the Social Science Citation Index/ Science Citation Index Expanded (SSCI/SCIE) when they are tenured, 1.6 times as many non-SSCI/SCIE articles, 1.4 times as many books and 1.2 times as many book chapters. Men completed their habilitation at a university of excellence about twice as often. No significant difference in the average number of academic awards exists anymore, contrary to the 2013 data, where women had significantly more awards than men (at the 10 percent level).

Of all tenured sociologists, 64 percent obtained a habilitation (75 percent in the original study). Among men, this figure is 70 percent, while only 54 percent of tenured women obtained a habilitation. Conversely, only 12 percent of all men but 25 percent of all women had a junior professorship before they got tenured, indicating that the junior professorship has become increasingly important as an alternative to the habilitation, particularly for women.

Forty-eight percent of tenured professors have children. Twenty-six percent are childless and a further 26 percent did not respond to this survey question. While 52 percent of male professors have children, this is only true for 43 percent of female professors. Twenty-two percent of male professors are childless, compared to 31 percent of female professors. There are no gender differences in the nonresponse rate to this survey question.

In 2019, women acquired non-significantly more DFG grants up to the time they received tenure. While 40 percent of all female tenured professors started their careers after the year 2000, this is only true for 26 percent of all male tenured professors. This reflects an increase of women in academia in the last two decades, so that men are overrepresented in older cohorts.

Who has left academia since 2013?

Because we hypothesize a gendered selection effect as a bias in the original study, we now take a closer look at who left academia. Table 3.1 shows that 263 sociologists left academia between 2013 and 2019, of which 55 percent were women and 45 percent men. There is a trend of gender-specific leavers by career stage; at early career stages (doctoral students), leaving rates are higher for women than for men (65 percent vs. 35 percent in the first wave; 60 percent vs. 40 percent in total). In contrast, leaving rates are higher for men in the postdoc phase (69 percent vs. 31 percent in the first wave; 52 percent vs. 48 percent over all waves). These results show that women leave disproportionately during the early stages of their career, before completing their PhD, while men tend to leave disproportionately after completing their PhDs.

Table 3.1. Absolute numbers of academic leavers, separately by gender and career stage (in parentheses: %).

	Career stage		
	Pre-doc	Post-doc	Total
	Leavers 1st wave (2013 – 2016)		
Male	31 (35)	20 (69)	51 (44)
Female	57 (65)	9 (31)	66 (56)
Total	88 (100)	29 (100)	117 (100)
	Leavers 2nd wave (2016 – 2019)		
Male	39 (46)	27 (44)	66 (45)
Female	46 (54)	34 (56)	80 (55)
Total	85 (100)	61 (100)	146 (100)
	Total leavers (2013–2019)		
Male	70 (40)	47 (52)	117 (45)
Female	103 (60)	43 (48)	146 (55)
Total	173 (100)	90 (100)	263 (100)

According to our theoretical discussion, lower productivity and having children could affect whether academics—particularly women—abandon an academic career. Table 3.2 compares how academic “leavers” and “remainers” differ in terms of SSCI/SCIE publications, book chapters and parenthood after an average of six years in academia.[7] Most strikingly, it is the number of SSCI/SCIE publications

7 On average, sociologists leave academia after six years. We therefore compare the numbers of publications and also the number of children when they left academia with those of remainers after six years in academia. Table 3.2 does not include academics who had been in academia for less than six years, which reduces the number of remainers.

that differs most significantly between those who left and those who remained in academia. Those who abandon an academic career have published 42 percent less than their counterparts who remain (among women: 45 percent). Female leavers also write fewer book chapters than female remainers, a difference that is only significant at the 10 percent level. Female and male sociologists who have left academia are equally likely to have children as sociologists who remain (36 percent vs. 38 percent were parents). Female leavers tend to have slightly more children than female remainers (0.61 vs. 0.52 children on average), while male leavers have fewer children than their counterparts who stayed (0.52 vs. 0.59). However, these differences are not significant.

Table 3.2. T-tests on academic leavers versus remainers (matched at equal years).

	Remainers (R)	Leavers (L)	Mean (R)	Mean (L)	ratio (L/R)	dif (%) 1-(L/R)	sig.
Overall							
SSCI/SCIE articles (ln)	1305	241	.73	.42	.58	-42 %	***
Book chapters (ln)	1305	241	2.35	2.09	.89	-11 %	
% Parents	957	123	.38	.36	.95	-5 %	
# of children	957	123	.56	.57	1.02	+2 %	
Only women							
SSCI/SCIE articles (ln)	568	130	.65	.36	.55	-45 %	***
Book chapters (ln)	568	130	2.27	1.80	.79	-21 %	+
% Parents	427	71	.36	.37	1.03	+3 %	
# of children	427	71	.52	.61	1.17	+17 %	
Only men							
SSCI/SCIE articles (ln)	737	111	.79	.49	.62	-38 %	*
Book chapters (ln)	737	111	2.42	2.42	1.00	0 %	
% Parents	530	52	.39	.35	.90	-10 %	
# of children	530	52	.59	.52	.88	-12 %	

Notes: Cases with incomplete publication lists were dropped. Numbers of remainers after six years in academia (as the average time when sociologists leave academia).

Mean differences between men and women significant at + p <.1, * p <.05, ** p <.01, *** p <.001; two-sided tests.

Cox regression results

Table 4 shows hazard ratios for the chances of gaining a tenured professorship in sociology. Testing our first hypothesis, Model 1 replicates the main results of the original study (see Model 6 of Table 3 in Lutter/Schröder 2016) including all waves.[8] Models 2 and 3 split the results by gender (replicating Models 5 and 6 of Table 4 in Lutter/Schröder 2016). To test our second hypothesis, we added parenthood in Model 4, and split it by gender in Models 5 and 6.

8 For detailed results on the stepwise regression models, see Table A3 in the appendix.

Table 4. Cox regression models: gaining tenure (including waves 2013, 2016, 2019).

	Test hypothesis 1 (replication)			**Test hypothesis 2 (children)**		
	(1)	(2)	(3)	(4)	(5)	(6)
	Full Model	Only Women	Only Men	Full Model	Only Women	Only Men
SSCI/SCIE journal articles (ln)	1.67*** (6.16)	1.36* (2.16)	2.01*** (6.41)	1.66*** (6.16)	1.36* (2.22)	1.98*** (6.24)
Non-SSCI/SCIE articles (ln)	1.20* (2.38)	1.29+ (1.87)	1.16 (1.56)	1.19* (2.33)	1.27+ (1.77)	1.16 (1.49)
Books (ln)	1.63*** (4.20)	1.59* (2.16)	1.57** (3.26)	1.59*** (3.99)	1.58* (2.15)	1.53** (3.06)
Edited volumes (ln)	1.36** (3.11)	1.29 (1.41)	1.42** (2.89)	1.35** (3.08)	1.29 (1.41)	1.38** (2.68)
Book chapters (ln)	1.10 (1.05)	1.26 (1.50)	1.05 (.40)	1.10 (1.03)	1.29 (1.63)	1.04 (.35)
Grey literature (ln)	.89+ (-1.84)	.92 (-.70)	.86* (-2.23)	.90+ (-1.80)	.92 (-.69)	.86* (-2.30)
Female	1.46** (3.21)			1.48*** (3.44)		
Prestige graduation	.63*** (-3.73)	.72 (-1.62)	.57*** (-3.41)	.63*** (-3.68)	.71+ (-1.65)	.58*** (-3.32)
Prestige doctorate	1.18 (1.23)	1.25 (1.12)	1.06 (.32)	1.20 (1.41)	1.33 (1.42)	1.08 (.44)
Prestige habilitation	1.38* (2.06)	1.46 (1.48)	1.40+ (1.80)	1.36+ (1.93)	1.40 (1.27)	1.41+ (1.81)
Awards (ln)	1.24 (1.60)	1.43+ (1.69)	1.04 (.22)	1.23 (1.55)	1.45+ (1.79)	1.04 (.20)
Months abroad (ln)	1.13** (3.14)	1.14* (2.16)	1.16** (2.93)	1.12** (3.13)	1.15* (2.26)	1.16** (2.91)
Studied abroad	.89 (-.96)	1.05 (.26)	.76 (-1.63)	.90 (-.86)	1.05 (.27)	.77 (-1.50)
Doctorate abroad	1.50* (2.39)	2.28** (3.02)	1.08 (.32)	1.49* (2.36)	2.35** (3.21)	1.07 (.30)
International publications (ln)	1.14+ (1.86)	1.02 (.20)	1.14 (1.44)	1.13+ (1.82)	1.03 (.25)	1.14 (1.41)
Mobility (ln)	2.45*** (8.71)	2.56*** (5.65)	2.47*** (7.12)	2.49*** (8.81)	2.53*** (5.56)	2.50*** (7.16)
Interim professor (ln)	1.21 (1.55)	1.07 (0.32)	1.25 (1.49)	1.24+ (1.83)	1.09 (.41)	1.29+ (1.68)
Department size (ln)	1.07 (0.74)	.92 (-.55)	1.21+ (1.85)	1.08 (.86)	.92 (-.56)	1.22+ (1.91)
Co-authors (ln)	1.11+ (1.75)	1.19+ (1.88)	1.10 (1.15)	1.12+ (1.85)	1.20* (1.99)	1.11 (1.21)
With children *(ref. childless)*				1.33* (2.18)	1.17 (.73)	1.40* (2.04)

	Test hypothesis 1 (replication)			Test hypothesis 2 (children)		
	(1)	(2)	(3)	(4)	(5)	(6)
	Full Model	Only Women	Only Men	Full Model	Only Women	Only Men
No info on children				1.30+	1.46+	1.24
(ref. childless)				(1.82)	(1.74)	(1.13)
Incomplete	2.06***	2.42**	1.96***	2.11***	2.60***	1.96***
	(4.88)	(3.28)	(4.06)	(5.19)	(3.64)	(4.12)
Open positions (ln)	.83+	.72*	.89	.83+	.72*	.90
	(-1.76)	(-2.03)	(-.87)	(-1.80)	(-2.00)	(-.84)
Years since habilitation	1.48***	2.00***	1.33***	1.47***	1.98***	1.32***
	(5.55)	(5.82)	(3.71)	(5.46)	(5.72)	(3.66)
Years since habilitation	.97***	.94***	.97**	.97***	.94***	.98**
(sq.)	(-4.22)	(-3.94)	(-3.04)	(-4.20)	(-3.91)	(-3.04)
Years since assistant prof.	2.28***	2.71***	2.26***	2.25***	2.69***	2.26***
(ln)	(7.85)	(7.08)	(5.82)	(7.74)	(7.20)	(5.74)
Pseudo r^2	.13	.17	.14	.13	.17	.14
Log-likelihood	-2643.51	-854.01	-1450.23	-2640.13	-852.25	-1447.84
Degrees of freedom	24	23	23	26	25	25
Chi^2	702.52	356.59	453.51	731.01	383.27	463.17
AIC	5335.03	1754.02	2946.45	5332.27	1754.50	2945.67
BIC	5546.92	1933.63	3139.23	5561.82	1949.73	3155.21
Number of events (tenure)	486	191	295	486	191	295
N (persons)	2,290	1,063	1,230	2,290	1,063	1,230
N (persons-publications)	50,457	18,197	32,260	50,457	18,197	32,260

Exponentiated coefficients (hazard ratios); t statistics in parentheses; ln = logged values; sq = squared.
+ p <.1, * p <.05, ** p <.01, *** p <.001.

According to the first hypothesis, the female advantage should be less than in the original study, as we employ a longer timeframe which should reduce the survivor bias. In the original study, women had a 41 percent greater chance of gaining tenure than did men. Contrary to Hypothesis 1, this effect is now 46 percent, all else being equal (Model 1 in Table 4). The female advantage even increases to 48 percent when controlling for parenthood in Model 4. This also contradicts the second hypothesis, which assumes that the female advantage decreases after controlling for parenthood as an important reason to leave academia, especially for women.

The effects of publishing on becoming a professor remain similar to the original study (see Models 1–3). SSCI/SCIE publications are still more beneficial for men (similar to the results with data from 2013); the effect even increases slightly. For women, it decreases but remains significant. Publishing books similarly affects both women's and men's chances of gaining tenure in the new analysis, increasing the chances of gaining tenure by about 1.6, while it had an effect of 3.27 for women in the original data in 2013. Contrary to 2013, publishing edited volumes is more advantageous for men. Moreover, non-SSCI/SCIE articles have increased the chances of gaining tenure by about 20 percent in recent years, while this effect was insignificant in the original study.

Interestingly, the enormous impact of scholarly awards on a woman's chance of obtaining tenure in the original study (it was the strongest predictor for women) is now weaker; it is now only significant at the 10 percent level (Model 2), although receiving awards is still more advantageous for women than for men. Academics who obtained their habilitation at a university of excellence have a 38 percent higher chance of obtaining tenure (Model 1), an effect that is stronger in the current data (particularly for men). Having graduated from such a university, however, still reduces the chance of gaining tenure, as it did in the 2013 sample.

None of the variables measuring transnational capital were statistically significant in the 2013 data. In Model 1 of the updated data, however, months spent abroad and having a doctorate from abroad significantly increase the chances of obtaining tenure. The positive effect of a doctorate abroad is due to the subsample of women: Women who earned their doctorate abroad have a 2.28 times greater chance of gaining tenure, while there is no significantly greater chance for men. This could indicate that international experience has become more important in sociology, especially for women.

As in 2013, mobility, i.e., the number of different institutions academics were linked to over their careers, is still a main predictor for gaining tenure. In the current study, the effect is stronger than using the earlier data (among both women and men, see Models 1 to 3). The effect of the number of co-authors also increased slightly, especially for women.

Having children is positively associated with the chance of obtaining tenure (Model 4). The effect seems to be driven by fathers having a 40 percent higher chance of gaining tenure (Model 6), while mothers only have a 17 percent (and insignificantly) greater chance of gaining tenure (Model 5). Women who refused to respond whether they had children have a 46 percent higher chance (at 10 percent significance level) of gaining tenure than did childless women.

To sum up, our analysis largely replicates the results of Lutter and Schröder's (2016) previous study. Negating our first hypothesis, we did not find that women appear less advantaged after accounting for a longer timeframe that takes into account the leaky pipeline effect. The effect also did not decrease when we controlled for parenthood, contrary to what we expected with the second hypothesis.

Robustness tests

Table 5 uses Model 4 in Table 4 as a baseline, adding independent variables absent in the original study, to test the robustness of the results. First, we added the number of research grants acquired from the DFG in Model 1 of Table 5. However, with the same quantity of acquired research grants, women still have a 47 percent higher chance of gaining tenure, similar to our general results. Thus, research grants do not explain why women are advantaged in reaching tenure, although they do increase the chance for tenure, net of other variables.

Model 2 adds when sociologists entered academia, grouped into 10-year brackets. This indicates whether specific academic cohorts are more likely to gain tenure, also indicating whether results reflect academic structures of the past. The results show that the models remain robust; this means that our results do not depend on some cohorts of academics who collectively have a higher chance of gaining tenure.

Model 3 excludes the observation years of sociologists who spent more than 15 years in academia without being tenured as W2 or W3 professors. This applies to observations of 126 sociologists, 70 percent of whom are men. Among the 126 sociologists are 25 adjunct professors. These so-called "außerplanmäßige" or "APL" professors are similar to "adjunct professors" in the US, of whom 84 percent are men. The other 101 sociologists (of whom 66 percent are men) may hold one of the rare permanent positions in academia below a tenured professorship, such as being a tenured lecturer (the German position of "*Lehrkraft für besondere Aufgaben*" or *"Akademischer Rat"*).[9] Sociologists with one of these rare permanent positions may not be in the "risk set" for becoming a full professor or may even never have been on this track. These positions are more often held by men. This suggests that men have found other ways towards non-temporary positions, however, the advantage of women in obtaining tenured professorships remains.

Model 4 excludes scholars who were appointed at a university of applied sciences (*Fachhochschule*), which applies to 17 professors (10 women, or 59 percent). However, even after accounting for tenure at universities of applied sciences, the female advantage effect is still clearly visible, if all other variables are held constant.

Model 5 restricts the sample to academics appointed as W2 professors (tenured associate professors), dropping 65 of 486 professors who obtained a W3 professorship (tenured full professor) directly. Of course, this was only possible if the respective information was given in the CV. This leads to a marginal increase in the female advantage effect. Women show a 48 percent higher chance of becoming a non-W3 professor than do men.

Finally, Models 6 to 8 restrict the sample to sociologists who had already obtained a PhD (Model 6), a habilitation or assistant/W1 professorship (Model 7), or only uses those who did eventually get a (W2/W3) tenured professorship (Model 8). Among the sample of tenured professors, women's chances of becoming professors

9 Academics are obliged to attain permanent employment after 12 years in academia due to the German fixed-term law, so that we assume academics who work in academia for longer than 15 years have permanent positions other than professorships. We opted for 15 years instead of 12 years because of parental leave, which extends the period by law. However, the German fixed-term law does not apply if further temporary contracts are funded by third-party grants, so academics can still be employed at universities after 12 years.

decrease to 30 percent. This means that women also have an advantage among those who actually became a tenured professor, but it is not as high as in the overall sample.

Table 5. Cox regression models on getting tenure for robustness tests (including waves 2013, 2016, 2019).

	(1) DFG funding	(2) Entry cohorts	(3) Other academic positions	(4) Universities of applied sciences	(5) W3 professors	(6) PhD	(7) Habil./ assist. prof.	(8) Tenured professors
Female	1.47***	1.47***	1.40**	1.44**	1.48**	1.46***	1.52***	1.30*
	(3.41)	(3.38)	(2.98)	(3.15)	(3.16)	(3.32)	(3.35)	(2.42)
DFG funding	1.40***	1.39***	1.28***	1.39***	1.43***	1.41***	1.40***	1.02
	(5.50)	(5.35)	(4.30)	(5.28)	(4.83)	(5.69)	(5.15)	(.36)
before 1990 *(ref.)*								
1990–1999		1.02	1.17	1.00	1.02	1.02	.99	2.04***
		(.11)	(.99)	(-0.02)	(.10)	(.13)	(-.03)	(4.73)
2000–2009		1.07	1.18	1.06	0.97	1.11	1.20	3.91***
		(.39)	(.94)	(0.36)	(-.17)	(.64)	(.96)	(6.93)
after 2009		1.33	1.48	1.37	1.25	1.65+	2.10*	24.09***
		(.92)	(1.27)	(1.01)	(.69)	(1.67)	(1.97)	(11.11)
Pseudo r²	.13	.13	.14	0.14	.13	.13	.12	.10
Log-likelihood	-2625.41	-2624.97	-2552.85	-2511.92	-2255.00	-2613.54	-1839.41	-2270.48
Degrees of freedom	27	30	30	30	30	30	30	30
Chi²	803.37	813.38	797.61	807.17	702.68	807.91	608.36	763.69
AIC	5304.81	5309.94	5165.71	5083.83	4570.00	5287.09	3738.82	4600.95
BIC	5543.19	5574.81	5429.07	5348.33	4833.07	5549.13	3983.40	4839.00
Number of events (tenure)	486	486	486	469	421	486	377	486
N (persons)	2,290	2,290	2,283	2,273	2,225	1,591	579	487
N (persons-publications)	50,457	50,457	47,989	49,843	47,525	45,922	25,662	20,636

Exponentiated coefficients (hazard ratios); t statistics in parentheses; ln = logged values; sq = squared.

+ p <.1, * p <.05, ** p <.01, *** p <.001.

Note: Controlling for all independent variables used in Model 4 of Table 4 (but not shown here). For the full models, see Table A4.

In Table A5 (appendix), we additionally test whether the determinants for becoming a sociology professor differ between women and men by calculating interaction terms. That women are rewarded more for their scientific achievements could explain why they have a higher chance of becoming sociology professors. For instance, Lutter et al. (2022) show that SSCI/SCIE articles are more beneficial for women aspiring to become psychology professors. However, according to Table A5, none of the determinants used in our models significantly differ statistically between women and men, except that SSCI/SCIE publications have a less positive influence for women (p <.1).

We also tested interaction effects separately for women and men with variables that measure career achievements. Table A6 shows interaction effects between SSCI/SCIE articles and DFG research grants (Models 1 and 2) separately for women and men. This tested whether the effect for women (or men) of SSCI/SCIE articles on becoming a professor is higher with more research grants (or vice versa). The interaction effect is insignificant in subsamples for both women and men, which means there is no particular advantage from publishing while having more grants, for either gender. We also tested whether sociologists who received their doctorate at a German university of excellence profit more from publishing SSCI/SCIE articles (Models 3 and 4). This is not the case for men but it is for women (see Model 3 of Table A6). Women benefit more strongly from publishing in SSCI/SCIE journals and increase their chances of becoming a professor significantly if they have received their doctorate from a university of excellence.

We also tested the proportional hazard assumption for Cox regressions by interacting gender with analysis time (as a time-dependent covariate). The interaction of gender and analysis time is nonsignificant, supporting the proportionality assumption for gender (0.99 at p >.7) that the chance of obtaining tenure does not differ for women and men with years in academia. This finding can be further seen by the Kaplan-Meier observed survival curves (Figure 2) and the Cox predicted survival curves (Figure 3), which fall proportionally. As an alternative robustness test to assess the proportional hazard assumption, we also conducted a log minus log (LML) plot (see Figure 4). The LML plot does not properly satisfy the PH assumption, as the curves are not genuinely parallel in the first six years in academia. This might mirror that women are particularly prone to leaving academia during the predoc stage—which our new panel design can take into account—while the chance of becoming a professor does not differ across the careers of female and male sociologists after about six years. This suggests that accounting for the leaky pipeline is likely important, though it did not change our substantial result.

Figure 2. Kaplan-Meier curves (without covariates).

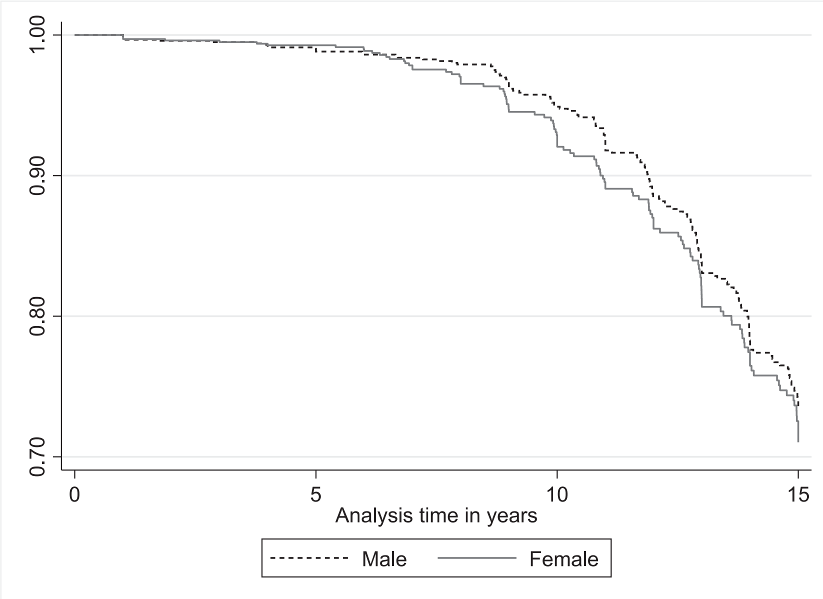


Figure 3. Survival curve (including covariates).

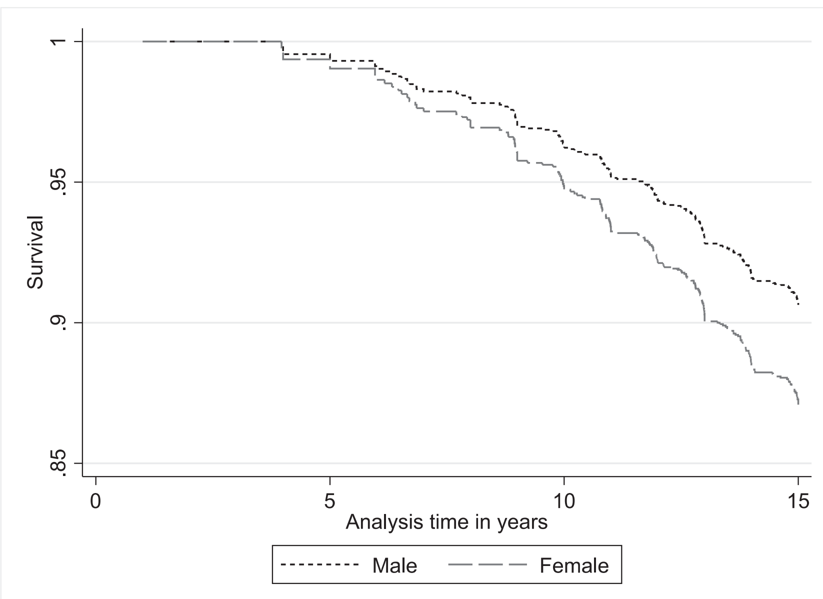
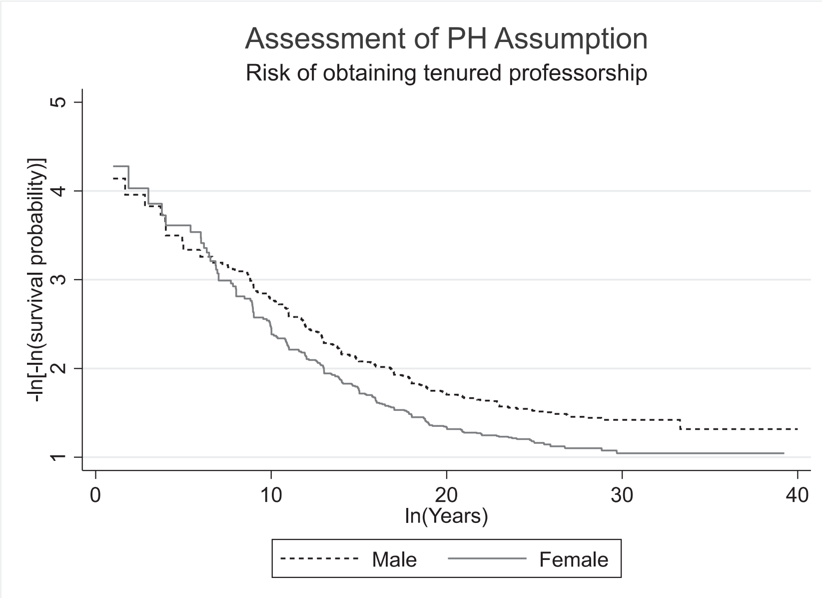


Figure 4. Log-log plot (LML).



Conclusions

This study examined the chances of becoming a sociology professor in Germany. We replicated the study of Lutter and Schröder (2016), which merely used data collected in 2013. We based our analysis on their original dataset, adding two follow-up waves from 2016 and 2019. We hypothesized that the original study design was biased by neglecting academia's gendered leaky pipeline, with notably less productive or committed women leaving academia disproportionately.

Based on these assumptions, we expected that the female advantage effect of the original study was overestimated. However, our results show that the leaky pipeline cannot explain women's higher chances of gaining tenure in sociology, and nor does parenthood. Further robustness tests, which incorporated research grants, cohort effects and different types of professorships and career stages also did not lead to a significant decline of the female advantage effect. We therefore reject both of our hypotheses and conclude that selection bias is not a relevant explanation for the female advantage effect found by earlier studies. What does this mean for the current state of research?

Other studies neglected to account for a leaky pipeline effect and sampled only the remaining scientists in academia (e.g., Auspurg et al., 2017; Jungbauer-Gans/Gross, 2013; Lutter et al., 2022). This could lead to a survivorship bias of particularly career-committed women. We improve on existing studies by showing that accounting for the leaky pipeline does not change the female advantage in the German academic landscape. It remains open as to whether more extended observational periods would give us more information on this result, and whether a female advantage in hiring decisions is visible in other disciplines as well. However, the female advantage we find confirms findings from recent experimental and observational research. Besides studies on German academia (Jungbauer-Gans/Gross, 2013; Lutter/Schröder, 2016; Solga et al., 2022), Carlsson et al. (2021) and also Moratti (2021) document a higher chance for women to achieve professorship in Scandinavian countries; Ceci (2018) and Williams and Ceci (2015) found similar results for women in the natural sciences in the United States, and Bol et al. (2022) report higher funding chances for women in the Netherlands.

Our study, to the best of our knowledge, is the only one that covers comprehensive data on academic leavers in addition to successful or ongoing academic careers. Our results support the leaky pipeline hypothesis as such (Blickenstaff, 2005; Hancock et al., 2013; Joecks et al., 2014; Leemann et al., 2009; Leemann et al., 2010; Pell, 1996), yet unlike much of the preceding literature, we can show that leaving academia mainly happens at the predoc stage. Supporting our results, Jaksztat et al. (2021) have also shown that in Germany, women are more likely than men to leave academia while pursuing doctoral degrees. However, we did not find a decrease in the share of women among junior professors, a position that is relatively new in the German academic system.

While women publish less than men (e.g., Cole/Zuckerman, 1984; Schubert/Engelage, 2011; Schucan Bird, 2011), the systematic opting out of less-productive women seems not to reduce women's higher chances of becoming sociology professors, probably because male leavers are also less productive. By the time they obtain tenure, women have published less than men. One possibility for why this might be the case is that they author fewer, but more high-quality publications. This would support the claims of Fox and Mohapatra (2007), who conclude that women might be more cautious in their publishing behavior. Another explanation seems less likely, however. Some have argued that women's work is devalued relative to men's (Cohen/Huffman, 2003; Magnusson, 2008; Ochsenfeld, 2014), yet none of the interaction effects of our career variables indicate that women's achievements indeed count less than men's (similarly, see Lutter et al., 2022). The only exception is SSCI/SCIE articles, which benefit male sociologists more than female sociologists, though the difference is only significant at the 10 percent level.

It is unsurprising that women with children leave academia due to family responsibilities (e.g., Ginther/Kahn, 2009; Mason et al., 2013; Preston, 2004), while children are less of an obstacle to male careers (Lutter/Schröder, 2020; Mason et al., 2013, pp. 28, 35; Schubert/Engelage, 2010; Wolfinger et al., 2009, p. 1611). Rather than concluding that mothers have a lesser chance of gaining tenure at the time of hiring, our data suggest that mothers have an insignificantly higher and fathers a significantly higher chance of obtaining tenure. However, our study is limited, as we cannot rely on different family types and partnership forms or on whether potential partners have children. Differences in these compositions can affect childcare and supportive factors, which in turn can affect jobs and research productivity (due to part-time positions, for example). However, our data also indicates that women leave academia disproportionately at the predoc stage, while men leave academia rather at the postdoc stage. Silander et al. (2013, pp. 184–185) draw a similar conclusion for Swedish social sciences, although more women leave academia initially, "the relationship is reversed after 10 years when more men than women in the social sciences have left academia." If this result is generalizable, and our results suggest that it is, then selectivity issues would generally be a lesser problem for studies than is commonly assumed, even in studies that rely only on one coding wave or a specific cohort of academics who already obtained their doctorate or habilitation. While future research should consider the critical question of who opts out of academia, we can conclude that it does not affect women's greater chances of becoming tenured sociology professors when they have the same characteristics as men.

Research grants increase the chances of gaining tenure, similar to related fields such as political science (Schröder et al., 2021). However, they cannot explain why women have a higher chance of reaching tenure, net of other influences. Studies have shown that women in German academia submit research proposals as often as men do, but receive less funding (Allmendinger/Hinz, 2002, but see Bol et al., 2022). According to our analyses in 2019, female professors have acquired slightly more research grants than male professors by the time they receive tenure (see Table 2). However, our results do not show that research grants affect women's chances of becoming professors differently. That our results differ from previous results may be due to our more recent data. While Allmendinger and Hinz used data from 1993 to 1999, our dataset extends to 2019. According to Allmendinger and Hinz, women's applications are concentrated in sub-disciplines, mostly gender studies. Our study is limited in that we cannot filter out sub-disciplines or consider disparities in funding volume. The specialization of women can also play a role beyond research grants; women may have a higher chance of being appointed to gender studies chairs (see also Jungbauer-Gans/Gross, 2013, p. 86). Due to multiple data collection points, we cannot test this retrospectively, but the original study suggests that accounting for gender studies chairs does not alter the female advantage (Lutter/Schröder, 2016, p. 1007).

Why then do we still find a greater chance for women to become tenured sociology professors? Possible explanations for the female advantage are affirmative action practices, the encouragement of women to apply for higher positions, mentoring programs or women's representatives. Gender equality is an explicit goal in German higher education, reflected in institutionalized and informal practices and explicitly used as a selection criterion. That universities strive for gender equality by hiring women and men equally—irrespectively of the gender proportion of applicants—might also explain why women are advantaged in getting professorships when they have the same characteristics as men. Although there are still fewer women in higher academic positions nowadays, their percentage has noticeably increased from 20 percent female professors in the social sciences in 2003 to 29 percent in 2008 and to 40 percent in 2018 (Statistisches Bundesamt, 2004, p. 81; 2009, p. 102; 2019, p. 107). The rising share of women may encourage more women to enter the academic labor market. However, little is known regarding whether social homophily is at work, i.e., whether the increasing share of women on the hiring committee leads to a higher preference for female candidates. One recent experimental study for Germany shows that women are preferred by both male and female professors when evaluating other applicants for professorships (Solga et al., 2022). A further limitation of our study is that we cannot measure what is invisible in CVs. For example, women may spend more time on administrative duties (for the US, see, e.g., Bird et al., 2004). Such administrative engagement might be considered favorably in hiring decisions. Another limitation is that our data is based on observations from university websites that may not be updated regularly. Our panel design with multiple data collection points and additional data sources at least offsets this. While there are a number of explanations that we cannot rule out, our results indicate that neither the leaky pipeline nor having children are sufficient explanations for why women are more likely to get professorships when they have the same observable characteristics as men.

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Appendix

Table A1: Summary of data collection

Wave	1	2	3
Year	2013	2016	2019
Population	75 sociology departments and two research institutes (sociology departments at the Max Planck Institute for the Study of Societies and the WZB Berlin Social Science Center)	75 sociology departments and two research institutes (sociology departments at the Max Planck Institute for the Study of Societies and the WZB Berlin Social Science Center)	75 sociology departments and two research institutes (sociology departments at the Max Planck Institute for the Study of Societies and the WZB Berlin Social Science Center)
Data collection from CVs	1) Hand-coded career and publication data from CVs	1) Updating of publications and CV data from wave 1 2) Identifying who left academia after wave 1, marking them as "leavers" 3) Identifying new academics since 2013, adding their publications and CV data to wave 2	1) Updating publications and CV data from wave 2 2) Identifying who left academia after wave 2, marking them as "leavers" 3) Identifying new academics since wave 2, adding their publications and CV data to wave 3
Data collection of information about children	Email survey (in 2014): response rate: 60 %		Replication of email survey from 1st wave (response rate: 54 %; valid information for 69 % of sociologists in the data)

Wave	1	2	3
Data collection about grants	Gepris website (hand-coded data): https://gepris.dfg.de/gepris/	Gepris website: https://gepris.dfg.de/gepris/	Gepris website: https://gepris.dfg.de/gepris/
Data collection to identify SSCI/SCIE articles	Journal Citation Report of Clarivate Analytics	Journal Citation Report of Clarivate Analytics	Journal Citation Report of Clarivate Analytics
Data collection to identify German universities of excellence	Ranking by the German Council of Science and Humanities in 2005	Excellence Strategy: https://www.dfg.de/en/research_funding/excellence_strategy/index.html 14 universities (up to 2017): Rheinisch-Westfälische Technische Hochschule Aachen, Freie Universität Berlin, Humboldt-Universität zu Berlin, Universität Bremen, Technische Universität Dresden, Albert-Ludwigs-Universität Freiburg, Georg-August-Universität Göttingen, Ruprecht-Karls-Universität Heidelberg, Karlsruher Institut für Technologie (KIT), Universität zu Köln, Universität Konstanz, Technische Universität München, Ludwig-Maximilians-Universität München and Eberhard Karls Universität Tübingen.	Excellence Strategy: https://www.dfg.de/en/research_funding/excellence_strategy/index.html 14 universities (up to 2017): Rheinisch-Westfälische Technische Hochschule Aachen, Freie Universität Berlin, Humboldt-Universität zu Berlin, Universität Bremen, Technische Universität Dresden, Albert-Ludwigs-Universität Freiburg, Georg-August-Universität Göttingen, Ruprecht-Karls-Universität Heidelberg, Karlsruher Institut für Technologie (KIT), Universität zu Köln, Universität Konstanz, Technische Universität München, Ludwig-Maximilians-Universität München and Eberhard Karls Universität Tübingen.

We adjusted the data across the data collection points. The reason for this is the "dynamic structures" of CVs. While updating CV information in 2016 and 2019, some CVs were more or less comprehensive than in 2013. While we previously included a few political scientists at social science institutes in the original study design, we made a clearer distinction between sociologists and political scientists in 2019 so that numbers of academics differ slightly.

Instead of including only articles from journals ranked in the Web of Science Social Science Citation Index (SSCI) in our measurement, we extended this category to also include those ranked in the Science Citation Index Expanded (SCIE). Although the latter is not ideal-typical for the social sciences but rather for the natural sciences (and therefore only takes into account 4 percent of the number of articles within the Web of Science), it should not be neglected.

Lutter and Schröder (2016) operationalized symbolic capital according to the prestige of the faculty to which the scientists belonged during their career, as indicated by the German Council of Science and Humanities in 2005. We used another operationalization in the new study design in 2019. In 2005, the Excellence Initiative was introduced in Germany to increase competitiveness and international visibility in German research so that certain universities were ranked as having "excellence", and got financial support. In the new analyses, we used this university status to generate variables for "prestige graduation", "prestige doctorate", and "prestige habilitation".

Instead of coding only "*Juniorprofessuren*" introduced in Germany in 2002, we also coded equivalent assistant professorships according to US academic system.

Table A2.1. Summary statistics (including waves 2013, 2016, 2019) at time of first appointment.

	N	Mean/Prop	SD	Min	Max	p25	Median	p75
Time to professorship	396	15.40	4.84	3.97	33.31	12.06	14.98	18.40
SSCI/SCIE articles	396	4.43	4.24	0	28.67	1.15	3.42	6.33
Non-SSCI/SCIE articles	396	7.25	7.18	0	79.80	2.83	5.12	10
Books	396	2.43	1.99	0	22.50	1	2	3
Edited volumes	396	1.67	1.94	0	14.97	0	1.07	2.59
Book chapters	396	15.89	12.03	0	112.70	7.50	13.33	20.88
Grey literature	396	7.69	9.78	0	68	1	4.64	9.73
Female	396	.40		0	1	0	0	1
Prestige graduation	396	.31		0	1	0	0	1
Prestige doctorate	396	.30		0	1	0	0	1
Prestige habilitation	396	.19		0	1	0	0	0
Awards	396	.39	.96	0	9	0	0	0
Months abroad	396	21.94	34.07	0	216	0	10	26
Studied abroad	396	.27		0	1	0	0	1
Doctorate abroad	396	.13		0	1	0	0	0
International publications	396	11.10	12.89	0	75	2	7	16
Mobility	396	3.25	1.77	0	10	2	3	4
Interim professor	396	.83	1.04	0	7	0	1	1
Department size	396	10.87	8.99	1	37	5	8	13
Co-authors	396	31.96	32.94	0	205	11.50	23	38.50
Habilitation	396	.64		0	1	0	1	1
Years since habilitation	396	2.02	2.63	0	17	0	1	3
Assistant professor	396	.17		0	1	0	0	0
Years since assistant professor	396	.78	1.92	0	12	0	0	0
Childless	396	.26		0	1	0	0	1
With children	396	.48		0	1	0	0	1

	N	Mean/Prop	SD	Min	Max	p25	Median	p75
No info on children	396	.26		0	1	0	0	1
DFG funding	396	.56	.84	0	4	0	0	1
Entry cohort before 1990	396	.29		0	1	0	0	1
Entry cohort 1990–1999	396	.40		0	1	0	0	1
Entry cohort 2000–2009	396	.29		0	1	0	0	1
Entry cohort after 2009	396	.03		0	1	0	0	0

Table A2.2. Only men: Summary statistics (including waves 2013, 2016, 2019) at time of first appointment.

	N	Mean/Prop	SD	Min	Max	p25	Median	p75
Time to professorship	239	15.65	4.77	3.97	33.31	12.61	15.66	18.47
SSCI/SCIE articles	239	5.09	4.65	0	28.67	1.67	4	7.33
Non-SSCI/SCIE articles	239	8.46	8.13	0	79.8	3.4	6.83	11.29
Books	239	2.76	2.26	0	22.5	1	2.33	3.65
Edited volumes	239	1.75	1.88	0	11	.40	1.17	2.90
Book chapters	239	17.23	11.70	0	55.33	7.83	15.83	23
Grey literature	239	8.77	10.77	0	68	1.67	5.33	11
Prestige graduation	239	.31		0	1	0	0	1
Prestige doctorate	239	.30		0	1	0	0	1
Prestige habilitation	239	.24		0	1	0	0	0
Awards	239	.35	1.01	0	9	0	0	0
Months abroad	239	19.9	30.53	0	180	0	10	26
Studied abroad	239	.23		0	1	0	0	0
Doctorate abroad	239	.11		0	1	0	0	0
International publications	239	11.30	13.07	0	73	2	7	15
Mobility	239	3.28	1.78	0	10	2	3	4
Interim professor	239	.85	1.02	0	5	0	1	1
Department size	239	11.01	9.21	1	37	5	8	13

	N	Mean/Prop	SD	Min	Max	p25	Median	p75
Co-authors	239	34.34	33.03	0	205	14	25	42
Habilitation	239	.70		0	1	0	1	1
Years since habilitation	239	2.46	2.85	0	17	0	2	4
Assistant professor	239	.12		0	1	0	0	0
Years since assistant professor	239	.52	1.57	0	8	0	0	0
Childless	239	.22		0	1	0	0	0
With children	239	.52		0	1	0	1	1
No info on children	239	.26		0	1	0	0	1
DFG funding	239	.53	.85	0	4	0	0	1
Entry cohort before 1990	239	.35		0	1	0	0	1
Entry cohort 1990–1999	239	.40		0	1	0	0	1
Entry cohort 2000–2009	239	.24		0	1	0	0	0
Entry cohort after 2009	239	.02		0	1	0	0	0

Table A2.3. Only women: Summary statistics (including waves 2013, 2016, 2019) at time of first appointment.

	N	Mean/Prop	SD	Min	Max	p25	Median	p75
Time to professorship	157	15.01	4.94	4	29.70	11.90	14.76	18
SSCI/SCIE articles	157	3.43	3.31	0	22.16	1	2.95	5.17
Non-SSCI/SCIE articles	157	5.41	4.91	0	30.50	2.20	4	7.33
Books	157	1.94	1.36	0	10.57	1	1.67	2.67
Edited volumes	157	1.55	2.03	0	14.97	0	1	2.33
Book chapters	157	13.85	12.27	0	112.70	6.50	11	17.33
Grey literature	157	6.04	7.78	0	55	1	4	7.83
Prestige graduation	157	.31		0	1	0	0	1
Prestige doctorate	157	.29		0	1	0	0	1
Prestige habilitation	157	.11		0	1	0	0	0
Awards	157	.45	.87	0	5	0	0	1

	N	Mean/Prop	SD	Min	Max	p25	Median	p75
Months abroad	157	25.06	38.75	0	216	0	11	26
Studied abroad	157	.32		0	1	0	0	1
Doctorate abroad	157	.16		0	1	0	0	0
International publications	157	10.80	12.65	0	75	2	7	16
Mobility	157	3.20	1.76	0	9	2	3	4
Interim professor	157	.81	1.07	0	7	0	0	1
Department size	157	10.66	8.66	1	37	5	8	13
Co-authors	157	28.34	32.59	0	197	9	19	32
Habilitation	157	.54		0	1	0	1	1
Years since habilitation	157	1.35	2.09	0	10	0	0	2
Assistant professor	157	.25		0	1	0	0	0
Years since assistant professor	157	1.17	2.31	0	12	0	0	0
Childless	157	.31		0	1	0	0	1
With children	157	.43		0	1	0	0	1
No info on children	157	.25		0	1	0	0	1
DFG funding	157	.61	.82	0	4	0	0	1
Entry cohort before 1990	157	.19		0	1	0	0	0
Entry cohort 1990–1999	157	.41		0	1	0	0	1
Entry cohort 2000–2009	157	.36		0	1	0	0	1
Entry cohort after 2009	157	.04		0	1	0	0	0

Table A3. Stepwise Cox regression models on getting tenure (including waves 2013, 2016, 2019).

	(1) Controls	(2) Publications	(3) Gender	(4) Symbolic capital	(5) Transnational capital	(6) Social capital
SSCI/SCIE journal articles (ln)		1.96***	2.00***	1.94***	1.75***	1.67***
		(9.40)	(9.26)	(8.64)	(6.79)	(6.16)
Non-SSCI/SCIE articles (ln)		1.10	1.13	1.14^{+}	1.15^{+}	1.20*
		(1.23)	(1.56)	(1.77)	(1.92)	(2.38)
Books (ln)		1.51***	1.59***	1.55***	1.64***	1.63***
		(3.57)	(3.83)	(3.60)	(4.19)	(4.20)
Edited volumes (ln)		1.40***	1.41***	1.44***	1.38***	1.36**
		(3.44)	(3.45)	(3.65)	(3.42)	(3.11)
Book chapters (ln)		1.26**	1.25**	1.26**	1.32**	1.10
		(2.84)	(2.71)	(2.81)	(3.23)	(1.05)
Grey literature (ln)		.90^{+}	.91	.92	.89^{+}	.89^{+}
		(-1.77)	(-1.49)	(-1.44)	(-1.87)	(-1.84)
Female			1.54***	1.54***	1.50***	1.46**
			(3.68)	(3.74)	(3.65)	(3.21)
Prestige graduation				.70**	.69**	.63***
				(-2.80)	(-2.99)	(-3.73)
Prestige doctorate				1.13	1.17	1.18
				(.93)	(1.21)	(1.23)
Prestige habilitation				1.24	1.24	1.38*
				(1.40)	(1.46)	(2.06)
Awards (ln)				1.29^{+}	1.25^{+}	1.24
				(1.82)	(1.66)	(1.60)
Months abroad (ln)					1.19***	1.13**
					(5.04)	(3.14)
Studied abroad					.87	.89
					(-1.13)	(-.96)

	(1) Controls	(2) Publications	(3) Gender	(4) Symbolic capital	(5) Transnational capital	(6) Social capital
Doctorate abroad					1.26	1.50*
					(1.50)	(2.39)
International publications (ln)					1.10	1.14+
					(1.50)	(1.86)
Mobility (ln)						2.45***
						(8.71)
Interim professor (ln)						1.21
						(1.55)
Department size (ln)						1.07
						(.74)
Co-authors (ln)						1.11+
						(1.75)
Incomplete	1.66***	2.21***	2.34***	2.31***	2.27***	2.06***
	(3.74)	(5.59)	(5.59)	(5.51)	(5.83)	(4.88)
Open positions (ln)	.87	.95	.92	.93	.88	.83+
	(-1.44)	(-.45)	(-.76)	(-.66)	(-1.17)	(-1.76)
Years since habilitation	1.90***	1.53***	1.56***	1.54***	1.54***	1.48***
	(8.47)	(5.95)	(6.13)	(6.07)	(6.38)	(5.55)
Years since habilitation (sq.)	.95***	.96***	.96***	.97***	.97***	.97***
	(-5.16)	(-4.11)	(-4.18)	(-4.18)	(-4.34)	(-4.22)
Years since assistant prof. (ln)	3.41***	2.51***	2.39***	2.34***	2.22***	2.28***
	(13.15)	(8.72)	(7.88)	(7.33)	(7.29)	(7.85)
Pseudo r^2	.06	.10	.10	.10	.11	.13
Log-likelihood	-2839.35	-2737.12	-2728.05	-2720.38	-2694.70	-2643.51
Degrees of freedom	5	11	12	16	20	24
Chi²	280.79	422.22	410.07	454.43	618.78	702.52

	(1) Controls	(2) Publications	(3) Gender	(4) Symbolic capital	(5) Transnational capital	(6) Social capital
AIC	5688.70	5496.24	5480.11	5472.77	5429.41	5335.03
BIC	5732.85	5593.36	5586.06	5614.03	5605.99	5546.92
Number of events (tenure)	486	486	486	486	486	486
N (persons)	2,290	2,290	2,290	2,290	2,290	2,290
N (persons-publications)	50,457	50,457	50,457	50,457	50,457	50,457

Exponentiated coefficients (hazard ratios); t statistics in parentheses; ln = logged values; sq = squared.
+ p <.1, * p <.05, ** p <.01, *** p <.001.

Table A4. Cox regression models on getting tenure, including all independent variables and additional robustness tests (including waves 2013, 2016, 2019).

	(1) DFG funding	(2a) Entry cohorts	(2b) Post 2013[1]	(3) Other academic positions	(4) Universities of applied sciences	(5) W3 prof.	(6) PhD	(7) Habil./ assist. prof.	(8) Tenured Professors
Female	1.47***	1.47***	1.49***	1.40**	1.44**	1.48**	1.46***	1.52***	1.30*
	(3.41)	(3.38)	(3.48)	(2.98)	(3.15)	(3.16)	(3.32)	(3.35)	(2.42)
DFG funding	1.40***	1.39***	1.40***	1.28***	1.39***	1.43***	1.41***	1.40***	1.02
	(5.50)	(5.35)	(5.52)	(4.30)	(5.28)	(4.83)	(5.69)	(5.15)	(.36)
Entry cohorts *(ref. before 1990)*									
1990–1999		1.02		1.17	1.00	1.02	1.02	.99	2.04***
		(.11)		(.99)	(-.02)	(.10)	(.13)	(-.03)	(4.73)
2000–2009		1.07		1.18	1.06	.97	1.11	1.20	3.91***
		(.39)		(.94)	(.36)	(-.17)	(.64)	(.96)	(6.93)
after 2009		1.33		1.48	1.37	1.25	1.65^{+}	2.10*	24.09***
		(.92)		(1.27)	(1.01)	(.69)	(1.67)	(1.97)	(11.11)

	(1) DFG funding	(2a) Entry cohorts	(2b) Post 2013[1]	(3) Other academic positions	(4) Universities of applied sciences	(5) W3 prof.	(6) PhD	(7) Habil./ assist. prof.	(8) Tenured Professors
Post 2013			.71**						
			(-3.06)						
SSCI/SCIE journal articles (ln)	1.61***	1.63***	1.55***	1.52***	1.67***	1.61***	1.63***	1.41***	1.29***
	(5.82)	(5.79)	(5.24)	(4.90)	(5.95)	(5.21)	(5.88)	(3.81)	(3.31)
Non-SSCI/SCIE articles (ln)	1.25**	1.25**	1.27**	1.24**	1.24**	1.30**	1.26**	1.25**	1.12
	(2.98)	(2.93)	(3.12)	(2.86)	(2.80)	(3.17)	(3.05)	(2.64)	(1.48)
Books (ln)	1.55***	1.56***	1.51***	1.54***	1.52***	1.56***	1.51***	1.28^{+}	1.32*
	(3.82)	(3.78)	(3.58)	(3.49)	(3.49)	(3.51)	(3.50)	(1.90)	(2.26)
Edited volumes (ln)	1.35**	1.35**	1.34**	1.36**	1.30**	1.28*	1.39***	1.33**	1.29*
	(3.06)	(3.06)	(3.04)	(3.01)	(2.65)	(2.30)	(3.34)	(2.59)	(2.57)
Book chapters (ln)	1.05	1.06	1.02	.99	1.09	1.06	1.05	1.10	.91
	(.54)	(.63)	(.17)	(-.06)	(.98)	(.61)	(.55)	(.92)	(-1.13)
Grey literature (ln)	.90^{+}	.90^{+}	.90^{+}	.87*	.89*	.93	.90^{+}	.91	.95
	(-1.75)	(-1.77)	(-1.73)	(-2.22)	(-2.00)	(-1.20)	(-1.87)	(-1.52)	(-.90)
Prestige graduation	.63***	.63***	.65***	.67**	.64***	.62***	.64***	.63***	.87
	(-3.70)	(-3.71)	(-3.53)	(-3.28)	(-3.64)	(-3.61)	(-3.62)	(-3.47)	(-1.15)
Prestige doctorate	1.14	1.14	1.17	1.20	1.17	1.05	1.10	1.04	1.12
	(1.06)	(1.03)	(1.23)	(1.46)	(1.23)	(.33)	(.79)	(.24)	(.93)
Prestige habilitation	1.37*	1.38*	1.31^{+}	1.59**	1.37^{+}	1.36^{+}	1.41*	1.37^{+}	1.44**
	(1.99)	(2.04)	(1.74)	(2.98)	(1.95)	(1.77)	(2.17)	(1.94)	(2.83)
Awards (ln)	1.23	1.21	1.27^{+}	1.19	1.22	1.21	1.20	1.22	1.06
	(1.58)	(1.47)	(1.78)	(1.33)	(1.53)	(1.27)	(1.40)	(1.38)	(.51)
Months abroad (ln)	1.13**	1.13**	1.12**	1.12**	1.14***	1.12**	1.13**	1.15**	1.01
	(3.28)	(3.26)	(2.92)	(2.86)	(3.41)	(2.64)	(3.20)	(3.13)	(.29)
Studied abroad	.89	.89	.92	.93	.89	.89	.88	.78^{+}	1.14
	(-.92)	(-.96)	(-.69)	(-.66)	(-.95)	(-.87)	(-1.01)	(-1.77)	(1.18)

	(1) DFG funding	(2a) Entry cohorts	(2b) Post 2013[1]	(3) Other academic positions	(4) Universities of applied sciences	(5) W3 prof.	(6) PhD	(7) Habil./ assist. prof.	(8) Tenured Professors
Doctorate abroad	1.49*	1.49*	1.47*	1.31	1.51*	1.47*	1.43*	1.12	1.20
	(2.35)	(2.35)	(2.24)	(1.60)	(2.44)	(2.18)	(2.15)	(.59)	(1.13)
International publications (ln)	1.10	1.09	1.15*	1.21*	1.10	1.11	1.08	1.04	1.15^{+}
	(1.43)	(1.25)	(2.01)	(2.52)	(1.30)	(1.32)	(1.05)	(.50)	(1.91)
Mobility (ln)	2.53***	2.52***	2.58***	2.40***	2.50***	2.49***	2.45***	2.49***	2.07***
	(8.99)	(8.98)	(9.14)	(8.48)	(8.73)	(8.12)	(8.75)	(7.81)	(6.94)
Interim professor (ln)	1.22	1.21	1.23^{+}	1.31*	1.19	1.19	1.18	1.02	1.20
	(1.63)	(1.61)	(1.71)	(2.20)	(1.42)	(1.39)	(1.39)	(.12)	(1.53)
Department size (ln)	1.08	1.08	1.07	1.08	1.05	1.08	1.07	1.01	1.10
	(.84)	(.84)	(.79)	(.86)	(0.50)	(.78)	(.77)	(.11)	(1.16)
Co-authors (ln)	1.11^{+}	1.11^{+}	1.14*	1.13*	1.10	1.07	1.10	1.05	1.11^{+}
	(1.80)	(1.70)	(2.17)	(2.03)	(1.53)	(1.14)	(1.63)	(.67)	(1.71)
With children *(ref. childless)*	1.30*	1.29*	1.32*	1.25^{+}	1.30*	1.32*	1.26^{+}	1.27^{+}	1.04
	(2.00)	(1.99)	(2.16)	(1.72)	(2.03)	(1.98)	(1.83)	(1.66)	(.31)
No info on children *(ref. childless)*	1.32^{+}	1.32^{+}	1.37*	1.33*	1.36*	1.39*	1.34*	1.33^{+}	1.20
	(1.95)	(1.95)	(2.18)	(2.04)	(2.11)	(2.18)	(2.06)	(1.77)	(1.38)
Incomplete	2.01***	2.01***	2.03***	2.29***	1.96***	2.08***	2.04***	1.96***	2.18***
	(4.85)	(4.89)	(4.82)	(6.02)	(4.63)	(4.84)	(5.05)	(4.06)	(5.51)
Open positions (ln)	.78*	.77*	.78*	.76*	.78*	.78*	.77*	.71**	.66***
	(-2.43)	(-2.33)	(-2.29)	(-2.39)	(-2.17)	(-2.08)	(-2.32)	(-2.83)	(-3.74)
Years since habilitation	1.44***	1.44***	1.42***	1.39***	1.47***	1.47***	1.43***	1.54***	1.32***
	(5.41)	(5.39)	(5.29)	(7.16)	(5.45)	(4.94)	(5.36)	(5.54)	(6.53)
Years since habilitation (sq.)	.97***	.97***	.97***	.98***	.97***	.97***	.97***	.96***	.98***
	(-4.28)	(-4.26)	(-4.24)	(-5.75)	(-4.23)	(-3.79)	(-4.27)	(-4.34)	(-5.55)
Years since	2.19***	2.18***	2.27***	2.19***	2.20***	2.14***	2.15***	2.31***	1.62***

	(1) DFG funding	(2a) Entry cohorts	(2b) Post 2013[1]	(3) Other academic positions	(4) Universities of applied sciences	(5) W3 prof.	(6) PhD	(7) Habil./ assist. prof.	(8) Tenured Professors
assistant prof. (ln)	(7.76)	(7.71)	(8.25)	(7.51)	(7.74)	(6.77)	(7.70)	(7.62)	(5.29)
Pseudo r²	.13	.13	.13	.14	0.14	.13	.13	.12	.10
Log-likelihood	-2625.41	-2624.97	-2620.36	-2552.85	-2511.92	-2255.00	-2613.54	-1839.41	-2270.48
Degrees of freedom	27	30	28	30	30	30	30	30	30
Chi²	803.37	813.38	812.27	797.61	807.17	702.68	807.91	608.36	763.69
AIC	5304.81	5309.94	5296.73	5165.71	5083.83	4570.00	5287.09	3738.82	4600.95
BIC	5543.19	5574.81	5543.93	5429.07	5348.33	4833.07	5549.13	3983.40	4839.00
Number of events (tenure)	486	486	486	486	469	421	486	377	486
N (persons)	2,290	2,290	2,290	2,283	2,273	2,225	1,591	579	487
N (persons-publications)	50,457	50,457	50,457	47,989	49,843	47,525	45,922	25,662	20,636

Exponentiated coefficients (hazard ratios); t statistics in parentheses; ln = logged values; sq = squared.
+ p <.1, * p <.05, ** p <.01, *** p <.001.
[1] Alternate to entry cohorts.

Table A5.1 Cox regression models on getting tenured (including waves 2013, 2016, 2019), including interaction terms with gender (models 1–11).

	(1) Female × SSCI/SCIE publications	(2) Female × non-SSCI/SCIE publications	(3) Female × books	(4) Female × edited volumes	(5) Female × book chapters	(6) Female × grey literature	(7) Female × prestige graduation	(8) Female × prestige doctorate	(9) Female × prestige habilitation	(10) Female × awards	(11) Female × months abroad
Female	1.94***	1.21	1.20	1.42*	1.23	1.34+	1.39*	1.36*	1.40**	1.46**	1.42*
	(3.73)	(.90)	(.80)	(2.32)	(.83)	(1.67)	(2.49)	(2.31)	(2.82)	(2.95)	(2.05)
SSCI/SCIE journal	1.78***	1.63***	1.63***	1.63***	1.63***	1.63***	1.63***	1.62***	1.64***	1.63***	1.63***
articles (ln)	(5.96)	(5.78)	(5.80)	(5.78)	(5.78)	(5.80)	(5.81)	(5.73)	(5.87)	(5.79)	(5.79)

	(1) Female × SSCI/SCIE publications	(2) Female × non-SSCI/SCIE publications	(3) Female × books	(4) Female × edited volumes	(5) Female × book chapters	(6) Female × grey literature	(7) Female × prestige graduation	(8) Female × prestige doctorate	(9) Female × prestige habilitation	(10) Female × awards	(11) Female × months abroad
Non-SSCI/SCIE	1.23**	1.20*	1.26**	1.25**	1.25**	1.25**	1.24**	1.25**	1.25**	1.25**	1.25**
articles (ln)	(2.75)	(2.13)	(3.01)	(2.92)	(2.96)	(2.94)	(2.88)	(2.98)	(2.95)	(2.94)	(2.92)
Books (ln)	1.56***	1.57***	1.46**	1.57***	1.56***	1.56***	1.56***	1.54***	1.55***	1.56***	1.56***
	(3.81)	(3.82)	(2.90)	(3.80)	(3.78)	(3.76)	(3.81)	(3.71)	(3.75)	(3.78)	(3.80)
Edited volumes (ln)	1.36**	1.34**	1.36**	1.33*	1.35**	1.35**	1.35**	1.36**	1.35**	1.35**	1.35**
	(3.10)	(2.95)	(3.14)	(2.47)	(3.02)	(3.04)	(3.06)	(3.12)	(3.04)	(3.06)	(3.06)
Book chapters (ln)	1.06	1.06	1.05	1.06	1.03	1.06	1.06	1.06	1.06	1.06	1.06
	(.64)	(.68)	(.55)	(.62)	(.29)	(.60)	(.67)	(.64)	(.63)	(.63)	(.63)
Grey literature (ln)	.89^{+}	.90^{+}	.90^{+}	.90^{+}	.90^{+}	.88^{+}	.90^{+}	.90^{+}	.90^{+}	.90^{+}	.90^{+}
	(-1.87)	(-1.75)	(-1.80)	(-1.76)	(-1.75)	(-1.95)	(-1.76)	(-1.74)	(-1.68)	(-1.77)	(-1.77)
Prestige graduation	.63***	.63***	.63***	.63***	.63***	.63***	.59***	.63***	.62***	.63***	.63***
	(-3.77)	(-3.74)	(-3.69)	(-3.71)	(-3.69)	(-3.72)	(-3.40)	(-3.73)	(-3.78)	(-3.69)	(-3.71)
Prestige doctorate	1.14	1.15	1.13	1.14	1.15	1.14	1.14	1.03	1.14	1.14	1.14
	(1.05)	(1.09)	(.97)	(1.05)	(1.08)	(1.06)	(1.07)	(.19)	(1.02)	(1.02)	(1.04)
Prestige habilitation	1.37^{+}	1.38*	1.39*	1.38*	1.38*	1.39*	1.39*	1.40*	1.28	1.38*	1.38*
	(1.95)	(2.05)	(2.06)	(2.04)	(2.05)	(2.06)	(2.08)	(2.14)	(1.38)	(2.01)	(2.04)
Awards (ln)	1.20	1.22	1.20	1.21	1.21	1.21	1.21	1.20	1.19	1.19	1.21
	(1.40)	(1.55)	(1.43)	(1.48)	(1.50)	(1.46)	(1.49)	(1.40)	(1.29)	(1.05)	(1.47)
Months abroad (ln)	1.14***	1.14**	1.14***	1.13**	1.13**	1.14**	1.13**	1.14***	1.14***	1.13**	1.13**
	(3.36)	(3.27)	(3.33)	(3.26)	(3.27)	(3.28)	(3.25)	(3.30)	(3.30)	(3.26)	(2.63)
Studied abroad	.87	.89	.88	.89	.89	.88	.88	.88	.88	.89	.89
	(-1.10)	(-.96)	(-.99)	(-.95)	(-.95)	(-1.03)	(-1.00)	(-1.02)	(-1.07)	(-.96)	(-.93)
Doctorate abroad	1.48*	1.46*	1.48*	1.49*	1.49*	1.47*	1.49*	1.48*	1.51*	1.49*	1.49*
	(2.36)	(2.23)	(2.31)	(2.36)	(2.35)	(2.28)	(2.37)	(2.34)	(2.43)	(2.36)	(2.35)
International	1.09	1.09	1.09	1.09	1.09	1.09	1.09	1.09	1.09	1.09	1.09
publications (ln)	(1.17)	(1.17)	(1.19)	(1.22)	(1.20)	(1.19)	(1.23)	(1.22)	(1.13)	(1.24)	(1.24)

	(1) Female × SSCI/SCIE publications	(2) Female × non-SSCI/SCIE publications	(3) Female × books	(4) Female × edited volumes	(5) Female × book chapters	(6) Female × grey literature	(7) Female × prestige graduation	(8) Female × prestige doctorate	(9) Female × prestige habilitation	(10) Female × awards	(11) Female × months abroad
Mobility (ln)	2.50***	2.51***	2.52***	2.52***	2.53***	2.53***	2.52***	2.51***	2.54***	2.52***	2.51***
	(8.96)	(8.93)	(9.01)	(8.96)	(8.97)	(9.03)	(8.99)	(8.93)	(9.06)	(8.98)	(8.88)
Interim professor	1.23^{+}	1.20	1.20	1.21	1.20	1.21	1.21	1.22	1.21	1.22	1.21
(ln)	(1.70)	(1.49)	(1.49)	(1.60)	(1.50)	(1.58)	(1.56)	(1.63)	(1.59)	(1.62)	(1.61)
Department size (ln)	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.07
	(.87)	(.91)	(.88)	(.84)	(.85)	(0.89)	(.85)	(.89)	(.89)	(.83)	(.82)
Co-authors (ln)	1.11^{+}	1.11^{+}	1.11^{+}	1.11^{+}	1.11^{+}	1.11^{+}	1.11^{+}	1.11^{+}	1.11^{+}	1.11^{+}	1.11^{+}
	(1.77)	(1.70)	(1.73)	(1.70)	(1.72)	(1.68)	(1.68)	(1.77)	(1.70)	(1.69)	(1.66)
With children (ref.	1.29*	1.31*	1.31*	1.30*	1.30*	1.30*	1.29*	1.29*	1.29^{+}	1.29*	1.29*
childless)	(2.00)	(2.06)	(2.07)	(2.02)	(2.05)	(2.04)	(1.99)	(1.98)	(1.95)	(1.99)	(1.99)
No info on children (ref.	1.32^{+}	1.32^{+}	1.32*	1.32^{+}	1.33*	1.32^{+}	1.32^{+}	1.32*	1.31^{+}	1.32^{+}	1.32*
childless)	(1.96)	(1.95)	(1.97)	(1.95)	(1.97)	(1.94)	(1.93)	(1.96)	(1.92)	(1.95)	(1.96)
DFG funding	1.39***	1.40***	1.40***	1.39***	1.39***	1.39***	1.39***	1.40***	1.40***	1.39***	1.40***
	(5.32)	(5.45)	(5.42)	(5.34)	(5.37)	(5.37)	(5.33)	(5.40)	(5.49)	(5.30)	(5.36)
Entry cohorts (ref. before 1990											
>1991–1999	1.02	1.02	1.00	1.02	1.02	1.03	1.02	1.02	1.00	1.02	1.02
	(.16)	(.15)	(.03)	(.14)	(.13)	(.17)	(.16)	(.11)	(.03)	(.11)	(.13)
2000–2009	1.07	1.08	1.06	1.07	1.07	1.07	1.08	1.07	1.07	1.07	1.07
	(.39)	(.43)	(.36)	(.42)	(.41)	(.42)	(.44)	(.40)	(.39)	(.39)	(.41)
after 2009	1.34	1.36	1.34	1.34	1.35	1.34	1.34	1.35	1.34	1.33	1.33
	(.96)	(.99)	(.96)	(.95)	(.97)	(.95)	(.95)	(.98)	(.95)	(.92)	(.93)
Incomplete	2.01***	1.99***	2.00***	2.01***	2.00***	2.00***	2.03***	2.03***	2.01***	2.01***	2.01***
	(4.98)	(4.77)	(4.79)	(4.90)	(4.80)	(4.83)	(5.02)	(5.00)	(4.93)	(4.91)	(4.89)
Open positions (ln)	.77*	.77*	.77*	.77*	.77*	.77*	.77*	.77*	.77*	.77*	.77*
	(-2.37)	(-2.30)	(-2.31)	(-2.33)	(-2.33)	(-2.33)	(-2.29)	(-2.29)	(-2.33)	(-2.33)	(-2.33)

	(1) Female × SSCI/SCIE publications	(2) Female × non-SSCI/SCIE publications	(3) Female × books	(4) Female × edited volumes	(5) Female × book chapters	(6) Female × grey literature	(7) Female × prestige graduation	(8) Female × prestige doctorate	(9) Female × prestige habilitation	(10) Female × awards	(11) Female × months abroad
Years since habil.	1.43***	1.45***	1.44***	1.44***	1.45***	1.44***	1.44***	1.44***	1.44***	1.44***	1.44***
	(5.34)	(5.47)	(5.43)	(5.40)	(5.46)	(5.43)	(5.41)	(5.39)	(5.44)	(5.39)	(5.40)
Years since habil. (sq.)	.97***	.97***	.97***	.97***	.97***	.97***	.97***	.97***	.97***	.97***	.97***
	(-4.24)	(-4.32)	(-4.28)	(-4.25)	(-4.30)	(-4.27)	(-4.28)	(-4.28)	(-4.31)	(-4.25)	(-4.26)
Years since assistant prof. (ln)	2.23***	2.19***	2.19***	2.18***	2.18***	2.18***	2.20***	2.21***	2.21***	2.18***	2.18***
	(7.99)	(7.69)	(7.88)	(7.67)	(7.68)	(7.67)	(7.93)	(7.98)	(7.94)	(7.70)	(7.70)
Female × SSCI/SCIE journal articles (ln)	.79^{+}										
	(-1.83)										
Female × non-SSCI/SCIE articles (ln)		1.13									
		(1.04)									
Female × books (ln)			1.24								
			(1.03)								
Female × edited volumes (ln)				1.05							
				(.28)							
Female × book chapters (ln)					1.08						
					(.71)						
Female × grey literature (ln)						1.07					
						(.56)					
Female × prestige graduation							1.21				
							(.82)				
Female × prestige doctorate								1.28			
								(1.11)			
Female × prestige habilitation									1.37		
									(1.08)		
Female × awards (ln)										1.04	
										(.15)	

	(1) Female × SSCI/SCIE publications	(2) Female × non-SSCI/SCIE publications	(3) Female × books	(4) Female × edited volumes	(5) Female × book chapters	(6) Female × grey literature	(7) Female × prestige graduation	(8) Female × prestige doctorate	(9) Female × prestige habilitation	(10) Female × awards	(11) Female × months abroad
Female × months abroad (ln)											1.02 (.26)
Pseudo r²	.13	.13	.13	.13	.13	.13	.13	.13	.13	.13	.13
Log-likelihood	-2623.09	-2624.36	-2624.37	-2624.93	-2624.69	-2624.76	-2624.56	-2624.29	-2624.32	-2624.96	-2624.94
Degrees of freedom	31	31	31	31	31	31	31	31	31	31	31
Chi²	823.07	813.18	823.45	817.77	813.80	814.56	820.27	816.03	829.56	815.32	815.33
AIC	5308.17	5310.72	5310.74	5311.85	5311.38	5311.51	5311.13	5310.58	5310.64	5311.92	5311.87
BIC	5581.87	5584.42	5584.44	5585.55	5585.07	5585.21	5584.82	5584.27	5584.34	5585.61	5585.57
Number of events (tenure)	486	486	486	486	486	486	486	486	486	486	486
N (persons)	2,290	2,290	2,290	2,290	2,290	2,290	2,290	2,290	2,290	2,290	2,290
N (persons-publications)	50,457	50,457	50,457	50,457	50,457	50,457	50,457	50,457	50,457	50,457	50,457

Exponentiated coefficients (hazard ratios); t statistics in parentheses; ln = logged values; sq = squared.
+ p <.1, * p <.05, ** p <.01, *** p <.001.

Table A5.2 Cox regression models on getting tenured (including waves 2013, 2016, 2019), including interaction terms with gender (models 12–21).

	(12) Female × studied abroad	(13) Female × doctorate abroad	(14) Female × international publications	(15) Female × mobility	(16) Female × interim professorships	(17) Female × department size	(18) Female × co-authors	(19) Female × children	(20) Female × DFG funding	(21) Female × entry cohorts
Female	1.41**	1.41**	1.82**	1.51	1.45**	1.94	1.61+	1.42	1.42**	1.41
	(2.69)	(2.76)	(3.08)	(1.54)	(2.83)	(1.59)	(1.90)	(1.60)	(2.77)	(1.29)
SSCI/SCIE journal articles (ln)	1.63***	1.63***	1.62***	1.63***	1.63***	1.62***	1.63***	1.63***	1.63***	1.63***
	(5.81)	(5.79)	(5.75)	(5.79)	(5.79)	(5.75)	(5.79)	(5.81)	(5.79)	(5.76)

	(12) Female × studied abroad	(13) Female × doctorate abroad	(14) Female × international publications	(15) Female × mobility	(16) Female × interim professorships	(17) Female × department size	(18) Female × co-authors	(19) Female × children	(20) Female × DFG funding	(21) Female × entry cohorts
Non-SSCI/SCIE	1.25^{**}	1.24^{**}	1.25^{**}	1.25^{**}	1.25^{**}	1.24^{**}	1.25^{**}	1.25^{**}	1.25^{**}	1.25^{**}
articles (ln)	(2.95)	(2.80)	(2.90)	(2.94)	(2.93)	(2.89)	(2.91)	(2.90)	(2.96)	(2.92)
Books (ln)	1.56^{***}	1.56^{***}	1.55^{***}	1.56^{***}	1.56^{***}	1.56^{***}	1.56^{***}	1.56^{***}	1.56^{***}	1.55^{***}
	(3.78)	(3.79)	(3.76)	(3.78)	(3.78)	(3.76)	(3.79)	(3.79)	(3.78)	(3.72)
Edited volumes (ln)	1.35^{**}	1.35^{**}	1.36^{**}	1.35^{**}	1.35^{**}	1.36^{**}	1.35^{**}	1.34^{**}	1.35^{**}	1.35^{**}
	(3.08)	(3.04)	(3.11)	(3.06)	(3.06)	(3.12)	(3.06)	(2.98)	(3.03)	(3.09)
Book chapters (ln)	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.05	1.06
	(.63)	(.65)	(.63)	(.62)	(.60)	(.63)	(.61)	(.68)	(.59)	(.63)
Grey literature (ln)	$.90^{+}$	$.90^{+}$	$.90^{+}$	$.90^{+}$	$.90^{+}$	$.90^{+}$	$.90^{+}$	$.90^{+}$	$.90^{+}$	$.90^{+}$
	(-1.86)	(-1.82)	(-1.75)	(-1.77)	(-1.76)	(-1.79)	(-1.77)	(-1.80)	(-1.76)	(-1.76)
Prestige graduation	$.63^{***}$	$.63^{***}$	$.63^{***}$	$.63^{***}$	$.63^{***}$	$.63^{***}$	$.63^{***}$	$.63^{***}$	$.63^{***}$	$.63^{***}$
	(-3.72)	(-3.66)	(-3.72)	(-3.72)	(-3.70)	(-3.66)	(-3.69)	(-3.74)	(-3.72)	(-3.68)
Prestige doctorate	1.14	1.13	1.13	1.14	1.14	1.14	1.13	1.15	1.14	1.14
	(1.03)	(.97)	(.95)	(1.03)	(1.03)	(1.00)	(.99)	(1.07)	(1.04)	(1.03)
Prestige habilitation	1.37^{*}	1.40^{*}	1.40^{*}	1.38^{*}	1.38^{*}	1.38^{*}	1.39^{*}	1.39^{*}	1.39^{*}	1.38^{*}
	(1.97)	(2.09)	(2.09)	(2.04)	(2.05)	(2.01)	(2.05)	(2.05)	(2.06)	(2.01)
Awards (ln)	1.21	1.21	1.21	1.21	1.21	1.22	1.21	1.21	1.20	1.21
	(1.48)	(1.48)	(1.49)	(1.46)	(1.49)	(1.54)	(1.47)	(1.49)	(1.41)	(1.46)
Months abroad (ln)	1.14^{***}	1.13^{**}	1.14^{***}	1.13^{**}	1.13^{**}	1.13^{**}	1.14^{**}	1.13^{**}	1.14^{**}	1.13^{**}
	(3.34)	(3.28)	(3.31)	(3.25)	(3.28)	(3.27)	(3.26)	(3.29)	(3.28)	(3.26)
Studied abroad	.83	.89	.88	.89	.89	.89	.89	.89	.89	.89
	(-1.20)	(-.91)	(-1.02)	(-.97)	(-.97)	(-.95)	(-.97)	(-.99)	(-.96)	(-.96)
Doctorate abroad	1.49^{*}	1.30	1.48^{*}	1.49^{*}	1.48^{*}	1.48^{*}	1.48^{*}	1.50^{*}	1.49^{*}	1.49^{*}
	(2.36)	(1.24)	(2.34)	(2.35)	(2.35)	(2.32)	(2.35)	(2.42)	(2.37)	(2.37)
International	1.09	1.10	1.15^{+}	1.10	1.09	1.10	1.09	1.10	1.09	1.09
publications (ln)	(1.24)	(1.27)	(1.69)	(1.25)	(1.22)	(1.28)	(1.24)	(1.26)	(1.23)	(1.24)

	(12) Female × studied abroad	(13) Female × doctorate abroad	(14) Female × international publications	(15) Female × mobility	(16) Female × interim professorships	(17) Female × department size	(18) Female × co-authors	(19) Female × children	(20) Female × DFG funding	(21) Female × entry cohorts
Mobility (ln)	2.52***	2.50***	2.51***	2.54***	2.52***	2.52***	2.51***	2.51***	2.52***	2.51***
	(9.04)	(8.91)	(8.99)	(7.41)	(8.97)	(8.98)	(8.96)	(8.89)	(8.96)	(8.86)
Interim professor (ln)	1.21	1.21	1.23^{+}	1.21	1.20	1.22^{+}	1.22	1.21	1.21	1.22
	(1.59)	(1.56)	(1.72)	(1.62)	(1.29)	(1.65)	(1.64)	(1.59)	(1.60)	(1.63)
Department size (ln)	1.07	1.08	1.08	1.08	1.08	1.13	1.08	1.08	1.08	1.08
	(.82)	(.83)	(.89)	(.85)	(.84)	(1.24)	(.84)	(.84)	(.85)	(.85)
Co-authors (ln)	1.11^{+}	1.11^{+}	1.11^{+}	1.11^{+}	1.11^{+}	1.11^{+}	1.12	1.11^{+}	1.11^{+}	1.11^{+}
	(1.71)	(1.67)	(1.73)	(1.69)	(1.70)	(1.68)	(1.63)	(1.69)	(1.69)	(1.69)
With children (ref.	1.29*	1.29^{+}	1.30*	1.29*	1.30*	1.29*	1.29*	1.30	1.30*	1.29*
childless)	(1.99)	(1.94)	(2.04)	(1.98)	(2.00)	(1.98)	(1.99)	(1.62)	(2.02)	(1.99)
No info on children (ref.	1.32^{+}	1.33*	1.32*	1.32^{+}	1.32*	1.31^{+}	1.32*	1.23	1.33*	1.32^{+}
childless)	(1.94)	(1.99)	(1.96)	(1.96)	(1.97)	(1.91)	(1.96)	(1.13)	(1.98)	(1.95)
DFG funding	1.40***	1.40***	1.39***	1.40***	1.39***	1.39***	1.40***	1.39***	1.37***	1.39***
	(5.36)	(5.42)	(5.29)	(5.37)	(5.33)	(5.30)	(5.35)	(5.34)	(3.89)	(5.35)
Entry cohorts *(ref. before 1990)*										
1991–1999	1.02	1.03	1.01	1.02	1.02	1.02	1.02	1.01	1.02	1.00
	(.13)	(.18)	(.05)	(.12)	(.13)	(.11)	(.11)	(.09)	(.14)	(.00)
2000–2009	1.07	1.08	1.06	1.07	1.07	1.06	1.07	1.07	1.07	1.05
	(.40)	(.45)	(.36)	(.39)	(.41)	(.37)	(.38)	(.39)	(.41)	(.26)
after 2009	1.33	1.32	1.32	1.33	1.33	1.33	1.33	1.33	1.34	1.39
	(.93)	(.90)	(.91)	(.92)	(.93)	(.93)	(.92)	(.92)	(.95)	(.84)
Incomplete	2.01***	2.01***	2.05***	2.01***	2.01***	2.03***	2.02***	2.02***	2.02***	2.01***
	(4.85)	(4.90)	(5.05)	(4.89)	(4.89)	(4.96)	(4.94)	(4.97)	(4.91)	(4.96)
Open positions (ln)	.77*	.77*	.77*	.77*	.77*	.77*	.77*	.77*	.77*	.77*
	(-2.36)	(-2.33)	(-2.37)	(-2.33)	(-2.32)	(-2.31)	(-2.33)	(-2.30)	(-2.30)	(-2.31)

	(12) Female × studied abroad	(13) Female × doctorate abroad	(14) Female × international publications	(15) Female × mobility	(16) Female × interim professorships	(17) Female × department size	(18) Female × co-authors	(19) Female × children	(20) Female × DFG funding	(21) Female × entry cohorts
Years since habil.	1.44***	1.44***	1.44***	1.44***	1.44***	1.44***	1.44***	1.44***	1.44***	1.44***
	(5.38)	(5.42)	(5.36)	(5.37)	(5.37)	(5.40)	(5.38)	(5.37)	(5.38)	(5.42)
Years since habil. (sq.)	.97***	.97***	.97***	.97***	.97***	.97***	.97***	.97***	.97***	.97***
	(-4.23)	(-4.28)	(-4.24)	(-4.26)	(-4.25)	(-4.27)	(-4.25)	(-4.25)	(-4.24)	(-4.27)
Years since assistant prof. (ln)	2.17***	2.19***	2.21***	2.18***	2.19***	2.18***	2.18***	2.19***	2.18***	2.18***
	(7.67)	(7.66)	(7.94)	(7.75)	(7.71)	(7.63)	(7.72)	(7.75)	(7.70)	(7.69)
Female × studies abroad	1.17									
	(.67)									
Female × doctorate abroad		1.33								
		(.95)								
Female × international publications (ln)			.89							
			(-1.28)							
Female × mobility (ln)				.98						
				(-.12)						
Female × interim professor (ln)					1.03					
					(.16)					
Female × department size						.88				
						(-.69)				
Female × co-authors (ln)							.97			
							(-.38)			
Female × with children								.97		
								(-.13)		
Female × no info on children								1.21		
								(.65)		
Female × DFG funding									1.06	
									(.51)	

	(12) Female × studied abroad	(13) Female × doctorate abroad	(14) Female × international publications	(15) Female × mobility	(16) Female × interim professorships	(17) Female × department size	(18) Female × co-authors	(19) Female × children	(20) Female × DFG funding	(21) Female × entry cohorts
Female × entry cohorts *(ref. before 1990)*										
1990–1999										1.06
										(.17)
2000–2009										1.06
										(.18)
after 2009										.94
										(-.12)
Pseudo r²	.13	.13	.13	.13	.13	.13	.13	.13	.13	.13
Log-likelihood	-2624.71	-2624.43	-2624.09	-2624.96	-2624.95	-2624.61	-2624.89	-2624.50	-2624.85	-2624.92
Degrees of freedom	31	31	31	31	31	31	31	32	31	33
Chi²	818.11	817.27	813.34	812.73	819.39	813.00	812.93	816.63	824.89	825.32
AIC	5311.43	5310.85	5310.19	5311.93	5311.91	5311.23	5311.79	5312.99	5311.71	5315.84
BIC	5585.12	5584.55	5583.88	5585.62	5585.60	5584.92	5585.48	5595.51	5585.40	5607.20
Number of events (tenure)	486	486	486	486	486	486	486	486	486	486
N (persons)	2,290	2,290	2,290	2,290	2,290	2,290	2,290	2,290	2,290	2,290
N (persons-publications)	50,457	50,457	50,457	50,457	50,457	50,457	50,457	50,457	50,457	50,457

Exponentiated coefficients (hazard ratios); t statistics in parentheses; ln = logged values; sq = squared.
+ p <.1, * p <.05, ** p <.01, *** p <.001.

Table A6. Cox regression models on getting tenured (interactions between important tenure criteria, separately for women and men).

	(1) SSCI/SCIE article × DFG funding (women)	(2) SSCI/SCIE article × DFG funding (men)	(3) SSCI/SCIE article × Prestige doctorate (women)	(4) SSCI/SCIE article × Prestige doctorate (men)
Conditional effect				
SSCI/SCIE journal articles (ln)	1.50*	2.00***	1.13	1.81***
	(2.47)	(5.66)	(.77)	(4.97)
DFG funding	1.94**	1.58*	1.56***	1.34***
	(3.23)	(2.29)	(4.36)	(3.48)
Prestige doctorate	1.28	1.03	.62	.75
	(1.22)	(.16)	(-1.43)	(-.92)
Interaction effect				
DFG funding × SSCI/SCIE journal articles (ln)	.85	.91		
	(-1.28)	(-.95)		
Prestige doctorate × SSCI/SCIE journal articles (ln)			1.96**	1.26
			(2.70)	(1.14)
Non-SSCI/SCIE articles (ln)	1.40*	1.18^{+}	1.45**	1.17^{+}
	(2.36)	(1.70)	(2.64)	(1.65)
Books (ln)	1.57*	1.51**	1.57*	1.55**
	(2.07)	(2.85)	(2.06)	(3.08)
Edited volumes (ln)	1.30	1.40**	1.25	1.39**
	(1.38)	(2.79)	(1.25)	(2.71)
Book chapters (ln)	1.19	1.01	1.16	1.03
	(1.08)	(.07)	(.94)	(.28)
Grey literature (ln)	.91	.86*	.93	.86*
	(-.72)	(-2.36)	(-.57)	(-2.26)
Prestige graduation	.67^{+}	.60**	.71	.60**
	(-1.92)	(-3.18)	(-1.61)	(-3.17)

	(1) SSCI/SCIE article × DFG funding (women)	(2) SSCI/SCIE article × DFG funding (men)	(3) SSCI/SCIE article × Prestige doctorate (women)	(4) SSCI/SCIE article × Prestige doctorate (men)
Prestige habilitation	1.55	1.39^{+}	1.64^{+}	1.39^{+}
	(1.53)	(1.75)	(1.77)	(1.71)
Awards (ln)	1.22	1.07	1.26	1.09
	(.91)	(.36)	(1.07)	(.49)
Months abroad (ln)	1.18*	1.16**	1.19**	1.16**
	(2.47)	(2.84)	(2.68)	(2.89)
Studied abroad	1.02	.77	1.01	.77
	(.11)	(-1.54)	(.03)	(-1.50)
Doctorate abroad	2.44***	1.09	2.46***	1.12
	(3.39)	(.38)	(3.53)	(.47)
International publications (ln)	.98	1.11	1.01	1.11
	(-.18)	(1.07)	(.05)	(1.11)
Mobility (ln)	2.38***	2.57***	2.27***	2.57***
	(5.13)	(7.22)	(4.87)	(7.25)
Interim professor (ln)	1.10	1.25	1.03	1.28
	(.43)	(1.48)	(.13)	(1.63)
Department size (ln)	.92	1.21^{+}	.90	1.19^{+}
	(-.55)	(1.82)	(-.74)	(1.66)
Co-authors (ln)	1.16	1.10	1.19^{+}	1.10
	(1.57)	(1.17)	(1.86)	(1.16)
Incomplete	2.61***	1.82***	2.83***	1.86***
	(3.57)	(3.71)	(4.06)	(3.92)
Open positions (ln)	.67*	.83	.66*	.82
	(-2.34)	(-1.34)	(-2.43)	(-1.43)
Years since habilitation	1.97***	1.31***	1.94***	1.31***
	(6.12)	(4.03)	(5.92)	(3.76)

	(1) SSCI/SCIE article × DFG funding (women)	(2) SSCI/SCIE article × DFG funding (men)	(3) SSCI/SCIE article × Prestige doctorate (women)	(4) SSCI/SCIE article × Prestige doctorate (men)
Years since habilitation (sq.)	$.94^{***}$	$.98^{***}$	$.94^{***}$	$.98^{**}$
	(-4.52)	(-3.70)	(-4.28)	(-3.24)
Years since assistant prof. (ln)	2.55^{***}	2.15^{***}	2.66^{***}	2.13^{***}
	(7.17)	(5.34)	(7.78)	(5.15)
With children	1.14	1.32^{+}	1.17	1.32^{+}
(ref. childless)	(.63)	(1.69)	(.73)	(1.70)
No info on children	1.54^{*}	1.24	1.53^{+}	1.24
(ref. childless)	(1.97)	(1.17)	(1.95)	(1.17)
1990–1999	1.25	1.01	1.24	1.03
(ref. <1990)	(.76)	(.05)	(.73)	(.15)
2000–2009	1.44	1.02	1.30	1.03
(ref. <1990)	(1.13)	(.11)	(.83)	(.14)
>2009	1.92	1.31	1.74	1.34
(ref. <1990)	(1.38)	(.64)	(1.16)	(.70)
Pseudo r^2	.18	.14	.18	.14
Log-likelihood	-842.94	-1439.19	-840.01	-1438.82
Degrees of freedom	30	30	30	30
Chi^2	419.08	517.75	428.66	507.04
AIC	1745.89	2938.38	1740.01	2937.63
BIC	1980.16	3189.82	1974.28	3189.08
Number of events (tenure)	191	295	191	295
N (persons)	1,063	1,230	1,063	1,230
N (persons-publications)	18,197	32,260	18,197	32,260

Exponentiated coefficients (hazard ratios); t statistics in parentheses; ln = logged values; sq = squared.
+ p <.1, * p <.05, ** p <.01, *** p <.001.

Jessica Ordemann* and Laura Naegele**

Forty and over the academic hill?

Biological and academic age and the race for tenure

Abstract: This paper investigates the relationship between age and attaining a tenured position in academia (postdoctoral researcher or professorship at a university of applied sciences or university). Following considerations about ageism towards doctoral graduates who were 40 years and older (40+) upon attaining a PhD and Robert K. Merton's idea of cumulative advantages in academic careers (*Matthew Effect*), we differentiate between *biological* and *academic age.* We test the relationships and the resources accumulated behind the latter using data from the DZHW PhD Panel 2014. Applying piecewise constant exponential estimations and an entropy balancing, we find that PhDs aged 40+ experience a significantly positive effect on attaining a professorship at a university of applied science or receiving tenure as a postdoctoral researcher. We interpret the finding as a positive effect of age discrimination.

Keywords: tenure in academia; biological age; academic age; Matthew Effect; ageism

Forty and over the academic hill?

Biologisches und akademisches Alter und die Entfristung im Wissenschaftssystem

Zusammenfassung: Der Beitrag untersucht, wie sich das Alter eines*r Wissenschaftler*in auf die Erreichung einer unbefristeten Stelle im deutschen Wissenschaftssystem (unbefristete Postdoktorand*innenstelle bzw. Professor*in an einer Fachhochschule oder Universität) auswirkt. Dabei unterscheiden wir basierend auf Überlegungen zu Altersdiskriminierung und zur von Merton geprägten Idee der kumulativen Vorteile (*Matthäus-Effekt*) zwischen dem *biologischen* und *akademischen Alter*. Wir testen unsere Überlegungen anhand der Daten des DZHW-Promotionspanels 2014. Unter Anwendung von Piecewise Constant Exponential-Schätzungen und von Entropy Balancing stellen wir fest, dass Wissenschaftler*innen, die bei ihrer Promotion 40 Jahre oder älter waren, einen signifikant positiven Effekt auf die Erlangung einer Professur an einer Fachhochschule und einer Anstellung als

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entfristeter Postdoc hatten. Wir interpretieren den ersten Befund als ein Beispiel für positive Altersdiskriminierung.

Stichworte: Entfristung im Wissenschaftssystem; biologisches Alter; akademisches Alter; Matthäus-Effekt; Altersdiskriminierung

1. Introduction

As early as 1942, Robert K. Merton noted that pursuing research as a profession should be marked by *universalism* and not depend on a scholar's personal or social attributes, such as gender, nationality, religion, or class membership (Merton 1973). Despite this call for equal access, certain social groups appear to be less successful when trying to obtain tenured positions in German academia. In particular, women and scholars with a migration background often find it hard to succeed, making them an often underrepresented group among tenured faculty members (BuWiN 2021; Engel 2021; GWK 2020). Surprisingly, a *scholar's age* is a seldom-discussed topic when trying to explain why the talent or individual performance of a scholar is seemingly not enough in the so-called 'race for tenure' (Hüther et al. 2018).

Besides one's *biological age*, every PhD graduate that stays in academia following graduation has an *academic age*, the time that has passed since the attainment of the PhD. During this time, an academic career is shaped, and a scholar can accumulate the necessary scientific output to achieve the pinnacle of success: The attainment of a tenured professorship (Laudel/Gläser 2008; Auspurg et al. 2017). As professorships and other tenured positions in German academia are rare, and the law limits employment on fixed-term contracts, the competition amongst potential tenure candidates is great, and the window of opportunity is small: *"[…] This means every postdoc [that wants to remain in academia; note from the authors] either has to become a tenured full professor or has to drop out of the system eventually – usually around the age of 40"* (Lutter/Schröder 2014: 1000). To achieve the output needed to succeed in the academic labor market, scholars are urged to be highly productive right from the start of their academic careers. This is an expectation Merton (1968) discussed under the heading of cumulative advantages (CA), the consequences of which are known as the *Matthew Effect*. This discussion has shaped a culture that today is often termed 'publish or perish' (van Dalen 2021).

A scholar's academic age is not mandatorily linked to biological age, making it possible that two PhD graduates have the same academic age but were born years apart. When looking at biological age as a source of unequal treatment in labor markets ('ageism'), a rich body of research can be found (Bal et al. 2011; Ng/Feldman 2012; Naegele et al. 2018; Marques et al. 2020; Cebola et al. 2021). Discrimination based on age is often linked to chrononormative expectations of what career step is appropriate at what age and which competencies are assigned to a specific age group. Paradoxically, although a higher age is generally associated with a higher level of competency, scholars who finish their PhDs in their 40s are often perceived as too old to start a research career afterwards ('being over the academic hill'). Behind this perception lies the stereotypical assumption that to gain experience and seniority and to be as productive as is needed for tenure (Evans 2014), one has to start out at a very early age. In fact, some studies indicate that a younger age at the time of achieving a 'Habilitation', that is, the formal teaching qualification in Germany, is beneficial for being appointed to a professorship (Jungbauer-Gans/Gross 2013).

At the moment, little is known about the relationship between biological age, academic age, and the achievement of a tenured position in German academia. In addition, most research concentrates on attaining professorships at university level, ignoring tenured positions in extra-university research institutions or universities of applied sciences. Therefore, this paper will focus on how both biological age and academic age affect academic success in regard to each of the three above-mentioned tracks. Hence, the definition of success will be expanded from the narrow specification of a tenured university professorship to the attainment of a professorship at universities of applied sciences and tenured postdoctoral positions in academia. We ask: *How do tenured positions in academia relate to the biological age and academic age of PhD graduates?*

To answer our research question, the paper is structured as follows: First, we provide an overview of the German academic labor market (Section 2) and the literature on the determinants of success in academia (Section 3). A special focus is placed on the literature and theoretical considerations behind biological and academic age as determinants of tenure in academia (Section 4). Using data from the DZHW PhD Panel 2014, we explore how biological age and academic age relate to attaining a tenured position in academia. The data, its operationalization, and the research design are described in Section 5. Section 6 presents the findings of our study. We find that a higher biological age reduces the probability of attaining a tenured post-doc position and increases the chance of attaining a professorship at universities (of applied sciences). However, once entropy balancing is applied to level differences in the performance of those younger than 40 years of age or older (40+), we find that only a positive age discrimination effect remains for a professorship at a university of applied science. Maturing academically only reduces the attainment of a postdoctoral position in academia. Section 7 concludes.

2. The German academic labor market

German academia can be considered a highly differentiated labor market that provides opportunities at different career stages and at varying institutions (for a description of its history, see Enders/Bommann 2001). However, German academia has a twofold reputation as a place for scholars to work. For one, universities and extra-university research institutes are known for their rich history and for being adamant about their scholars' scientific freedom. In addition, academia attracts international students and produces excellent scholars and research output, which are globally recognized (Backes-Gallner/Schlinghoff 2010; Scott 2005; Gewinner 2020; Schneijderberg et al 2022). Nevertheless, contrary to this positive perspective on academia, the academic labor market in Germany is repeatedly criticized for its insecure working conditions and precarious career paths, which can especially, but not exclusively, negatively affect early careers (Bahr et al. 2022; Dirnagl 2022).

When looking at how the academic labor market is structured, it should be noted that higher education in Germany is organized at the state level and allows for a high degree of freedom at the organizational level. In practice, higher education institutions have, to a certain extent, liberties regarding employment and granting of tenure to scholars. Hence, the following paragraph refers to the general situation at universities (of applied science), but exceptions—especially at extra-university research institutes—are possible. Generally speaking, academic positions at German higher education institutions—be it at universities (of applied science) or extra-university research institutes—primarily fall into one of two categories: tenured positions such as professors, department heads, or senior researchers and fixed-term junior faculty ('Mittelbau'). The latter presents a particularity to the German system (Musselin 2005). Germany's academic employment law ('WissZeitVG') currently limits the employment of junior faculty to six years before and six years (nine for medicine) after the doctorate ('6+6 rule').[1] Although initially created to prevent German academia from being clogged at the postdoctoral level, and to incentivize German higher education institutions to create more positions that lead to tenured positions under specified criteria (tenure-track), the law failed to achieve the expected effect (Goldan et al. 2022).

Tenured positions in universities (of applied sciences) have decreased between 2000 and 2020 by 19.8 percent, a trend that especially affects fixed-term junior faculty (34.2 to 17.4 percent, Authoring Group Educational Reporting 2022 and the author's own calculations). As a result, most junior faculty move from one temporary job to the next and, if they are unable to secure one of the very few tenured postdoctoral positions[2] or are appointed as a professor, they are ultimately

1 The six years for the postdoc phase specified in the WissZeitVG can be extended under certain conditions, such as parental leave, care activities of dependents, scientific or artistic activities abroad, equal opportunity representations, basic military and civilian service or illness (WissZeitVG § 2). Furthermore, fixed-term contracts under third-party funding can extend the time beyond six years.

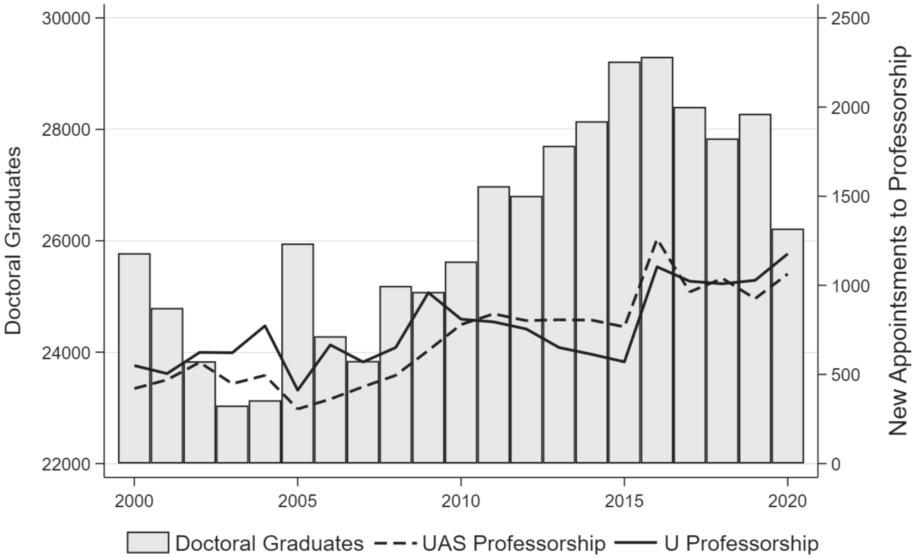
2 Albeit the cap that has been put upon untenured postdoctoral positions via the WissZeitVG, there still are some tenured positions available at postdoc level at universities (of applied sciences) such as e.g., 'Akademische Rät*in' or 'Lehrkraft für besondere Aufgaben (LfBA)'. It should be noted though, that these positions are more often the exception rather than the rule (less than five percent of all full-time personal, Authoring Group Educational Reporting 2022) and they have a strong teaching focus. Furthermore, tenured positions are more available in extra-university research institutions.

forced to leave academia for good, after 12 years (Dirnagl 2022; Schröder et al. 2021). If, during that time, they further qualify by submitting their 'Habilitation', and with it are accepted into professorial ranks, they must remain unpaid private lecturers ('Privatdozent*innen' (PD)) or otherwise lose this academic privilege. In 2002, an additional stepping stone toward becoming a professor was introduced, the 'Juniorprofessur' (W1). However, its nonobligatory tenure status, limited quota, and high workload contributed further to the often precarious career path in German academia rather than providing a remedy to it (Zimmer 2018; 2021). In June 2021, the already conflicted debate reached a new climax with the emergence of the hashtag #IchBinHanna on X (formerly Twitter). Since then, sensitivity to precarious working conditions in academia has increased. As at March 2022, according to the initiators of the hashtag, approximately 9,000 people had joined the discussion about #IchBinHanna in more than 134,000 tweets, criticizing employment conditions for junior faculty members in the German academic system (Bahr et al. 2022). This has been accompanied by a growing body of research that has sprung up, focusing on non-tenured scholars and the race for tenured professorships (e.g., Dirnagl 2022; Schröder et al. 2021).

Tenured professorships in Germany are anchored at universities (of applied sciences). There are no formal differences in academic rank between being appointed a professor at a university of applied science and being appointed at a university. However, neither institution has the same legal status and they also differ in teaching load and research mandate. Since introducing a new salary scheme in 2005, both institutions can appoint W2 and W3 professors. However, the position of a W3 professorship is a very rare occurrence at universities of applied science (Lutter/Schröder 2014; Backes-Gallner/Schlinghoff 2010). The formal entrance to a professorship appointment is, except in very few cases at universities of applied science, bound to a doctoral degree. When looking at the requirements for appointments at universities (of applied sciences), the main differences that can be found in regard to the 'practical work experience' of the candidates. Universities of applied science, with variations between the German states, usually require a mandatory three or more years of work experience outside of the university in a field relevant to the professorship that can only be exchanged for higher academic qualifications, the 'Habilitation', in some instances. As a consequence, the average age at appointment to a professorship at universities of applied sciences has gone up from an average of 41.5 years in 2000 to 43.0 years in 2020; at the same time the average age at appointment to a professorship at a university has gone down from 42.1 to 40.3 years (Statistisches Bundesamt 2022). It should be noted, however, that this sector is highly dynamic, and increasingly universities of applied science also emphasize the importance and relevance of research in their appointment decisions (Lackner 2020).

A professorship in Germany also means gaining privileges (e.g., appointment for life, generous salary, and social security entitlements) associated with the status

Figure 1: PhDs and newly-appointed professors, 2000 – 2020 (absolute)



Source: Special analysis by Statistisches Bundesamt (2022).

of a civil servant ('Beamte*r').[3] Therefore, the question of one's chances of appointment—or what might hinder them—is highly relevant. This is true not only for the individual but also from a societal point of view, e.g., if members of certain social groups—even though they are successful scholars—are being systematically excluded from the chance of attaining a professorship.

The selection process for a professorship is illustrated in Figure 1. It gives an overview of the numbers of PhDs (y-axis on the left) and newly-appointed professors (y-axis on the right) from 2000 to 2020. It is apparent at first glance that far more people receive doctoral degrees than appointments to professorships. Starting in 2010, increasing numbers of doctoral graduates have the formal entrance qualification to a professorship. However, we also find an expansion in newly appointed professors, albeit six years later. This dynamic is mainly driven by the expansion of new appointments at the universities of applied sciences. The ratio of junior faculty aiming for tenure to the total number of professorships available is very high, turning the time after receiving one's doctorate into a 'race for tenure' and scholars into competitors (Dirnagl 2022).

3 Influences of these privileges – albeit in a weakened form – also apply to tenured positions.

3. How to be successful? Determinants of research careers (in Germany)

How and whether a person can pursue a career in academia and what determines whether an academic career is successful enough to attain a professorship has been the subject of various studies (e.g., Auspurg et al. 2017; Jungbauer-Gans/Gross 2013; Lutter/Schröder 2014). While performance indicators such as a scholar's publication record (Schröder et al. 2021), relevant teaching experience (Heuchemer/Szczyrba 2016), access to research networks (Jaksztat et al. 2017), and the ability to acquire third-party funding (Jansen et al. 2007) are core indicators of professorship appointments, research has repeatedly pointed out that individual characteristics also play an important role in who can reach tenure. Contrary to this principle of selecting the best and most qualified candidate for the job, certain social groups seem to have unequal starting points in the 'race for tenure', which has led to an underrepresentation of these groups at the professor level (Schröder et al. 2021).

Reasons for this phenomenon are manifold, but in this paper, we want to explicitly address the effects of prejudices and related stereotypes regarding who is deemed suitable for a research career. Prejudice and stereotyping often lead to discrimination, which Aronson et al. (2021) define as *"[u]njustified negative or harmful action toward a member of a group solely because of his or her membership in that group"* (Aronson et al. 2021: 431). Discrimination may be obvious and direct, e.g., by choosing a candidate over another solely based on their gender, migration background, or age, a behavior that is in most cases illegal. However, in many cases, discrimination in the workplace or during the hiring process is internalized and/or institutionalized, making it more subtle and difficult to detect (Aronson et al. 2021). Older candidates might be viewed as less suitable for tenure due to an ageist perception of them being less productive or less innovative than their younger counterparts. In addition, they might be given less support or resources beforehand, making it difficult to even get to the position to compete on equal terms for tenure. Nevertheless, it should be noted that discrimination can go both ways, meaning in some cases a *preferential treatment of certain social groups* is observed ('positive discrimination'), for example, by assuming a person's age (and with that the stereotypical perception of the competences of members of this age group) is more fitting for a vacancy or a specific career step (Stypińska/Nikander 2018).

To demonstrate how discriminative behavior could hinder one's chances of tenure, this article first discusses two well-documented inequality categories in German academia: gender and migration background. Subsequently, the article will focus on ageism or ageist behavior in more detail to establish how a scholar's age could potentially become a source of unequal treatment on the pathway to tenure. It should be noted, however, that the categories described are by no means conclusive, and other inequality dimensions such as social status or social and family background (Keil 2018; Lörz/Schindler 2016; Möller 2016) have proven also to (re)produce inequality in the race for tenure. Furthermore, these inequalities might not apply to all disciplines, are likely to be interconnected (intersectional), and might change over time.

When looking at who climbs the career ladder in academia successfully, the influence of a candidate's *gender*, especially regarding women in academia, is one of the most well-documented findings in the literature. As early as the 1980s, studies have described the phenomenon of women prematurely leaving higher education and academia under the umbrella term *leaky pipeline* (Berryman 1983; Gasser/Shaffer 2014). As a result, the share of women declines with each step of the academic ladder, counteracting the ongoing trend of rising numbers of female students and women starting a doctorate in Germany (Statistisches Bundesamt 2021a; Krais 2003). The reasons for the leaky pipeline are manifold. Whereas some studies point in the direction of individual career choices (Fassinger 1990; Fitzgerald et al. 1995; Berlingo et al. 2018; Astin 1984), other studies highlight the importance of unequal access for women to resources. This might be seen in relation to socio-economic status and class (Lapour/Heppner 2009; Leppel et al. 2001) or as a result of 'gendered life courses', which assign care responsibilities primarily to women. Hence, due to difficulties in reconciling care and family responsibilities with career, not only is the track to tenure less often successful for women (Gasser/Shaffer 2014; Lynch 2008; McDowell 1982; Springer et al. 2009), but substantial negative impacts on female scholars' (mental) health have been reported as a consequence. Furthermore, newer research points out that gender biases and gender discrimination in academia, especially in academic recruitment processes, play an important role in whether and how women are appointed to professorships. Interestingly, women are given preferential treatment when applying for positions at the lower end of the qualification scale, but this advantage diminishes with each step on the academic ladder (Solga et al. 2023).

A different factor that has also proven to be highly influential in achieving tenure is the *migration background and/or nationality* of a person (Gewinner 2020). Although research in this regard is both insufficient and methodologically challenging due to the often imprecise operationalization of the term 'migration background' (Will et al. 2019), statistically an underrepresentation of people with non-German nationality in tenured positions within German academia cannot be denied. Whereas approximately 45,300 of the 200,300 doctoral students enrolled in Germany in 2021 are of non-German nationality (Statistisches Bundesamt 2022), only around seven percent of the professors have a non-German nationality (Statistisches Bundesamt 2020; 2021b). In addition, studies carried out by Löther (2012) and Pichler/Prontera (2012) find that scholars with non-German nationalities are less likely to pursue a 'Habilitation', hold fewer tenured positions than their German colleagues, and are more often involved in areas of research where they can utilize specific competencies of their migration background (e.g., language or cultural knowledge). When looking at the source of these inequalities, scholars have pointed toward the influence of *resource accessibility*, even though this factor could vary by country of origin. For example, it can be assumed that scholars from countries of the global South often have even fewer resources, such as funding opportunities, access to information or data, or not being granted a working visa for the host country (Arunachalam 2003; Bilecen 2012). Other studies suggest that *forms of (ethnic) discrimination* are the reasoning behind the stark underrepresentation of scholars with migration backgrounds. A study conducted amongst 406 professors in the German states of Berlin and Hessen finds that around one-third of the respondents reported having experienced negative impacts due to their migration background, with variations regarding gender, citizenship, and the specific migration background (Neusel et al. 2014). A qualitative study amongst scholars from the humanities summarizes the problem as follows: *"Scientists with a migration background seem to have a chance in the German university system mainly where 'German' scholars cannot be employed because they do not have the appropriate cultural, social and linguistic competences"* (Pichler/Prontera 2012: 100; translated).

4. Age-Stereotypes and age-based discrimination in academia

Until now, the influence of a *scholar's age* is a seldom-discussed source of unequal chances on the academic track. This underexposure is somewhat surprising since the educational trajectories and work courses of the younger cohorts are increasingly destandardized and consist of more detours, interruptions, equal allocations of care work and overall career changes than those of the older cohorts (Kohli 2003). Consequently, people not only enter academia right after obtaining their undergraduate degree but also after finishing vocational training or gaining work experience (Ordemann 2019; Ordemann et al. 2023) or after starting a family (Gasser/Shaffer 2014). In short, they come to academia from different life situations, at a later phase in life, and, on average, at an older age than ever before.

When talking about a *scholar's age* as a source of inequality, a distinction must be made between the *biological age* and the *academic age* of a scholar. Whereas the former is quite self-explanatory and starts with the birth of a person, *academic age* usually refers to the time that has passed since PhD attainment and the resources meanwhile accumulated (Auspurg et al. 2017; Reskin 1977).[4] Hence, it is possible that two scholars have the same *academic age*, even though they are born a decade

4 Some discussion deviates from how this article operationalizes the term 'academic age', mainly with regard to when to pinpoint the start of an academic career. In the international literature, academic age is often counted from the first publication (e.g., Primack et al. 2009, Milojević 2012). While we acknowledge this, our article bases its definition of academic age on two assumptions reflecting the German context: First, doctorate students are still somewhat bound to the leadership of a senior researcher (mainly professor) and only a completed dissertation will open the doors to a tenured professorship in academia. Secondly, many doctoral students opt to leave academia after receiving their degree; therefore, joining the race for tenure concerns only those who stay on to pursue an academic career.

or so apart (see also Milojević 2012) and that biological age can influence academic age (Cole 1979).

A broad body of research can be found regarding *biological age* as a determinant of inequalities in the labor market: *Ageism*, meaning discriminative behavior towards people of a specific age group due to stereotyping and misconceptions of their competencies and capabilities has proven to be prevalent in labor markets (Butler 1969; Iversen et al. 2012). Ageist behavior can be directed both towards younger as well as older age cohorts and can include both negative, e.g., older workers being less innovative, younger workers being too inexperienced, and positive stereotyping, e.g., older cohorts being more socially competent, younger cohorts being more digitally competent (Naegele et al. 2018; Marques et al. 2020; Marchiondo et al. 2016). These stereotypical perceptions of specific age groups are often based on chrononormative life-course expectations, which means the assumption of there being 'a right time' and 'a right age' for specific life phases or transitions. This links certain life phases (such as who should start a research career) to stereotypical perceptions of who should go through these phases and at what age, ultimately ignoring inter-personal differences (Freeman 2010; Wanka/Höppner 2020; Wanka 2020).

The academic labor market presents a fascinating case regarding age stereotypes and chrononormativity: Academia allows for a comparison of scholars with the same work experience, that is, academic age, but different biological ages (Allgood 2020). Although academic age is not necessarily related to a person's biological age, specific steps on the academic ladder are often attributed to certain age groups: for example, doctoral students in their 20s and people who reach a professorship in their early to mid-40s, depending on their discipline. Zuckerman and Merton (1972) already noted this age stratification regarding specific career steps in science and highlighted the importance of social definition and ascription: *"[I]n order for the given status to have social reality it must be validated by status judges, those institutions and agents charged with authenticating claims."* (Zuckerman/Merton 1972: 297). If these chrononormative expectations of said status judges are disrupted, e.g., by scholars being perceived as too old to start a scientific career or—on the contrary—appointment committees considering scholars to be too young, age stereotypes come into play. In addition, ageist perceptions with regard to older scholars being less productive and less innovative might play a role. Hence, one's (higher) *biological age* can become a source of unequal treatment when aiming for tenure.[5]

5 In this regard, it is important to address another particularity of the German academic labor market regarding the discussion of age and tenure in academia: The age barriers to becoming a civil servant. As mentioned before, with a professorship come certain benefits related to being a civil servant. However, in many states it is only possible to become a civil servant until the age of 50 or 52 years (see Appendix A1, also for the exceptions to this age barrier). Therefore, although an appointment as a regular employee without civil servanthood is still possible, the

Very few empirical studies explicitly address age other than it being a control variable, and even fewer studies look at age discrimination in the German academic labor market. Concerning *academic age,* Auspurg et al. (2017) find that in a study focused on 259 academic appointment procedures in one middle-sized university in Germany, the academic age has—depending on the statistical model used—either no or a negative effect on being appointed to a professorship. Schröder et al. (2021) find a positive effect for tenure if a scholar has completed prior steps on the academic ladder, e.g., completing a 'Habilitation' or 'Juniorprofessur'. The authors explain this in the form of a signaling effect that reduces the uncertainty for appointment committees as those candidates have undergone another form of external evaluation. These findings are not that surprising, as a long time spent in an academic career allows for more output (e.g., conference attendances, publications, third party funding raised), and gains in reputation, ultimately increasing a scholar's chances of an appointment. The latter ties into the idea of cumulated advantage (CA) over time, which Merton (1968; 1988) has applied to academic careers and dubbed the *Matthew Effect* or *Matthew Principle*. Here, the idea is that reputation and academic success are self-enforcing, in the sense that well-established scholars receive disproportionately more attention and recognition than relatively unknown scientists (Allison et al. 1982; Allison/Steward 1974; Feichtinger et al. 2021). Merton neglects to mention female scientists in his first paper and proceeds only to describe male academic career paths. However, later research has pointed out that this dynamic especially disadvantages women who often do not receive recognition for their scientific accomplishments, a phenomenon labeled the *Matilda Effect* (Rossiter 2003). Nevertheless, this does not mean that younger scholars or those with a lower academic age are less capable. Quite the opposite, as Zuckerman and Merton elaborate on in a later publication: *"Rather, it only announces a widespread belief that the best work in science is done at a comparatively early age. This posited linkage between age and significant productivity is still the focus of little research […]"* (Zuckerman/Merton 1972: 299). By linking scientific acknowledgment to productivity and age, scientists who start early and are highly productive are perceived to be more likely to succeed. At the same time, an academic culture is fostered that scholars have described as 'publish or perish' (Zuckerman 1977; Jungbauer-Gans/Gross 2013; van Dalen 2021).

This brings the effect of a scholar's *biological age* to the centre of interest. A study by Jungbauer-Gans/Gross (2013) shows that in line with Zuckerman's and Merton's age stratification argument, the median age varies at different stages of academic careers, across disciplines. Of the three disciplines investigated, sociologists have both the highest age and the widest age range when receiving a PhD or completing a 'Habilitation', followed by scholars of law and mathematics. Overall, the authors find that a relatively low biological age at the time of 'Habilitation' is

age barriers in place might divert scholars who have aged out of the opportunity to become a civil servant from academia.

beneficial for receiving a professorship. This effect remains stable for all examined disciplines. Other scholars find that women are usually younger in the early stages of a scientific career than men at the same stage (PhD graduation). However, further along the line, they need more time to attain a 'Habilitation' or to be appointed a professorship (Krimmer et al. 2003). Hillmert (2003) even postulates that scholars in Germany—in comparison to other countries—are 'unreasonably old' when attaining their first tenured professorship. It should be noted, though, that some of these publications are almost two decades old and cannot detect newer dynamics, e.g., the effect of the introduction of the 'Juniorprofessur' as track to tenure.

When looking at research from other countries, findings on the effect of biological age are inconclusive. Whereas some studies show no effect of age on the probability of obtaining tenure in the US (Yang/Webber 2015), other studies find that age is negatively associated with tenure in South Korea (Jung et al. 2022). An explanation the authors offer is, in alignment with the theoretical concept of the *Matthew Principle*, that younger scholars tend to be preferred by the already existing faculty members due to the notion that older scholars exhibit a lower level of research productivity. Some studies also look at subordinate effects, such as income differences between scholars that reached tenure at a younger age and those who accomplished this later. Allgood (2020) finds evidence for an 'age penalty' in Canada: those scholars who obtained their PhD at an older age earn less than those who received their doctorate earlier.[6]

Summing up the above research findings: A *scholar's biological age* and *academic age* are seldom the focus of research on tenure in academia, which—bearing the destandardization of life courses in mind—is quite surprising. Even though we have considered and presented biological and academic ages as somewhat separate entities or determinants of attaining tenure in academia, both are also strongly interlinked. Whereas scholars of different biological ages but with the same academic ages should have equal opportunity for tenure, research suggests otherwise: Chrononormative expectations of how old or young a person should be at what stage of a scientific career are equally influential as stereotypical perceptions of the productivity of specific age groups. Therefore, identifying ageist mechanisms that divert older PhDs from a sustainable academic career is important.

To gain insights into the interacting effects of biological and academic age, we address the following questions: *Do PhD graduates with different biological ages differ in the productivity associated with their academic ages? How does biological age relate to*

6 For Germany, in a study focusing on doctoral graduates, Goldan (2021) finds no statistically significant effect of age on income. It needs to be noted that the German higher education system is only partially comparable to systems in other countries as it presents, as explained earlier, a unique case.

transitioning to a tenured position in academia, and what influence does academic age have on tenure?

5. Empirical design

5.1 Data

We use data from the DZHW PhD Panel 2014 to understand how PhD attainment at 40+ affects integration into the academic labor market through productivity or age discrimination.[7] The panel started in the winter semester of 2013/2014 or the summer semester of 2014 (Brandt et al. 2020b; Vietgen et al. 2020). From 2015 onward, respondents were surveyed annually about their career development until 2020. This timeframe enables us to observe career trajectories over six years, covering most of the postdoctoral academic development and signaling the end of the time that a person can by law remain in a temporary position in academia. In addition, all sampled PhDs belong to the same cohort of graduates, which enables us to compare their different biological ages with a similar academic age.

The gross sample contains 5,408 respondents. We trim this sample in two steps. First, medical professionals and lawyers are excluded. Neither subject adheres to the fundamental elements of PhD training as stated in the Joint Declaration of Doctoral Training in Europe (HRK 2014/2015). Medical and law doctorates do not necessarily prepare for an academic career, with the former closely linked to the profession. In the latter, law doctorates can expect higher incomes outside of academia therefore not only choose to obtain a PhD but also to opt out from academia (Mertens/Röbken 2013).[8] Furthermore, PhD graduates who exit academia despite having the official entrance certificate to take up a tenured position are excluded in this step. However, we allowed respondents who exited but reentered academia during the observation window, into the analysis. This step reduces the initial sample by 63 percent to 2,028 PhD graduates. In a second step, we perform a complete case analysis excluding 5.4 percent of missings for birth date, sex, migration background, PhD grade, difference between end of studies and beginning of PhD, and the goal of remaining in academia. Our remaining net sample encompasses 1,918 PhD graduates with 6,719 observations.

7 We use a beta version of the 2014 PhD Panel 2014. The data will be available in the Research Data Centre for Higher Education Research and Science Studies in 2023. It is currently available for public use until wave 5 (Brand et al. 2020a). The replication files for the analysis can be found at: Ordemann, Jessica & Naegele, Laura (2023): Code/Syntax: "Forty and over the academic hill? Biological and academic age and the race for tenure". Version: 1. GESIS-Datenarchiv. https://doi.org/10.7802/2514.

8 Attaining a PhD as a medical professional or a lawyer corresponds to leaving science (medicine: 60.9 percent, dental medicine: 81.6 percent, veterinary: 67.5 percent, law: 81.6 percent).

5.2 Variables

Dependent Variable: We summarize the concept of the *academic hill* as the integration into three tenured destination states with competing risks: (1) tenured postdoctoral researcher and (2) tenured professorship at a university of applied sciences or (3) at university. The latter appointments to a tenured professorship are straightforward and operationalized by indicating whether the respondent is a professor and tenured at either institution. The first destination state is more complex in its demarcation. It includes all PhDs who will indicate that they have took up a tenured position inside academia. However, we do not have further information on whether the tenured position is situated in an extra-university research institution or at a university (of applied sciences) and what tasks the positions encompass. Therefore, the position will indicate that a person can remain in academia, but we cannot assess if this position will successfully integrate them into a scientific career.

Independent Variables: Biological age at the time of PhD graduation is operationalized by subtracting the graduate's birthday from the graduation date and then categorized as (0) under 40 years of age and (1) 40 years of age and older. The cut-off point of PhD attainment at 40+ is used based on the research of Lutter/Schröder (2014). Following Auspurg et al. (2017), we include academic age as a time-counting variable indicating the number of years after PhD attainment.

Academic Performance Indicators: We include academic performance indicators attained at a specific academic age that also influence the attainment of a professorship. Due to the limited number of cases for older PhDs, we limit these factors to the following determinants: number of publications with peer review, number of other publications, number of books published, number of conferences attained, successful grants, and reviews completed. All indicators reflect the academic performance of a postdoc and are correlated with each other. The highest correlations can be found between conference attendance and other publications (0.50*) or accepted grants (0.43*) and books with other publications (0.50*). Furthermore, they all show a right-skewed distribution and are therefore included as logarithmized variables in the multivariate analysis. All determinants are included as counter variables in the multivariate analysis that reflect the accumulation of resources over time, starting with 0 in the case that no resources were accumulated in the first year.

Control Variables: We furthermore control for sex (0=men; 1=women), migration background (0= none, 1=migration background) and PhD grade (summa, magna, or cum laude/satis bene). We also add the life goal of being in academia as a control variable. To reflect on the life goals, PhD graduates were asked: *"Every person has certain goals that are particularly important. Please indicate how important each goal is to you personally."* We included the answer *"Making a career in science"* that was given on a Likert scale from 1 not at all to 5 yes, certainly. Additionally, we include the time since the attainment of the qualifying degree for starting one's PhD studies in years as a proxy for previous work experience necessary for entering a professorship at a university of applied sciences. An overview of the variables can be found in the Appendix Table A2.

5.3 Methods

We will first give an overview of the occupational destinations after PhD attainment for those who remain in or reentered academia, and the academic resources they attained before and after, as well as reporting the time until they take up a tenured position as a professor or postdoctoral researcher to gain insight into the phenomena of older PhDs and their integration into the academic labor market. For this purpose, we draw on group comparisons between older and younger PhDs, including t-tests with Bonferroni adjustment for multiple testing and product-limit (Kaplan-Meier) estimation for entry into a professorship at university (of applied sciences) or as a tenured postdoctoral researcher.[9]

Second, we will estimate how biological age and academic age will impact reaching those destinations using a piecewise constant exponential model as we assume different transition rates for the three destinations under observation (Blossfeld et al. 2019). The model estimates how long it takes in years following PhD attainment to reach the multiple destinations or competing risks of attaining a tenured postdoctoral research position or a professorship at a university (of applied sciences). We estimate three separate models (not tenured → tenured postdoctoral researcher; not tenured → professorship at universities of applied sciences; not tenured → professorship at university.[10] All data is left-censored to the year of PhD attainment. We do not have information on all PhD graduates at the end of the observation period regarding whether a person received tenure or not, episodes for graduates without this data are right-censored. In the second analytical step, we look at the impact of the resources acquired following PhD attainment on the speed of reaching a tenured position. However, this approach will only indicate the relationship with the determinants described in the above variables section.

Finally, to better understand the discriminatory relationship of the biological age for reaching a tenured position, we match the groups of older to younger PhDs using entropy balancing (Hainmueller 2012). This matching approach will equalize the mean and variance of all included information (see Appendix A3), allowing us to better understand the influence of biological age and its discriminatory effect on

9 Robustness checks for the sample of all PhD graduates including those who exit academia have shown that those at 40+ exit academia sooner than those under 40 years of age but remain for longer in a 'Juniorprofessur' or similar.

10 Models which include exiting academia, as robustness checks have shown that those aged 40+ exit academia earlier, a pattern offset by the time that they remain as postdoctoral researchers. However, in the balanced model, the biological age effect does not remain. All other effects in this model remain similar except that PhD graduates that are older also have a higher probability of attaining a professorship at university.

attaining a tenured position in academia. However, the conditional correlations of our balanced model do not imply causality.

6. Findings

Descriptive: Academic performance and the pathway into tenure

Before assessing our first question of whether PhD graduates differ in the productivity associated with their academic age, we first look at who remains in or reenters academia. Overall, 1,918 PhD graduates remain in academia or reenter during the observation period, 6.8 percent of whom are aged 40+. Overall, PhD graduates in our sample remain in academia for 3.9 years before exiting to a tenured position either within or outside of academia, with no significant differences between those under 40 years of age and those aged 40+ (4.0 vs. 3.4 years).

Table 1: Accumulated resources following PhD attainment (absolute numbers)

	Total	PhD attainment		|t|-test
		under 40	aged 40+	
Publications				
Peer Review	9.2	9.3	7.5	1.419
Other publications such as contributions to anthologies	2.8	2.7	3.9	4.057***
Books	0.4	0.4	0.6	-4.215***
Conference Attendance	9.4	9.3	10.9	-2.765**
Successful Grant Application	1.1	1.1	0.8	2.653**
Peer Reviews	3.7	3.7	3.8	-0.149
n(observations)	6,719	6,313	406	

Note: N is based on the controlled sample of the multivariate analysis. * $p<0.05$; ** $p<0.01$; *** $p<0.001$.
Source: DZHW PhD Panel 2014 (2014–2020, beta), author's own estimations based on N=1,918.

In the years following the doctorate, PhD graduates mature as scholars and acquire different resources that qualify them for tenured positions in academia. Table 1 shows that during this period, PhD graduates invest their time publishing and presenting work in peer-reviewed publications and conferences. On average, they publish 9.2 articles that have gone through a peer-review process during the observation period that they remain in the sample. PhD graduates who were younger at the time of their doctorate are more likely to publish (12.3 publications) in peer-reviewed journals than those aged 40+. On average, they publish only 7.5 articles that have gone through a peer review process. However, they invest more time in other publications, such as contributions to edited volumes or transfer publications

(3.9 vs. 2.7 articles). Both age groups write few books, yet there is a significant difference here, and PhD graduates aged 40+ at the time of their doctorate publish more books (0.6 books) than those who are younger (0.4 books). Furthermore, PhD graduates aged 40+ attend conferences more often (10.9 conferences) than younger PhD graduates (9.3 conferences). Finally, on average, PhD graduates of both groups write one (accepted) research proposal in the first six years after the doctorate and review 3.7 and 3.8 articles, respectively, in peer-review procedures. The descriptive analyses indicate significant differences between PhD graduates who were younger at the time of their doctorate and those who were 40+ years old. However, there is no clear pattern: Although PhD graduates aged 40+ are generally more productive, they are on average behind the number of younger PhD graduates in one core indicator—peer-reviewed publications.

Let us turn to our second question about the relationship between biological age and tenured positions in academia: The descriptive overview in Table 2 indicates that older PhD graduates are more often found in tenured positions such as that of postdoctoral researcher (aged 40+: 41.2 vs. younger: 30.8 percent), or professor at universities of applied sciences (11.5 vs. 2.5 percent) or universities (3.8 vs. 1.2 percent) during the observation window after PhD attainment.

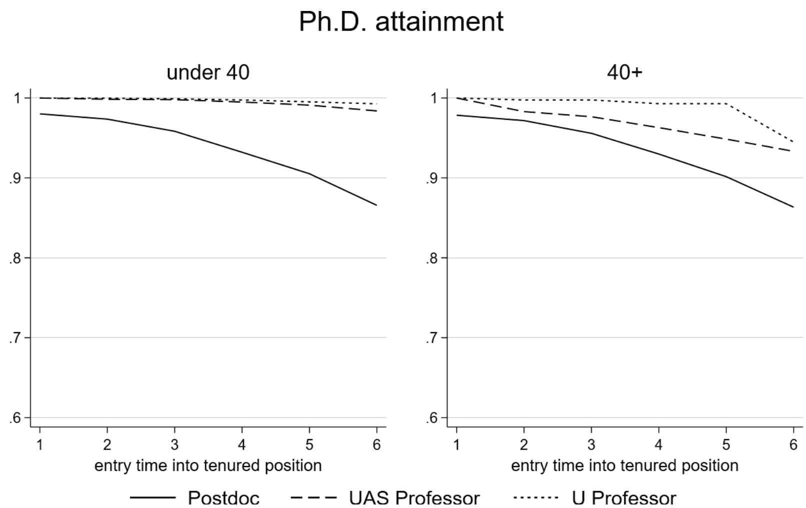
Table 2: Positions in academia, universities of applied sciences, or universities by temporary and tenure (in %)

			PhD attainment	
	N	**Total**	**under 40**	**aged 40+**
Postdoctoral researcher (temporary)	1,228	64.0	65.5	43.5
Postdoctoral researcher (tenured)	605	31.5	30.8	41.2
Professorship UAS	60	3.1	2.5	11.5
Professorship U	26	1.4	1.2	3.8
	1,918	100	100	100

Note: Due to rounding errors, percentages do not always equal 100 %. Chi² = 50.789***.
Source: DZHW PhD Panel 2014 (2014–2020, beta), author's own calculations based on N=1.918.

Over time and increasingly so, more PhD graduates who remain in academia enter a tenured position (see Figure A1 in the Appendix), and after six years, only 31.7 percent remain on temporary contracts. PhD graduates who earned their doctorates aged 40+ transition more quickly to permanent positions after their third year in the academic job market. Less than 2 percent of the original sample remain in nontenured positions at the end of the observation period, while 30 percent of the younger PhD graduates remain untenured at the end of the observation window. However, a potential widening gap between PhD graduates aged 40+ and younger graduates with respect to attaining a permanent position is not underlined by the statistics of the Wilcoxon test (Wilcoxon test=32.7***) which are sensitive to differences at the beginning of the survivor function, and the Log-Rank test (30.6***), highlighting increasing differences over the observation window. Both remain approximately the same but indicate a slight narrowing of the gap.

Figure 2: Survivor function for attaining a tenured postdoctoral research position, a university of applied sciences (UAS), or university (U) professorship by PhD attainment under 40 and aged 40+



Source: DZHW PhD Panel 2014 (2014–2020, beta), author's own estimates based on N=1.918.

However, the faster transition to tenured positions in academia varies between job types. The mapping of the survivor function in Figure 2 illustrates the temporal aspect of the transition of PhD graduates under 40 years old and aged 40+ into a permanent position. The attainment of a professorship at universities of applied sciences is faster for graduates aged 40+ than for those who earned a doctoral degree at a younger age. Two years into their postdoctoral research, more of them have entered tenured professorships at universities of applied sciences. In the latter group of younger PhDs, we see more dynamics once they reach the end of the observation window, that is, six years in academia (see the section on the German academic labor market).

Multivariate: Academic age, biological age, and their relationship with tenure

Bringing together the different variations behind the *biological age* and *academic age* of the PhD graduates and their accumulated resources, we estimate exponential transition rate models with multiple destinations (competing risks) for entry into a tenured position as a postdoctoral researcher, and into a professorship either at universities of applied sciences or universities. In total, 1,918 PhD graduates who remain in academia enter the analysis with 6,719 observations. The results in Table 3 on the left side (unbalanced results) show that we do find an indication of discriminatory age effects over the time frame under observation. However, those effects are only partially expected. When looking at tenured postdoctoral researchers, we find no relationship between *biological age* and attaining a permanent position at this academic level. Not only do those graduates who attained their doctoral degree aged 40+ less often enter a tenured position as postdoctoral researchers, but the time after graduation—their academic age—influences the attainment negatively. Similarly, the attainment of a professorship at a university of applied sciences does not show a relationship with the *biological age* of a person. Finally and under the control of the academic performance indicators, a professorship at a university is more visible for PhD graduates aged 40+, over the first six years after PhD attainment. At the same time, their *academic age* does not increase the probability of attaining a professorship at university.

Furthermore, our results on the left side of Table 3 indicate that academic age—the time that has passed since the doctorate was completed—is filled with academic productivity in the race for tenure; performance indicators such as publications, conference attendance, and writing reviews relate to the attainment of a professorship. In contrast, these activities do not relate to taking up a tenured position as a postdoctoral researcher. This may be due to the imprecise definition of this group, which is based on the data situation and for which no further information is available. For example, scholars in extra-university institutions or scientific employees in science management could fall into this group, potentially offsetting the individual effects. Finally, the time as a doctoral student retains an effect over the PhD grade: a PhD grade lower than the summa cum laude positively influences attaining a tenured position as a postdoctoral researcher.

To sum up, over the first six years following PhD attainment, we find a positive influence for PhD graduates who attained their PhD aged 40+ for entering a professorship at universities. However, as our descriptive and multivariate analyses have shown, the resources of the graduates vary between those who attained a PhD aged 40+ and those who attained it at a younger age. To find out whether there is any sign of a discriminatory age effect or if PhD graduates aged 40+ invest their time in resources that divert them from academia, we apply a methodological trick—entropy balancing—and equalize all distributions of resources and socioeconomic background variables for each academic year. As a result, there is no, or rather a very low, mean difference between the academic resources of PhD graduates aged 40+ and those who are younger (see Appendix Table A3). The weights operationalized in this way allow us to crystallize the residual *biological age effect* in the case of equal starting conditions on entry into the academic career (PhD grade) and the subsequent developments in their academic career. It furthermore minimizes inequalities that might occur due to the gender or migration background of the PhD graduates.

Table 3: Regression results of attaining a tenured position in academia, exponential transition rate models, unbalanced and balanced (in coefficients)

	unbalanced Results			balanced Results		
	Tenured Postdoc	UAS Professor	U Professor	Tenured Post-doc	UAS Professor	U Professor
Biological age 40+ (ref. under 40)	0.179	0.874	1.585*	0.404**	1.942***	0.363
Academic age (ref.: 1 year)						
2 years	-1.070***	16.678	13.974	-0.969***	18.328	16.496
3 years	-0.421**	15.378	13.974	-0.425*	17.267	16.127
4 years	-0.295	16.395	14.180	-0.317*	18.240	17.276
5 years	-0.518**	16.238	14.528	-0.523***	17.871	17.173
6 years	-0.589**	16.391	14.283	-0.547***	18.100	17.413
Women (ref. men)	-0.264**	-0.409	-0.090	-0.494***	-0.196	-1.130
Migration background (ref. none)	0.034	-2.124*	1.527*	0.137	-1.307	4.504*
PhD grade (ref. summa cum laude)						
Magna cum laude	0.290**	-0.286	-0.714	0.558*	-1.364	1.448
Cum laude	0.395**	-0.302	-0.037	0.321	-0.667	0.441
Distance to pre-doctoral degree	0.023	0.091**	-0.034	0.002	0.112*	-0.237
Future in academia	-0.134***	0.025	0.459*	0.016	0.446	-0.755
Publications						
Peer review	-0.007	-0.202	-0.251	0.096	-0.679	-0.409
Other	-0.009	0.484**	0.129	-0.312**	0.692	-0.696
Books	-0.033	0.044	0.535	-0.356	-0.477	3.063*
Conference attendence	0.117	-0.379*	0.263	0.259*	-0.324	0.111
Grant application	-0.041	0.495*	-0.049	0.038	0.255	1.307
Reviews	-0.070	0.085	0.900***	-0.340	0.282	0.654
_cons	-2.014***	-20.541	-23.188	-2.109***	-22.782	-22.495
AIC	3132.651	473.590	218.332	2786.705	411.598	219.896
N		1,918			1,918	

Note: * p<0.05; ** p<0.01; *** p<0.001. Postdoc stands for postdoctoral researcher, UAS stands for university of applied sciences, and U for universities.
Source: DZHW PhD Panel 2014 (2014–2020, beta), author's own estimations based on 6.710 observations.

Turning to the results of the balanced exponential transition rate estimations in Table 3 on the right side (balanced results), we find that the previous effect of the biological age changes its significance. While the *biological age* now relates to becoming a tenured postdoctoral researcher or professor at a university of applied science, there is no significant relationship with being a university professor. We interpret this as a positive discriminatory age effect. PhD graduates aged 40+ bring different resources to the race for tenure that enable them to attain a professorship faster than those who graduated at a younger age from their PhD studies—albeit at universities of applied sciences or as a tenured postdoc. However, biological age does not remain significant for (faster) entry into a university professorship. This effect may occur due to the short duration of six years.[11] Over a longer observation period, younger PhD graduates might offset the resources of those aged 40+ with their 'Habilitation' or 'Juniorprofessur'.

In particular, since academic age has a negative impact on attaining a tenured postdoctoral researcher position, meaning the longer PhD graduates stay in academia, the less likely they are to take up a tenured position as a postdoctoral researcher. The effects of the PhD grade and the performance variables indicate a high degree of selectivity among the group of postdoctoral researchers; over the observed period successful PhD graduates who stay in academia are probably more likely to aim for a professorship than a position as a tenured postdoctoral researcher. However, the group of tenured postdoctoral researchers is very diverse and includes highly competitive researchers who work in extra-university research institutions and those who hold nonacademic positions within universities of applied science or universities. The findings for this group should therefore be treated with caution. Although our main focus was on the different effects of biological and academic age, it is interesting to note two further findings that become apparent when balancing our data. First, the mean differences in the control variables beyond the determinant of age change once they are tailored to the full multivariate model (see Appendix A3); while in the first step, this also underlies the unbalanced multivariate findings, these distributions go beyond the multivariate findings presented above. Younger PhD graduates have greater academic resources than those aged 40+. Especially when looking at their peer-reviewed publications, conference attendances, and grant applications, it becomes clear that they are more active than scholars aged 40+. However, grant applications and conference attendances have no impact on tenure. Books, though, are a different matter. They have a positive effect on the entry into a university professorship. This might indicate potential subject-specific cultures that include the necessity of a 'Habilitation' for a university professorship.

11 Robustness checks based on an exponential model including the academic age as metric and metric^2 term show an increasing influence of the academic age that levels off after time. Additional calculations have shown that the tipping point is approximately 10 years after PhD attainment and therefore not in our observation window.

Finally, a note on the model fit using likelihood ratio tests and comparing the AIC. Looking at the socio-economic background, the PhD grade, and the goal of remaining in science, in addition to biological and academic age increases the goodness of model fit for the risk of attaining a tenured postdoctoral researcher position (LRT=44.44***). However, the academic performance indicators do not increase the model fit (LRT=5.37). This finding is also reflected in the high AIC. To achieve a university of applied science professorship including both socio-economic background and motive (LLT=13.31*) and academic performance indicators (LRT=31.38***) increases the goodness of fit. The same holds for the attainment of a professorship at the university (LRT=30.60*** and 38.40***). These statistics strengthen our argument that the group of tenured postdoctoral researchers should be looked at with caution due to their heterogeneity. Models such as those used are more suitable for estimating the race for tenure at a professorship.

7. Discussion

The central focus of the above paper was the different impacts of the *biological age* and *academic ages* of PhD graduates in reaching a tenured position in academia. We were especially interested in looking at the differences between the importance of the accumulated resources after the doctorate—the productivity of the PhD graduates—as part of the process of aging academically and the implications of the biological age by ways of discriminatory mechanisms. Using data from the DZHW PhD Panel 2014, we first provided a descriptive overview of the differences between younger PhD graduates and those aged 40+ in their retention rate, the resources they gather as they age academically, and the different temporal processes until they enter a tenured position. Secondly, we analyzed the effect of the biological age and academic age along with the socioeconomic background variables, and the resources that PhD graduates attain after graduation on attaining a tenured postdoctoral research position or a professorship at a university (of applied science).

Various findings can be derived from the study. From a descriptive perspective, the resources that graduates accumulate after their doctorate differ by age group and those aged 40+ enter more quickly into tenured positions than do younger PhD graduates. Our multivariate analysis then revealed that age has a subordinate role for tenure during the six years after PhD attainment. However, PhD graduates aged 40+ experience a significantly positive effect on attaining a professorship at a university of applied science or as postdoctoral researcher. PhD graduates aged 40+ are, according to these results, subjected to age discrimination, albeit in a positive way. Their life trajectories into academia and the academic resources they gather there seem to qualify them better than younger PhD graduates for professorships at universities of applied sciences.

Being 40+ years old when starting an academic career does not automatically equate to being ‘over the hill’, that is, not being suitable for tenure in academia anymore, but rather to taking alternative and sometimes even *faster paths to the peak* (tenure). Although the debate about which type of tenure, university vs. university of applied science, is more prestigious is seemingly as old as time, being appointed a professor at a university for applied science has become a valid and often-pursued career track, especially for those older; both in regard to the academic and the biological age. Acquiring life and practical work experience before starting on or parallel to an academic track seems to be something of a competitive advantage for candidates who pursue a career path towards a professorship at a university of applied science, probably as they are more likely to fulfil the practical experience requirements. In addition, our data suggest that instead of aiming to become a professor, a tenured position as a postdoctoral researcher, close to research but outside of the junior faculty system, is also proving to be a good alternative for achieving tenure. It should be noted, however, that not much is known about the group of tenured postdoctoral researchers and what the working conditions and career development opportunities in these jobs are.

In addition, when we look at these different academic tracks, we find a notion of track-specific publication cultures. Whereas writing a book will foster an academic career toward a professorship at the university, there is no clear pattern for appointments as professor at a university of applied science. This publication culture—if unknown to an aspiring scholar—can become a hindrance when climbing the academic ladder if, for example, a scholar has a personal preference for one specific track, but their publication record does not align with the track-specific publication culture apparent in our study. Furthermore, it could be argued that publication cultures that favor specific publication types (e.g., peer-reviewed papers over books or edited volumes) might disadvantage scholars from disciplines or areas of research where either those publication types or outlets to publish them are less common, or the resources to produce them are less available.

The study has various limitations. First, our dataset represents a specific subset of the German academic labor market and is insufficient to investigate those who work in extra-university research. While PhD graduates from extra-university research institutions are sampled in the DZHW PhD Panel 2014, the questionnaire does not reflect the opportunities for careers within these institutions. As scholars and research output from these research institutions have become an essential pillar of German academia (Powell/Dusdal 2017), it is crucial to investigate and better understand academic career pathways and their associated working conditions within these organizations. Second, the study focuses on selected scientific outputs and does not go into much detail with respect to the disciplinary details or life trajectories that foster the attainment of a professorship at universities (of applied sciences). Prospective research could benefit from investigating whether different clusters of academic productivity emerge during the race for tenure and how discipline-specific publication cultures and the achievement of an academic with respect to third-party funding or participation in administrative tasks ('Gremienarbeit') could affect tenure. Third: The family contexts and work-study-work trajectories of PhD graduates could shine light into the mechanisms of attaining tenure. Although the DZHW PhD panel currently covers the longest period after doctoral attainment in Germany, the period is still not long enough to reflect delays caused, for example, by parental leave or by appointment processes. Further research on a temporary position in science is needed once the data has matured further. Finally, it should be recognized that the described inequalities—be it on the basis of gender, migration background, or age—should not be seen as separate cleavages but as linked to one another. The low number of PhD graduates aged 40+ prevents an in-depth analysis of these intersectional inequalities. However, with better data, future research should focus on a more intersectional perspective to gain a more conclusive picture of the obstacles (older) scholars might face when racing for tenure.

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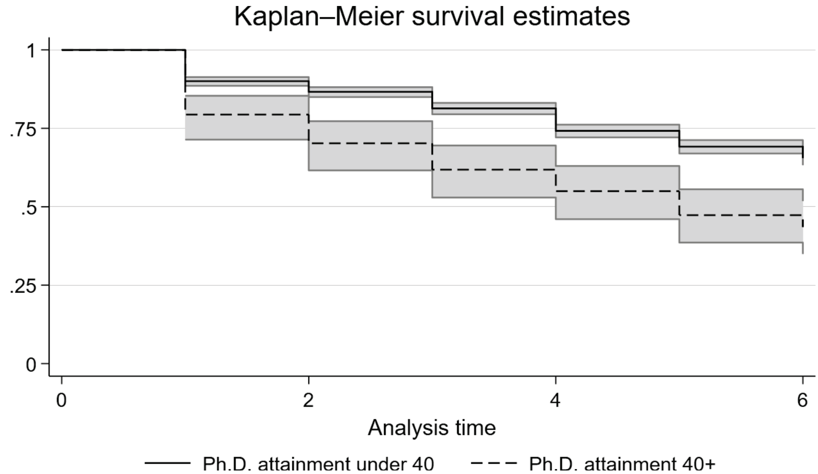
Online-Appendix

Figure A1: Product limit estimation (Kaplan-Meier) of remaining in a temporary position in academia by PhD attainment under 40 and 40+



Source: DZHW PhD Panel 2014 (2014–2020, beta), author's own estimation based on N=1.918.

Table A1: Overview of legal age limit to attain a professorship by German state

Federal state	Age limit	Legal act
Baden-Württemberg	47, 52 if previously employed as civil servant	Landeshaushaltsverordnung § 48.2 and § 48.5
Bavaria	52, exception in special cases	Article 10 Bayrisches Hochschulpersonalgesetz
Berlin	50	§ 53.5 Gesetz über die Hochschulen im Land Berlin
Brandenburg	50	§ 43.3 Brandenburgisches Hochschulgesetz
Bremen	55 exception possible	§ 48.1,2 Landeshaushaltsordnung
Hamburg	50	Letter from the University of Hamburg regarding the age limit of professors
Hessia	50 exceptions until age of 60	§ 11 HLV Hessische Laufbahnverordnung
Mecklenburg-Vorpommern	50	§ 117 Beamtengesetz für das Land Mecklenburg-Vorpommern
Lower Saxony	50	§ 27.2 Niedersächsisches Hochschulgesetz
North Rhine-Westphalia	50	§ 39.a Gesetz über die Hochschulen des Landes Nordrhein-Westfalen
Rhineland-Palatinate	50	§ 1 Landesverordnung über die Höchstaltersgrenze für die Berufung von bestimmten Hochschulbediensteten in ein Beamtenverhältnis auf Lebenszeit
Saarland	55	§ 49 Saarländisches Hochschulgesetz

Federal state	Age limit	Legal act
Saxony	52	§ 7 Abs. 1 Sächsisches Beamtengesetz, § 1 Altersgrenzenverordnung
Saxony-Anhalt	52	§ 8a Landesbeamtengesetz
Schleswig-Holstein	52	§ 48.1 Gesetz über die Hochschulen und das Universitätsklinikum Schleswig-Holstein
Thuringia	52	§ 97.7 Thüringer Hochschulgesetz

Source: Author's own compilation of state laws.

Table A2: Descriptive statistics from the (pooled) estimation samples 2014–2020 by PhD attainment under 40 and 40+ (mean (SD)/rel. freq.)

Variables	N	total	PhD attainment	
			under 40	40+
Making a career in science	6,719	3.1 (1.23)	3.1 (1.2)	3.1 (1.1)
Sex				
Men	3,336	49.7 %	50.1 %	43.4 %
Women	3,383	50.4 %	49.9 %	56.7 %
Migration background				
No	6,086	90.6 %	90.8 %	9.2 %
Yes	633	9,4 %	87.4 %	12.6 %
PhD grade				
Summa cum laude	2,168	32.3 %	33.3 %	17.2 %
Magna cum laude	3,895	58.1 %	58.2 %	55.4 %
Cum laude/satis bene	547	9.6 %	8.5 %	27.4 %
Time distance to predoctoral degree	6,719	1.8 (3.0)	1.4 (1.8)	8.9 (6.4)

Note: Variables described in the section 'Findings' are not included in this table.
Source: DZHW PhD Panel 2014 (2014–2020, beta), author's own estimation based on N=1.918.

Table A3: Summary of conditioning variables by PhD attainment under 40 and 40+ (Example for wave 6)

	Mean		Mean Difference	Mean under 40*
	under 40	aged 40+		
Women (ref. men)	1.518	1.649	0.131	1.628
Migration background (ref. no migration background)	1.090	1.081	-0.009	1.083
PhD grade (ref. summa cum laude)				
Magna cum laude	0.337	0.243	-0.094	0.256
Cum laude	0.585	0.541	-0.044	0.540
Future in academia	3.080	3.108	0.028	3.112
Publications				
Peer review	2.138	2.042	-0.096	2.064
Other publications	0.925	1.722	0.797	1.638
Books	0.157	0.339	0.182	0.322
Conference attendence	2.384	2.489	0.105	2.485
Successful grant application	0.554	0.491	-0.063	0.501
Reviews	1.084	1.163	0.079	1.165
N		6,710		

Note: Presented means differ from the descriptive findings in Table 2 since this analysis was restricted to the full multivariate model. *after entrophy balancing.
Source: DZHW PhD Panel 2014 (2014–2020, beta), author's own estimation based on N=1.918.

Knut Petzold[*] and Nicolai Netz[**]

How do signals of academic performance vary across disciplines?

Evidence from a survey experiment with university professors in Germany

Abstract: While recent research has investigated what signals of academic performance govern academics' access to professorships, whether the power of such signals varies across disciplines has to date hardly been examined. We argue that the signaling power of academic achievements depends on the discipline-specific degree of standardization of research and on the spatio-temporal universality of research objects. Using a factorial survey experiment with Germany-based university professors of German studies, selected social sciences, and chemistry, we investigate the suitability of fictitious candidates for a tenured professorship ($N_{respondents} = 874$, $N_{vignettes} = 6354$). Across disciplines, we find that professors consider conventional academic achievements, such as the formal qualification, publications, and teaching experience to be of primary importance. Rather novel academic achievements, such as international experience and connectivity, are considered to be less important – except for citations. Cross-level interaction analyses based on the responding professors' discipline reveal that the formal qualification is valued most in German studies and least in chemistry. For third-party funding, we find the opposite pattern. International publications and citations are similarly important in the social sciences and in chemistry, but less important in German studies. Teaching experience is rewarded equally in all disciplines. In sum, our study provides first systematic evidence of how the signaling power of academic achievements varies across the humanities, social, and natural sciences.

Keywords: academic career success, professorship, qualification, signaling theory, factorial survey, vignette study

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Inwiefern variiert die Signalkraft akademischer Leistungen nach Disziplinen?

Ergebnisse eines Survey-Experiments mit Universitätsprofessorinnen und -professoren in Deutschland

Zusammenfassung: Während weitgehend bekannt ist, welche Kriterien den Zugang zu einer Universitätsprofessur beeinflussen, wurde bislang nicht systematisch untersucht, wie sich die Signalkraft akademischer Leistungen nach Fachdisziplinen unterscheidet. Wir argumentieren, dass die Signalkraft akademischer Leistungen von der disziplinspezifischen Standardisierung des Forschungsprozesses sowie der raumzeitlichen Universalität der Forschungsgegenstände abhängt. Mithilfe eines faktoriellen Surveyexperiments unter Professorinnen und Professoren der Germanistik, ausgewählter Sozialwissenschaften und der Chemie untersuchen wir die eingeschätzte Eignung von fiktiven Kandidatinnen und Kandidaten für eine unbefristete Professur ($N_{Befragte}$ = 874, $N_{Vignetten}$ = 6354). Die Ergebnisse zeigen, dass konventionelle akademische Leistungen, wie die formale Qualifikation, Publikationen und Lehrerfahrung in allen Fachdisziplinen von hoher Bedeutung für die Eignung für eine Professur sind. Hingegen sind neuere akademische Leistungen, wie internationale Erfahrungen und Kooperationen weniger wichtig – mit Ausnahme von Zitationen. Cross-Level-Analysen auf Basis der Fachdisziplin der befragten Professorinnen und Professoren verdeutlichen, dass die formale Qualifikation in der Germanistik am wichtigsten und in der Chemie am wenigsten wichtig ist. Hinsichtlich der Bedeutung von Drittmitteln zeigt sich das umgekehrte Muster. Internationale Publikationen und Zitationen sind sowohl in den Sozialwissenschaften als auch in der Chemie bedeutsam, weniger jedoch in der Germanistik. Lehrerfahrung wird in allen Disziplinen gleichermaßen honoriert. Insgesamt liefert die Studie erste systematische Belege für die unterschiedliche Signalkraft akademischer Leistungen in den Geistes-, Sozial- und Naturwissenschaften.

Stichworte: Akademischer Karriereerfolg, Professur, Qualifikation, Signaltheorie, faktorieller Survey, Vignettenstudie

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1. Introduction

From the perspectives of the sociology of education, labor markets, and science, it is highly relevant to understand the criteria that allow academics to become professors. While recent research has made great progress in identifying criteria that govern access to professorships, it has not yet sufficiently examined how the value attached to specific signals of academic performance varies across academic disciplines.

Several studies set out to identify the major criteria that influence access to professorships within single academic disciplines. The disciplines examined include political science (e.g., Habicht et al. 2021; Plümper/Schimmelfennig 2007; Schröder et al. 2021), sociology (e.g., Lutter/Schröder 2016), psychology (e.g., Abele-Brehm/Bühner 2016; Lang/Neyer 2004), economics and business administration (e.g., Schulze et al. 2008), life sciences (e.g., Jonkers 2011), and biology (e.g., Lawson/Shibayama 2015). Further studies cover several disciplines (e.g., Auspurg et al. 2017; Carlsson et al. 2021; Ceci 2018; Ceci/Williams 2015; Cruz-Castro/Sanz-Menéndez 2010; Filandri/Pasqua 2021; Gross et al. 2008; Jungbauer-Gans/Gross 2013; Sanz-Menéndez et al. 2013; Weisshaar 2017; Williams/Ceci 2015). However, most of the latter studies concentrate on differences in the odds of attaining a professorship contingent on the academic discipline. While they occasionally touch upon disciplinary differences in the relevance of specific determinants of gaining a professorship, most notably regarding the publication record, they do not focus on such disciplinary differences. In particular, they tend not to develop and test plausible theoretical explanations for potential disciplinary differences in the signaling value of specific academic achievements.

Previous research has also not sufficiently acknowledged that career success in academia does not depend solely on the characteristics of candidates for professorships. Rather, other academics in gatekeeping positions—usually professors—evaluate candidates for professorships depending on their own background, and thereby produce discipline-specific logics and traditions in academic career success.

Moreover, we argue that societal developments have gradually changed the relevance of the criteria that make academics suitable for professorships. In addition to *conventional academic achievements*, such as the formal qualification, the publication record, and teaching experience, *novel academic achievements* have gained importance, such as third-party funding (Abele-Brehm/Bühner 2016; Lawson/Shibayama 2015; Schröder et al. 2021) as well as international mobility, connectivity, and visibility (Geuna 2015; Hamann/Zimmer 2017; Netz et al. 2020).

As elaborated in the theory section, both conventional and novel academic achievements can be theorized as signals of academic performance. They should display the suitability of potential candidates for professorships in all academic disciplines. However, the signaling power of these achievements is likely to vary across disciplines. The literature on disciplinary academic cultures illustrates that disciplines differ regarding the degree of standardization of research and regarding the spatio-temporal universality of the research objects under investigation (Becher 1994; Biglan 1973; Simpson 2017). In the humanities, for example, research usually focuses on specific epochs and regions, so that study designs are less standardized. Conversely, the natural sciences examine more general research objects, which concern the entire natural world. Therefore, they tend to follow highly standardized criteria for assessing scientific quality. Consequently, the signaling power of formally similar academic achievements may well differ across academic disciplines.

Previous (quantitative) studies on access to professorships also have methodological shortcomings. They typically rely on survey data that describe the careers of academics (e.g., Jungbauer-Gans/Gross 2013; Plümper/Schimmelfennig 2007; Schulze et al. 2008), register data of academics (e.g., Lang/Neyer 2004), information from public websites (e.g., Habicht et al. 2021; Lutter/Schröder 2016; Schröder et al. 2021), or processual data from appointment committees (e.g., Auspurg et al. 2017). Data from such observational studies (Rosenbaum 2010) often suffer from potential endogeneity bias, which results from self-selection of the examined individuals into the sample. They are also characterized by confounder problems resulting from unobserved heterogeneity between the examined individuals, implying that the possibilities of causal inferences are limited (Rubin 2008). Some studies also apply experimental designs to investigate access to academic positions, and therefore do not suffer from these problems. However, their research focus differs from ours in that the designs are used to study gender effects in particular (Carlsson et al. 2021; Ceci 2018; Ceci/Williams 2015; Solga et al. 2023; Williams/Ceci 2015).

Against this background, we examine access to professorships using a factorial survey experiment administered to Germany-based university professors of German studies, selected social sciences (political science and sociology[1]), and chemistry. To each professor, we randomly presented fictitious candidates for professorships, thereby varying different ascriptive and meritocratic characteristics, i.e., gender, the formal qualification, publications and citations, teaching experience, third-party funding, international mobility experience, and cross-border cooperation experience. We measured professors' judgments of the suitability of the presented candidates for tenured professorship at a German university. Due to our design, we can estimate both unbiased direct effects of the candidates' characteristics and cross-level interaction effects with the responding professors' discipline. Based on this design, we can compare the signaling power attributed to major academic achievements across exemplary disciplines of the humanities, social sciences, and natural sciences.

1 Our survey also targeted professors of geography, which we did not include in this analysis because geography comprises very different disciplinary cultures, making it hard to compare to sociology and political science, which are more homogeneous in many respects.

We proceed by developing theoretical thoughts on why the value of the discussed signals of academic performance should vary across the exemplary academic disciplines. Thereafter, we elaborate on our factorial survey design, the sample of responding professors, and the estimation methods. We then present our empirical results, before discussing the main contributions, limitations, and implications of our study.

2. The discipline-specific value of signals of academic performance

Academic performance is characterized by the fact that new knowledge is generated and disseminated. While research areas, paradigms, theoretical approaches, research methods, and resources differ substantially across disciplines, the processes of knowledge generation and dissemination are generally characterized by contingency, which academics need to deal with productively. In our view, academics' skills and abilities to cope with this contingency determine their academic performance. Such skills and abilities include, for example, intelligence, creativity, a systematic way of working, diligence, and resilience. Yet, academic performance is not only reflected in the research output itself, but also in its reception by other academics, and in academics' ability to build networks and collaborate with others. Professional contacts not only reflect integration into the scientific community, but may also generate important resources (e.g., Granovetter 1973; Lin 1999). Such resources can, in turn, increase academic performance. While a positive reception is more likely when academics are innovative and attract attention, establishing networks requires, for example, communication skills, trustworthiness, and loyalty.

When it comes to evaluating candidates' suitability for a professorship, the evaluators are interested in precisely such qualities of potential candidates. The suitability for a professorship should thus be the greater, the stronger an academic's performance is. However, such qualities are not easily directly observable, if at all.

In this context, signaling theory addresses the fundamental communication problem of how a receiver (in our case a professor) can establish whether a sender (candidate for a professorship) is telling the truth about his or her qualities, and, relatedly, how a sender can persuade the receiver that he or she is telling the truth. To this end, a connection is established between the sender's unobservable traits and his or her observable features. Since the inception of signaling theory in labor economics, the primary quality to be displayed refers to an employee's productivity (Akerlof 1970; Bills 2003; Bills et al. 2017; Spence 1973; Stiglitz 1975). However, the behavioral and social sciences have further developed signaling theory to include features beyond an individual's productivity (e.g., Podolny 2005; Posner 2000; Searcy/Nowicki 2005). From a broader point of view, any feature intentionally displayed for the purpose of convincing a receiver of a sender's desired quality can thus be considered a signal (Gambetta 2009).

In the present study, displayed signals refer to qualities upon which the candidate's academic performance rests. It is in the interests both of candidates with the desired qualities and of professors that these qualities are truthfully displayed. From the perspective of signaling theory, the solution is that only those candidates with specific qualities will try to signal them through observable properties, provided that the signals are cheap enough for candidates possessing such qualities to acquire and emit, but too costly for those candidates without them. In this framework, academic achievements meet the essential requirements needed to function as signals of academic performance: In a perfectly separating case, all candidates with the unobservable traits will be divided from those without them by being able to emit signals of academic performance (separating equilibrium). Conversely, if both candidates with and without the qualities of interest, or none of these groups, can afford to acquire and emit the signals of academic performance, they become uninformative (pooling equilibrium). Finally, if a certain proportion of the non-quality candidates emits the signal in addition to the quality candidates, the signals do not conclusively reflect the qualities in question (semisorting equilibrium).

However, what counts as a signal and what makes it more or less costly for different types of senders depends on the specific context (Gambetta 2009): The power of signals is not only determined by the cost of acquiring them but also by the normative systems of the senders and receivers. Successful signals are constrained by what is accepted by tradition. In this regard, it is necessary to consider the domain—and in our case the scientific discipline—in which signals are acquired, displayed, and received.

Based on the literature on disciplinary academic cultures (Becher 1994; Biglan 1973; Simpson 2017), we therefore argue that the power of signals is likely to vary across academic disciplines. In our analysis, we consider German studies, sociology and political science, and chemistry as specific representatives of the humanities, the social sciences, and the natural sciences.

As elaborated in the introduction, we distinguish between conventional and novel academic signals of academic performance.

2.1. Conventional signals of academic performance

2.1.1. Qualifications

Completing an academic qualification process is a well-established signal of academic performance. Importantly, disciplines differ in the degree of standardization regarding how research is conducted (Biglan 1973; Simpson 2017): While there is a high level of agreement on standardized criteria for assessing scientific quality in the natural sciences, the social sciences are characterized by a greater variety of epistemological paradigms. Research in the humanities is comparatively object-oriented, so that the assessment of scientific quality depends more on relevant experts in the research field, who make their evaluations with respect to research objects within formal qualification procedures.

Relatedly, the natural sciences are more internationally oriented, so that the signaling power of country-specific formal qualifications might be comparatively weak in this discipline—even if they are assessed in the country where they were acquired. For instance, a habilitation, which is uncommon in many countries, is likely to have a much lower signaling power in the natural sciences than in other disciplines.

Following these arguments, we assume that formal qualifications should have the strongest signaling power in German studies, followed by the social sciences, and then by chemistry (hypothesis 1).

2.1.2. Publication record

Scientific publications are a core signal of academic performance (Habicht et al. 2021; Jungbauer-Gans/Gross 2013; Long et al. 1993; Lutter/Schröder 2016; Sanz-Menéndez et al. 2013; Schulze et al. 2008). They are an essential part of the academic production process and usually the result of a successful research process, which requires qualities related to academic performance. Therefore, a high level of publication activity should serve as a signal of academic performance in all disciplines. As the signaling value might depend on the type of publication, we differentiate between German and international publications in our empirical analysis.[2]

Research in German studies usually focuses on specific epochs and regions within the German-speaking cultural context. Research in chemistry, by contrast, is typically quite universal, so that research laboratories around the world work on similar research questions. The social sciences comprise research fields that can be defined as regional and epochal as well as universal, in that they sometimes also concern the entire humanity (Becher 1994; Biglan 1973; Simpson 2017).

Accordingly, we assume that the signaling value of German publications is strongest in German studies, moderate in the social sciences, and weakest in chemistry (hypothesis 2a). In contrast, international publications should have most signaling value in chemistry, a moderate value in the social sciences, and least value in German studies (hypothesis 2b).

2.1.3. Teaching experience

In addition to research, teaching is a core task of professors at German universities. The ability to communicate theoretical approaches, methods, and findings to students and doctoral candidates and to integrate insights from current research into teaching represents a separate area of academic performance. Because teaching is

2 For disciplinary comparisons, it would also be relevant to compare the relative signaling power of different numbers of publications, publication quality, and publications formats, e.g., books versus journal articles. As we did not consider these dimensions in our experimental design for practical reasons, they will have to be considered in further research.

essential for maintaining any discipline, we do not expect any differences in the signaling value of teaching experience between disciplines (hypothesis 3).

2.2. *Novel signals of academic performance*

2.2.1. Third-party funding

Scientific activities are always associated with financial costs, which require funds. Nowadays, funds are increasingly being awarded to researchers through competitive procedures. Researchers must apply for third-party funding and their proposed projects are critically assessed to ensure scientific quality. Third-party funding thus requires a high degree of academic performance. In that sense, third-party funding is another signal of academic performance (Habicht et al. 2021; Schröder et al. 2021).

Importantly, disciplines differ in terms of the degree to which high-quality research depends on costly research infrastructure and technical equipment (Becher 1994; Biglan 1973; Simpson 2017): Research in the natural sciences is highly dependent on research infrastructure and technical equipment, whereas in the humanities, researchers mainly need access to their primary objects of investigation, which are increasingly available online. In the social sciences, large-scale data collection may require substantial funding, but large parts of social science research can also be carried out with small samples, or even without any empirical design, and therefore entail a comparatively low financial burden.

We therefore expect the strongest signaling effect of third-party funding in chemistry, followed by the social sciences, and the weakest effect in German studies (hypothesis 4).

2.2.2. International mobility, connectivity, and visibility

International mobility, connectivity, and visibility are also associated with academic performance (Cruz-Castro/Sanz-Menéndez 2010; Franzoni et al. 2014; Netz et al. 2020). Stays in another country are costly in terms of the monetary, organizational, social, and psychological burdens. Yet, the returns include the acquisition of specialized knowledge and new contacts, which can promote research activities and output (Aman 2020; Geuna 2015). Therefore, experiences and characteristics related to international mobility and connectivity may also represent signals of academic performance.

As already discussed, the importance of internationality may depend on the spatio-temporal universality of research objects, and therefore vary across disciplines: The natural sciences tend to have universal research objects, while German studies tend to focus on research objects in German-speaking countries, and the social sciences are both universally and locally oriented.

We therefore assume that stays abroad (hypothesis 5a) and contact with scientists in other countries (hypothesis 5b) have the strongest signaling value in chemistry, followed by the social sciences, and the weakest signaling value in German studies.

Besides a high publication activity, international mobility and cooperation also tend to promote international visibility. Scholars who are internationally mobile and visible are likely to create new network ties, which are then likely to cite the work of the newly acquainted colleagues (Franzoni et al. 2014; Netz et al. 2020; Petersen 2018). Citations, in turn, can be important signals of academic performance for gaining access to professorships (Baruffaldi et al. 2020; Schröder et al. 2021). Following the same reasoning as with stays and contacts abroad, we assume that citations in German and in international publications have a different signaling value across disciplines.

In detail, we hypothesize that a high number of citations in German publications are the strongest signal in German studies, followed by the social sciences and chemistry (hypothesis 6a). For a high number of citations in international publications, we expect the inverse pattern (hypothesis 6b).

3. Data and methods

Unlike most previous studies, we test our hypotheses using a factorial survey experiment (Auspurg/Hinz 2015; Jasso 2006; Rossi/Anderson 1982). Following this approach, the values (levels) of experimental treatment conditions (dimensions) are systematically varied in the descriptions of hypothetical situations or persons (vignettes). In our full experimental design (vignette universe), all vignette dimensions are balanced, orthogonal, and thus not correlated amongst each other. To avoid the vignette dimensions being correlated with the respondents' own characteristics, the vignettes are randomly assigned to the respondents.

In our study, we have randomly presented fictitious candidates for professorships to professors at German universities to measure their judgments of the presented candidates' suitability for a tenured professorship at a German university. Due to the experimental design, we can estimate unbiased direct effects of the candidates' characteristics and their interaction with the responding professors' own characteristics, including their disciplinary affiliation (for details on the potentials and pitfalls of this design see Petzold/Netz 2022).

With a few exceptions (Carlsson et al. 2021; Ceci 2018; Ceci/Williams 2015; Solga et al. 2023; Williams/Ceci 2015), most previous studies on success in the German academic system used survey data on the careers of academics (e.g., Jungbauer-Gans/Gross 2013; Plümper/Schimmelfennig 2007; Schulze et al. 2008), information from literature data bases and handbooks of academics (e.g., Lang/Neyer 2004), career and publication data available on public websites (e.g., Habicht et al. 2021; Lutter/Schröder 2016; Schröder et al. 2021), or processual data from appointment committees (Auspurg et al. 2017). Other studies used qualitative research designs (Gross et al. 2008), thereby following different methodological foundations than quantitative studies. The advantages of such non-experimental data are that they provide information on real-world situations and, in the case of processual data, that they are non-reactive.

However, most studies using non-experimental data suggest that academics who eventually win a professorship differ in many unobserved characteristics from those who do not, so that the candidates' meritocratic and ascribed traits are probably confounded. For instance, there is evidence that academic achievements correlate with the size and nature of personal networks (Gross/Jungbauer-Gans 2007; Lang/Neyer 2004). Moreover, the characteristics of candidates and of their employing institutes can correlate due to the self-selection of candidates into specific appointment procedures for professorships (Auspurg et al. 2017). Due to problems of unobserved heterogeneity and potential endogeneity bias when using observational studies (Rosenbaum 2010), causal inferences are typically associated with a higher degree of uncertainty (Rubin 2008). We address this issue by using an experimental design that already minimizes unobserved heterogeneity bias during data collection (Jackson/Cox 2013).

Former studies also neglect the fact that academic success results from an interaction of the candidates' signals of academic performance and their evaluation through other academics. Studies focusing on candidates' characteristics tend to capture the evaluations of other relevant academics only indirectly (except for Gross et al. 2008, who conducted expert interviews with academics). By contrast, a factorial survey experiment enables a direct and detailed investigation of professors' judgments of candidates' suitability for a professorship. The weights attributed to candidates' academic achievements can be estimated directly and independently from each other. Importantly, the survey experiment does not suffer from a survivor bias, as it generates data on the fictitious candidates independently of whether they are eventually considered suitable for a professorship or not. For these reasons, our experimental design produces results with a high internal validity (Mutz 2011).

3.1. Experimental design

To avoid overly complex decision situations, factorial surveys can only consider a limited number of influencing factors. Still, the presented vignettes should contain enough information to capture the theoretically most relevant factors influencing the respondents' judgements (Auspurg/Hinz 2015).

Based on the results of previous studies on academic career success (Abele-Brehm/Bühner 2016; Baruffaldi et al. 2020; Cruz-Castro/Sanz-Menéndez 2010; Jungbauer-Gans/Gross 2013; Lang/Neyer 2004; Lutter/Schröder 2016; Sanz-Menéndez et al. 2013; Schulze et al. 2008; Williams/Ceci 2015), we varied the characteristics of the fictitious candidates across ten dimensions, which comprised between two and four levels (Table 1). In detail, we varied the type of formal qualification[3], the relative number of German and international publications, and teaching experience as conventional academic achievements. In order to capture more novel academic achievements, we further considered third-party funding, international mobility experience during the PhD and the postdoc period, contact with scientists abroad, and the relative number of citations in German and in international publications.[4]

In order to help the responding professors evaluate the fictitious candidates and increase the explanatory power of our results, we fixed some relevant pieces of information in the vignette introduction. First, we asked the respondents to assess the fictitious candidates only on the basis of the information provided. Second, respondents had to evaluate the candidates' general suitability for a tenured professorship, independently of their fit with a concrete vacant position. Third, we made clear that we were interested in the suitability for a tenured professorship with an average infrastructure at a German university in the respondents' own discipline. Finally, we clarified that German publications mainly target a readership in Germany, while international publications target a readership both in Germany and abroad.

The product of the number of all levels of all dimensions (Cartesian product) reflects the maximum number of unique vignettes (vignette universe). With n = 8,192, the size of the vignette universe clearly exceeded the number of vignettes that we could present to the responding professors. Therefore, we drew a D-efficient sample of 200 vignettes (D-efficiency = 98.00). To do so, we used the modified Federov search algorithm, which sustains maximal orthogonality and level balance of all dimensions (Atzmüller/Steiner 2010; Dülmer 2016). In our sample, all vignette dimensions were very well balanced (Table 1) and nearly zero-correlated (Table A1 in the appendix). Also based on the algorithm, we blocked the selected vignette sample into 25 decks with eight vignettes each. Deliberate blocking allowed us to optimally balance the levels even within each deck, helping us to obtain true instead of random differences between respondents (Dülmer 2016). Finally, we presented each respondent with a deck based on a random selection with a random order of the eight vignettes.

3 The methodological literature suggests that dimensions varying on many levels may attract more attention-biasing responses (Verlegh et al. 2002). We must therefore take into account the possibility of such a number-of-levels-effect regarding the dimension of formal qualifications, which is the only dimension comprising four levels.

4 We also varied the ascribed characteristic of candidates' gender. However, we did not consider candidates' gender in this study because the underlying mechanisms of group-based stereotyping and discrimination differ from the mechanism of performance-related meritocracy, which are relevant for academic performance. In order to reduce the complexity of our analyses and due to its subordinate empirical relevance, we also did not include the dimension of international mobility during studies in our analyses.

Table 1 Variation of fictitious candidates' characteristics on dimensions and levels

Treatments	Frequencies	Percent
Conventional academic achievements		
Qualification		
None of the mentioned	1605	25.26
Junior professorship (evaluated)	1579	24.85
Habilitation (postdoctoral qualification)	1601	25.20
Non-tenured associate (W2) professorship	1569	24.69
Publications (German)		
Low number of German publications	3178	50.02
High number of German publications	3176	49.98
Publications (international)		
Low number of international publications	3178	50.02
High number of international publications	3176	49.98
Teaching experience		
Little teaching experience	3203	50.41
Much teaching experience	3151	49.59
Novel academic achievements		
Third-party funding		
Little third-party funding	3168	49.86
Much third-party funding	3186	50.14
International experience during the PhD		
PhD gained in Germany	3179	50.03
PhD gained abroad	3175	49.97
International experience during the postdoc		
Postdoc gained in Germany	3193	50.25
Postdoc gained abroad	3161	49.75
International networks		
Contact with few scientists abroad	3188	50.17
Contact with many scientists abroad	3166	49.83
Citations (German)		
Low number of citations in German publications	3148	49.54
High number of citations in German publications	3206	50.46
Citations (international)		
Low number of citations in international publications	3173	49.94
High number of citations in international publications	3181	50.06
$N_{vignettes}$	6354	100.00

Data source: SciMo Survey of Professors (2018).

We implemented our factorial survey experiment using an online questionnaire (CAWI), which provided advantages over paper-based surveys regarding the random assignments and ordering of the vignettes, the recruitment of respondents (e.g., for the invitation and reminders) and convenient questionnaire completion (e.g., by enabling completion after breaks).

As Figure 1 illustrates, we asked respondents to answer the following question: "To what extent is the described person suited for a tenured professorship in your discipline at a German university?" We captured the respondents' assessment on a 9-point scale without previously specified values, as recommended in methodological literature (Sauer et al. 2011). The scale ranged from "totally unsuitable" (-4) to "totally suitable" (4). Although we captured respondents' assessment regarding both associate (W2) and full (W3) professorships, we focus on full professorships in this analysis.[5]

Figure 1 Vignette example

DZHW.

Inwiefern eignet sich die beschriebene Person in Ihrem Fachgebiet für eine unbefristete Professur an einer deutschen Universität?

- **Wissenschaftlerin mit Habilitation**
- Studium **in Deutschland,** Promotion **im Ausland,** Post-doc **in Deutschland**

- Hat **wenige** deutsche / **viele** internationale Publikationen
- Wird **selten** in deutschen / **selten** in internationalen Publikationen zitiert

- Hat **wenig** Lehrerfahrung
- Hat **wenige** Drittmittel eingeworben
- Verfügt über Kontakte zu **vielen** Wissenschaftler*innen im Ausland

Eignung für eine ...

	vollkommen ungeeignet -4				0				vollkommen geeignet 4
... W2-Professur?	○	○	○	○	○	○	○	○	○
... W3-Professur?	○	○	○	○	○	○	○	○	○

Achtung: Wenn Sie "Zurück" und dann "Weiter" klicken, stellen wir Ihnen ggf. eine neue Person vor.

Source: SciMo Survey of Professors (2018).

5 Sensitivity analyses show that our results are very similar for both types of professorships.

3.2. Sample of professors

The survey of professors was part of the project “Determinants and career effects of scientists’ international mobility” (SciMo). This project was administered by the German Centre for Higher Education Research and Science Studies (DZHW) and funded by the German Federal Ministry of Education and Research (BMBF) between 2016 and 2019. The main goal of the SciMo project was to examine factors influencing scientists’ international mobility and the effects of international mobility on scientists’ careers (for details see Netz 2020). However, the survey of professors was not restricted to the analysis of international mobility, but designed in such a way as to allow for broad conclusions on the relative importance of major factors influencing access to tenured professorships.

We strove for a total survey of all professors of German studies, political science, sociology, geography, and chemistry at universities in Germany. To determine this population and its composition, we used statistical information on university staff provided by the German Federal Statistical Office, which we cross-validated using data from a student information portal (studium.org). According to these sources, the population of all professors in the selected disciplines consisted of 2729 professors in the summer semester of 2018, all of whom were invited to take part in an online survey entitled “Who is suitable for a professorship?”.

Data collection took place between August and October 2018. We sent out three e-mail reminders, at one week, four weeks, and six weeks after the initial invitation. All responding professors gave their full and explicit informed consent to participate in the anonymous survey. The questionnaire was accessed by 1162 professors (42.6 percent) and completed by 894 of them (32.8 percent). This response rate can be considered very satisfying, taking into account that highly educated individuals with highly demanding occupations are typically underrepresented in surveys and that response rates in online surveys are usually comparatively low (see also Jungbauer-Gans/Gross 2013).

In the present analysis, we only include professors of German studies, sociology, political science, and chemistry to better account for the discipline-specific standards and to be able to investigate effects for clearly demarcated disciplines. As already explained in footnote 1, we do not include professors of geography for these reasons. Considering their many similarities, we include professors of sociology and political science in a joint category for the social sciences. Overall, 6,354 fictitious candidates were judged by 874 professors of these disciplines, including those who did not complete the entire questionnaire.[6]

6 Thirty-one respondents evaluated only one out of the eight vignettes. One hundred and forty-two respondents evaluated between two and seven vignettes (2: 23, 3: 20, 4: 14, 5: 14, 6: 14, 7: 57). Seven hundred and one respondents made evaluations of all eight vignettes of their deck (including 10 respondents we classified as satisfiers as they gave exactly the same ratings across the entire deck of vignettes). In this regard, M4 in Table A3 provides a robustness check.

Besides the address data needed for inviting the professors to our survey, we collected data from the invited professors' CVs as a supplement to the information gathered through the questionnaire. The collected CV data include information on professors' gender, year of birth, type of professorship, current university, year of obtaining the PhD, habilitation and/or evaluated junior professorship, academic discipline (disaggregated by their areas of teaching and research, the so-called *Lehr- und Forschungsbereiche*), international mobility during the studies, the PhD, and the postdoc, as well as potential awards. These data allowed us to evaluate the sample composition in comparison to the composition of the original population, and thus to assess the sensitivity of our results to processes of self-selection. Table 2 describes the target population and the estimation sample based on selected variables.

There are minor deviations between the target population and the estimation sample regarding professors' qualifications, international experience, and federal state of the current university, which are very unlikely to limit the external validity of the results. Moreover, female professors and junior professors are somewhat overrepresented. Professors from German studies and the social sciences took part more often, while professors from chemistry are slightly underrepresented. There is thus selectivity into the estimation sample of responding professors. Yet, our experimental design itself is not biased regarding randomization and non-response. To check for the robustness of our results, we carried out a number of additional estimations. First, we re-estimated our main model (Figure 3) additionally controlling for the CV characteristics of professors described in the previous paragraph, which does not lead to substantial changes in the effects of the varied academic achievements (see M1 and M2 in Table A3 in the appendix). Second, we estimated a model with fixed effects for the responding professors, which also results in almost identical estimators (see M3 in Table A3). Both additional models (with covariates and with fixed effects) thus indicate a successful randomization of the vignettes across the responding professors. Third, not all responding professors judged all vignettes of their deck. To check whether this non-response was systematic with regard to the content presented in the vignettes, we estimated a model with a reduced sample including only those professors for whom all eight vignette judgments were available (see M4 in Table A3). Again, the effects deviate only minimally and allow for the same substantial interpretations as the model with incompletely evaluated vignette decks. Therefore, we use our main model with full statistical power in the following analyses.

Table 2 Characteristics of professors in the target population and in the sample for analyses

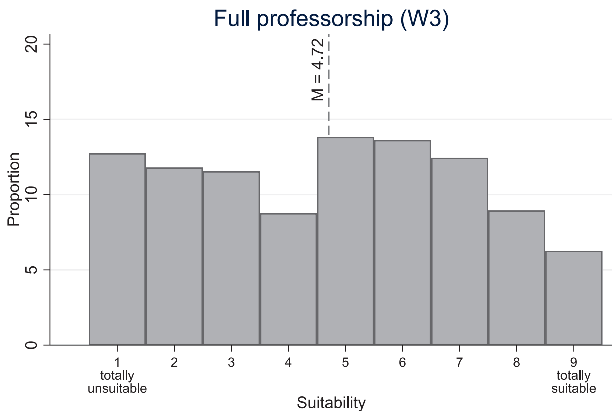
	Target Population		Sample for Analyses		
	Frequencies	Percent	Frequencies	Percent	χ^2 (p)
Gender					
Male	1905	69.81	547	62.59	31.80 (0.001)
Female	824	30.19	327	37.41	
Professorship					
Junior professor (W1)	166	6.08	78	8.92	18.17 (0.001)
(Full) professor (W2/W3)	2563	93.92	796	91.08	
Discipline					
German studies	662	24.26	267	30.55	38.31 (0.001)
Sociology	419	15.35	187	21.40	
Political Science	323	11.84	105	12.01	
Chemistry	1033	37.85	315	36.04	
Geography	292	10.70	-	-	
Qualification					
Doctoral degree	2410	88.31	795	90.96	8.75 (0.003)
Habilitation (postdoctoral qualification)	1566	57.38	478	54.69	3.81 (0.051)
Junior professorship (evaluated)	43	1.58	11	1.26	0.83 (0.361)
International experience					
As a student	722	26.46	247	28.26	2.15 (0.142)
As an academic	1726	63.25	555	63.50	0.04 (0.850)
Academic award	797	29.20	260	29.75	0.18 (0.668)
Federal state					
Baden-Württemberg	388	14.22	131	14.99	21.23 (0.130)
Bayern	397	14.55	115	13.16	
Berlin	202	7.40	64	7.32	
Brandenburg	51	1.87	21	2.40	
Bremen	49	1.80	19	2.17	
Hamburg	81	2.97	24	2.75	
Hessen	257	9.42	73	8.35	
Mecklenburg-Vorpommern	52	1.91	14	1.60	
Niedersachsen	226	8.28	74	8.47	
Nordrhein-Westfalen	608	22.28	186	21.28	
Rheinland-Pfalz	129	4.73	49	5.61	
Saarland	26	0.95	13	1.49	
Sachsen	120	4.40	35	4.00	
Sachsen-Anhalt	50	1.83	22	2.52	
Schleswig-Holstein	22	0.81	11	1.26	
Thüringen	71	2.60	23	2.63	
$N_{respondents}$	2729	100.00	874	100.00	
$N_{vignettes}$	21832		6354		

Data source: SciMo Survey of Professors (2018).

3.3. Estimation methods

Figure 2 shows the distribution of the judgments of suitability for a full professorship on our 9-point scale across all presented vignettes. There is a reasonable variance, without an overly frequent rating of the ends of the scale, indicating that the varied candidates' characteristics were relevant for the responding professors. Moreover, there is no evidence of biasing censoring effects. The rather symmetrical distribution (M = 4.72; SD = 2.45; Skewness = 0.02) justifies the use of linear estimation models.[7]

Figure 2 Distribution of judged suitability for a full professorship across all candidates



$N_{vignettes}$ = 6354; $N_{respondents}$ = 874
Data source: SciMo Survey of Professors (2018).

The assessment of up to eight fictitious candidates by each professor resulted in a hierarchical data structure (Hox et al. 1991; Jasso 2006). We take this data structure into consideration by estimating random intercept fixed slope models, which account for the variation in the outcome variable between respondents (Snijders/Bosker 2012). Because of the small size of the decks, we only estimate the intercepts with a random component. We corrected for potential remaining non-modeled heteroscedasticity through robust Huber-White standard errors (White 1980). We estimate the following equation:

$$I_{ij} = \beta_0 + \beta_1 X_{ij} + \beta_2 Z_j + v_j + \varepsilon_{ij};\ i = 1, \ldots, n;\ j = 1, \ldots, m$$

I_{ij}: Judgment of fictitious candidate i by responding professor j

X_{ij}: Vector of fictitious candidates' characteristics varied in vignettes

7 Although the outcome variable differs from a normal distribution, the underlying assumption that the model residuals are normally distributed is fulfilled. We verified this through graphical analyses and a normality test (skewness and kurtosis test: adjusted overall Chi² = 0.67, p = 0.714). Hence, the p-values of our significance tests are likely to be valid.

Z_j: Vector of responding professors' characteristics

v_j: Error term at responding professors' level

ε_{ij}: Error term at fictitious candidates' level

We are particularly interested in how the responding professors' academic discipline moderates the weights attributed to candidates' signals of academic performance. For this purpose, we additionally include cross-level interaction terms between the fictitious candidates' meritocratic dimensions and the responding professors' discipline ($X_{ij}Z_j$). This strategy reflects a subgroup analysis with efficient estimations of vignette evaluations differentiated by all professors who belong to the same discipline.

$$I_{ij} = \beta_0 + \beta_1 X_{ij} + \beta_2 Z_j + \beta_3 X_{ij} Z_j + v_j + \varepsilon_{ij};\ i = 1, \ldots, n;\ j = 1, \ldots, m$$

4. Empirical results

4.1. General signaling value of academic achievements

As argued above, academic achievements can be seen as signals of academic performance and thus unfold positive effects on the evaluation of the suitability for a professorship. Figure 3 shows a test of this assumption based on a joint estimation model for all covered disciplines.[8] As expected, the considered academic achievements increase the suitability for a professorship if compared to the respective reference categories. However, it becomes clear that professors consider most of the conventional academic achievements to be more important than the novel academic achievements.

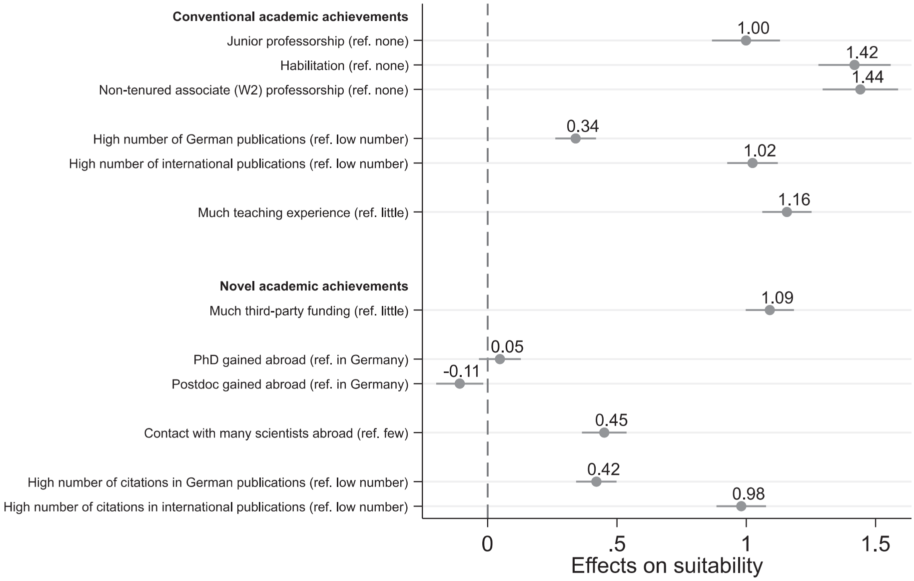
A habilitation and a non-tenured associate (W2) professorship show the strongest effects.[9] These achievements are associated with an average increase of 1.4 points on the suitability scale if compared to not having any of the presented formal qualifications. A junior professorship, on the other hand, increases the suitability slightly less than a habilitation and a non-tenured associate (W2) professorship, that is, by about one scale point. A junior professorship thus has about the same effect as much teaching experience (compared to little) or as a high number of international publications (compared to a low number). Having a high number of German publications is far less effective than having a high number of international publications.

Among the novel academic achievements, much third-party funding (compared to little) and a high number of citations in international publications (compared to a

8 For the sake of an easy interpretation, we present the main results using graphical plots. Table A2 in the appendix provides detailed estimates and model information.

9 The reference category in this dimension reflects a very low level of formal qualification (none of the mentioned qualifications). Accordingly, the importance of the effects of being habilitated and of holding a W2 professorship should not be overstressed. Instead, differences between the three formal qualifications are more informative.

Figure 3 Main effects of the varied academic achievements on the suitability for a professorship



Random effects regression with covariates at respondents' level (see Table A1: M1)
b-coefficients, robust standard errors, 95% CI; $N_{vignettes}$ = 6354; $N_{respondents}$ = 874
Data source: SciMo Survey of Professors (2018).

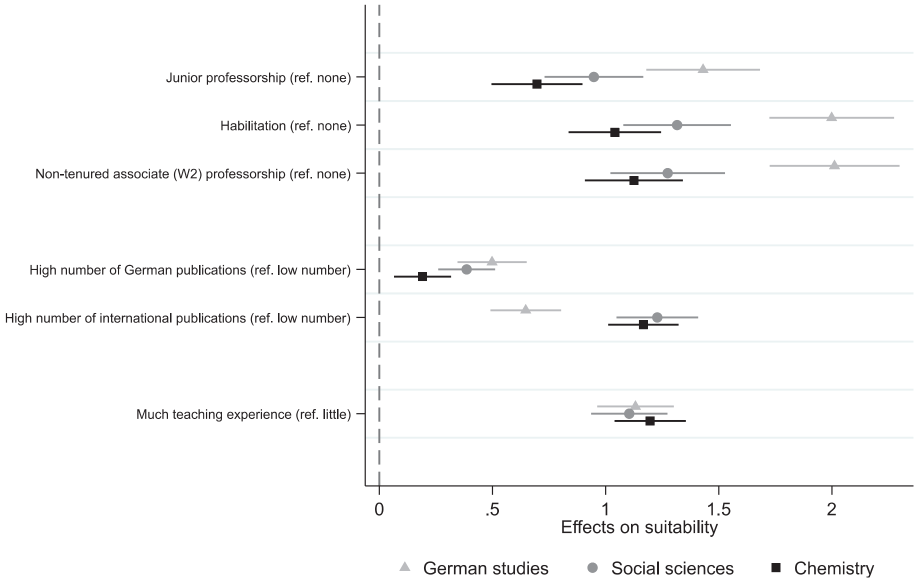
low number) prove to be the strongest predictors of suitability for a professorship, with effects of around one scale point. With effect sizes of just under half a scale point, contact with many scientists abroad (compared to few) are about as important as a high number of citations in German publications (compared to a low number). The effect of a PhD gained abroad, on the other hand, is near zero and insignificant. Contrary to expectations, a postdoc gained abroad even has a significantly negative effect.

4.2. Signaling value of conventional academic achievements across disciplines

Cross-level interaction analyses reveal remarkable heterogeneity of the effects of the candidates' academic achievements across the disciplines of the responding professors. Figure 4 shows the conditional effects for the conventional academic achievements, and Figure 5 for the novel academic achievements.

We assumed that formal qualifications should have most signaling value in German studies, followed by that in the social sciences and in chemistry, the reason being differences in the criteria for assessing scientific quality in these fields (hypothesis 1). Indeed, all varied formal qualifications are more important for the judged

Figure 4 Effects of conventional academic achievements conditional on academic disciplines of responding professors



Random effects regression with covariates at respondents' level (see Table A1: M2)
b-coefficients, robust standard errors, 95% CI; $N_{vignettes}$ = 6354; $N_{respondents}$ = 874
Data source: SciMo Survey of Professors (2018).

suitability for a professorship in German studies than in the social sciences and chemistry. With two scale points, the effects of a habilitation and a non-tenured associate (W2) professorship are about twice as large in German studies as in chemistry. A junior professorship has the weakest effect in all three disciplines compared to the other types of formal qualification. However, a junior professorship still has more signaling value in German studies than a habilitation and a non-tenured associate (W2) professorship in the social sciences or in chemistry. This analysis thus clearly supports hypothesis 1.

As scientific publications are a core signal of academic performance, we expected a high publication activity to be rewarded in all disciplines. However, in accordance with the more or less universal character of discipline-specific research subjects concerning region and epoch, international and German publications may have different signaling values. Accordingly, we assumed that German publications might be stronger signals in German studies than in the social sciences and in chemistry (hypothesis 2a). As Figure 4 shows, the effect of a high number of German publications (reference: low number of German publications) is strongest in German studies, weaker in the social sciences, and weakest in chemistry. The difference is only significant between German studies and chemistry. Still, the relations of all effect sizes correspond to hypothesis 2a (see M2 in Table A2 for detailed effect differences).

Moreover, we expected less signaling power of international publications in German studies compared to the social sciences and especially compared to chemistry (hypothesis 2b). In fact, international publications are of much less importance in German studies than in the other two disciplines. Yet, there is no difference between the effects of a high number of international publications in the social sciences and chemistry. The signaling value of German and international publications differs only slightly in German studies, while international publications weigh more than twice as much as German publications in the social sciences and in chemistry. Regarding the comparison of chemistry and German studies, our results thus align with hypothesis 2b.

Because of its fundamental character in all academic disciplines, we did not expect any differences in the signaling power of teaching experience (hypothesis 3). The empirical analysis confirms this hypothesis. In comparison to little teaching experience, much teaching experience has a notable effect on the suitability for a professorship (more than one scale point) regardless of the evaluating professors' discipline.

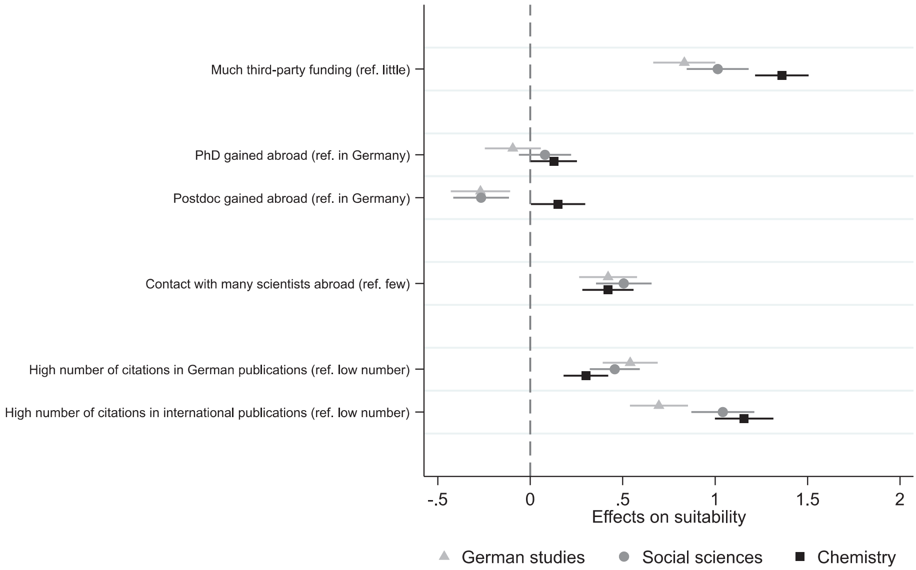
4.3. Signaling value of novel academic achievements across disciplines

Third-party funding is an important signal among the novel academic achievements (Figure 5). While research in chemistry is almost impossible without generous funding of technical equipment, research in German studies primarily requires the funding of personnel and access to literature. In the social sciences, researchers may incur different amounts of cost depending on the chosen research design. We therefore expected the strongest signaling effect of third-party funding in chemistry, followed by the social sciences and German studies (hypothesis 4). In line with our expectations, third-party funding has the strongest signaling value in chemistry and the weakest in German studies; this difference is statistically significant. Although third-party funding is considered more valuable in the social sciences than in German studies, this difference is not statistically significant. It is worth mentioning that much third-party funding shows the strongest effect of all varied achievements in chemistry. In summary, our results support hypothesis 4.

Furthermore, we expected characteristics related to international mobility, connectivity, visibility, and reception to serve as signals of academic performance. Once again referring to the degree of spatio-temporal universality of discipline-specific research subjects, we expected differences in their signaling values across academic disciplines.

We assumed stays abroad (hypothesis 5a) and many international contacts (hypothesis 5b) to be most important in chemistry, to be of moderate importance in the social sciences, and to be least important in German studies. However, our analyses

Figure 5 Effects of novel academic achievements conditional on academic disciplines of responding professors



Random effects regression with covariates at respondents' level (see Table A1: M2)
b-coefficients, robust standard errors, 95% CI; $N_{vignettes}$ = 6354; $N_{respondents}$ = 874
Data source: SciMo Survey of Professors (2018).

reveal that gaining either a PhD or a postdoc in another country have (weakly positive) significant effects on the suitability for a professorship only in chemistry. In German studies and in the social sciences, a PhD gained abroad has very small and insignificant effects. A postdoc gained abroad even has a significantly negative effect in the latter two disciplines. While the effects of stays abroad in chemistry thus correspond to hypothesis 5a, this cannot be confirmed for either German studies or the social sciences.

Neither do our analyses provide empirical support for the assumed discipline-specific differences regarding the effect of contact with other scientists internationally (hypothesis 5b). The importance of contact with many scientists abroad is weighted positively in all three disciplines, but we do not observe significant differences between disciplines in this respect.

Finally, we hypothesized that a high number of citations in German publications are the strongest signal of suitability for a professorship in German studies, followed by the social sciences and chemistry (hypothesis 6a). For a high number of citations in international publications, we assumed the inverse pattern (hypothesis 6b). In line with our expectations, the results show a pattern quite similar to the signaling value attributed to German and international publications. Citations in German publications are rewarded most by professors of German studies and rewarded least by professors of chemistry. However, these differences are only marginally significant. The result is clearer for citations in international publications: In German studies, a high number of citations in international publications have a similar signaling value as a high number of citations in German publications do. In the social sciences and in chemistry, a high number of citations in international publications have substantially more signaling power than a high number of citations in German publications. Overall, our findings therefore align with hypotheses 6a and 6b.

5. Discussion and conclusion

We examined how the value attributed to specific signals of academic performance varies across academic disciplines when considering the suitability of academics for a professorship. Our contribution is twofold: First, building on signaling theory, we proposed an approach that takes into account that success in academia largely depends on assessment by other academics. From this perspective, academic achievements are screened by professors in terms of their power to signal qualities that candidates' academic performance rests upon. In this context, we distinguished between conventional and novel academic achievements, assuming that they both promote the suitability of potential candidates for professorships in all academic disciplines. Following the literature on disciplinary academic cultures, we additionally argued that the signaling power of academic achievements should vary across disciplines because of discipline-specific degrees of standardization of research and the spatio-temporal universality of research objects.

Second, in contrast to most previous studies, we examined access to professorships using a factorial survey experiment, which was administered to Germany-based university professors. We randomly presented fictitious possible candidates for professorships, thereby varying major academic achievements, and measured the responding professors' judgments of the suitability of the presented candidates for tenured professorship at a German university. This research design allowed us to estimate unbiased effects of the candidates' academic achievements conditional on the responding professors' discipline. We compared the estimated effects across professors of German studies, selected social sciences (political science and sociology), and chemistry. In summary, our analyses revealed remarkable heterogeneity in the effects of the examined academic achievements across the covered disciplines.

As expected, formal qualifications do not play a prominent role in chemistry. Here, the qualification is no more important than a high number of international publications and much teaching experience. Much third-party funding is the most important criterion in chemistry, followed by a high number of citations in international publications. German publications and citations are of less importance.

In German studies, in contrast, formal qualifications, such as a habilitation or non-tenured professorship, are the most important criterion for the assessed suitability for a professorship. Publications and citations have less weight, regardless of whether they appear in German or international publication media. The relative importance of third-party funding and teaching experience is also evident in German studies.

In the social sciences, the attributed signaling values tend to range between those of chemistry and those of German studies. In terms of formal qualifications as well as German and international publications and citations, the effects are similar to those in chemistry. Conversely, third-party funding and international mobility are evaluated in a similar way as in German studies.

There are no significant disciplinary differences regarding teaching experience and contact to scientists abroad. If the effect of international mobility is estimated net of the effects of all other dimensions, which is the case in our study by design, it hardly plays a role in the considered disciplines or is even slightly detrimental (German studies).

The facts that existing studies seldom strove for systematic disciplinary comparisons regarding the signaling value of specific academic achievements, and that many studies focused on different disciplines than the ones we examined impede robust comparisons of our results to existing ones. Broadly speaking, however, our results align with existing evidence for German academia in that the formal qualification, most notably a habilitation, has a larger signaling value in disciplines that are geared towards German society, such as German studies or law, while—especially internationally visible—publications are more relevant in the social and the natural sciences (Gross et al. 2008).[10] We also confirm research for the German social sciences that the qualification exerts a positive signaling effect even net of the publication performance (Lutter/Schröder 2016; Schröder et al. 2021).

Moreover, our results correspond to previous evidence in that they did not reveal notable disciplinary differences concerning the signaling value of teaching experience in German academia (Gross et al. 2008).

Regarding third-party funding, our analyses tend to support recent empirical evidence for the social sciences suggesting that this is of high importance (Abele-Brehm/Bühner 2016; Schröder et al. 2021; Solga et al. 2023), rather than older empirical evidence suggesting that it is only marginally important for obtaining a professorship (Plümper/Schimmelfennig 2007; Schulze et al. 2008). On a broader note and beyond the comparison of disciplines, this supports our initial argument that novel signals of academic performance may have become more important over the past decades.

10 Our results also substantiate the picture that internationally visible publications are nowadays equally important in the social sciences as in the natural and technical sciences (Abele-Brehm/Bühner 2016; Jonkers 2011; Jungbauer-Gans/Gross 2013; Lang/Neyer 2004; Lutter/Schröder 2016; Schröder et al. 2021; Schulze et al. 2008).

Finally, our results confirm previous evidence that ascriptions of internationality play a greater role in the natural sciences than in the social sciences and especially than in the humanities (Hamann/Zimmer 2017).

Our study has several limitations, which represent starting points for future research. As with every experiment, we had to select specific theoretically relevant treatments that influence the suitability for a professorship. The existing literature has shown the chosen dimensions to be important determinants of academic career success. Still, the theoretical proposition to understand academic achievements as signals of academic performance readily allows for extensions. Signaling theory can easily be applied to different regional and temporal contexts when it comes to displaying academic performance through observable features. Accordingly, future studies may set other priorities when varying dimensions and levels.

We studied the relative proportion of German and international publications and citations. In the future, it would be interesting to also differentiate types of publications more explicitly, for example written books, editorships, and peer-reviewed journal articles. Moreover, the share of co-authorships typically differs between disciplines due to discipline-specific cooperation norms (Gross et al. 2017). It is therefore possible that the diverging importance of the number of publications corresponds to differing proportions of co-authorships across disciplines. In this respect, further research is needed considering the competing signaling values of co-authorships reflecting scientific cooperation on the one hand and single authorships reflecting scientific contributions attributable to individual researchers on the other. Finally, single publications can be particularly influential and generate large numbers of citations, for example when new theoretical approaches or empirical methods are successfully introduced. The role of such outstanding publications and the associated citations could also be examined in future research, including the possibility that publications presenting entirely novel approaches might—at least initially—be more difficult to publish and face a citation penalty (Wang et al. 2017).

A more nuanced analysis of different types of international mobility would also be beneficial. For instance, it is plausible that the value of academic stays abroad —and corresponding variation across disciplines—differs depending on the host country and institution. In German studies, stays in German-speaking countries may be particularly beneficial, while stays in Anglophone countries could be more relevant in chemistry, where English is the lingua franca; as the social sciences often have a regional focus, stays in countries related to the specific objects of study arguably matter. Similar patterns might be observable regarding institutional prestige. Ultimately, stays in specific countries and at specific institutions may thus be understood as a matter of (mis)fit of academic cultures. From this perspective, our finding that professors in German studies and the social sciences assess a postdoc gained abroad negatively may reflect a suspicion that candidates are insufficiently socialized in the German academic system if they completed their postdoc abroad.

Typically, candidates for professorships differ regarding their individual academic achievements. Someone may have published a lot and gained extensive international experience, but only have a little teaching experience and possibly no qualifications beyond the doctorate. This raises the question of whether specific signals of academic performance can be substituted by each other. For example, can international experience be substituted by a comparatively large number of international publications, or vice versa? Such substitution processes—and possible variation of these processes across disciplines—deserve more attention.

We focused on academic achievements, which are usually gained through one's own efforts and thus follow a meritocratic principle. However, previous research has shown that academic careers are also determined by ascribed characteristics such as gender and immigrant background (e.g., Gross/Jungbauer-Gans 2007; Lutter/Schröder 2016; Solga et al. 2023; Williams/Ceci 2015). In addition, the signaling effect of specific universities is becoming more and more differentiated. The importance of ascribed and institutional characteristics, and of potential interactions with more meritocratic academic achievements, should also be examined more closely in the future, inter alia by applying experimental research designs.

Furthermore, we only compared the signaling power of academic achievements across German studies, sociology and political science, and chemistry, which served as representatives of the humanities, the social sciences, and the natural sciences. Moreover, we focused on German academia. Due to possible discipline-specific and country-specific idiosyncrasies, the generalizability or our results is thus limited. Comparative studies including further disciplines and countries are therefore desirable.

Addressing these and other aspects may help to further understand the varying importance of academic achievements across different disciplinary, institutional, and country contexts. The present experimental study on the signaling value of specific academic achievements in German studies, selected social sciences, and chemistry has laid the foundations for this line of research.

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Appendix

Table A1 Correlations (r) of fictitious candidates' characteristics

Experimental design	1	2	3	4	5	6	7	8	9	10
1 Qualification	1.000									
2 Publications (German)	-0.011	1.000								
3 Publications (international)	0.029	0.001	1.000							
4 Teaching experience	-0.000	0.008	-0.001	1.000						
5 Third-party funding	-0.005	-0.015	-0.017	-0.006	1.000					
6 International experience during the PhD	0.009	0.008	0.003	-0.010	0.032	1.000				
7 International experience during the postdoc	-0.016	-0.027	0.035	0.007	-0.004	-0.003	1.000			
8 International networks	0.007	0.012	0.003	0.011	-0.019	0.002	0.029	1.000		
9 Citations (German)	0.009	0.004	-0.014	-0.010	0.017	0.021	0.009	-0.025	1.000	
10 Citations (international)	0.003	-0.023	0.074	0.009	-0.021	0.005	0.012	0.028	0.005	1.000

Data source: SciMo Survey of Professors (2018).

Table A2 Estimations of main effects of vignette dimensions and effects of interactions with professors' discipline

Dependent variable: Suitability for a full professorship	M1	M2
Qualification		
Junior professorship (evaluated) (ref. none)	0.999***	1.431***
	(14.826)	(11.148)
Habilitation (postdoctoral qualification) (ref. none)	1.417***	1.999***
	(19.818)	(14.213)
Non-tenured associate (W2) professorship (ref. none)	1.441***	2.012***
	(19.343)	(13.740)
High number of German publications (ref. low number)	0.343***	0.498***
	(8.474)	(6.388)
High number of international publications (ref. low number)	1.026***	0.647***
	(20.487)	(8.100)
Much teaching experience (ref. little)	1.155***	1.132***
	(23.720)	(13.087)
Much third-party funding (ref. little)	1.092***	0.833***
	(22.808)	(9.733)
PhD gained abroad (ref. in Germany)	0.0475	-0.0944
	(1.149)	(-1.221)
Postdoc gained abroad (ref. in Germany)	-0.109*	-0.269**
	(-2.347)	(-3.288)
Contact with many scientists abroad (ref. few)	0.449***	0.421***
	(10.145)	(5.279)
High number of citations in German publications (ref. low number)	0.419***	0.540***

Dependent variable: Suitability for a full professorship	M1	M2
	(10.446)	(7.114)
High number of citations in international publications (ref. low number)	0.982***	0.696***
	(19.986)	(8.682)
Discipline of responding professor		
Social sciences (ref. German studies)	0.293*	0.204
	(2.476)	(0.845)
Chemistry (ref. German studies)	-0.810***	-0.996***
	(-6.359)	(-4.442)
Interaction terms		
Qualification		
Social sciences * Junior professorship (evaluated)		-0.483**
		(-2.844)
Social sciences * Habilitation (postdoctoral qualification)		-0.683***
		(-3.677)
Social sciences * Non-tenured associate (W2) professorship		-0.737***
		(-3.776)
Chemistry * Junior professorship (evaluated)		-0.734***
		(-4.467)
Chemistry * Habilitation (postdoctoral qualification)		-0.958***
		(-5.469)
Chemistry * Non-tenured associate (W2) professorship		-0.887***
		(-4.838)
Social sciences * High number of German publications		-0.113
		(-1.114)
Chemistry * High number of German publications		-0.307**
		(-3.038)
Social sciences * High number of international publications		0.581***
		(4.770)
Chemistry * High number of international publications		0.520***
		(4.608)
Social sciences * Much teaching experience		-0.0274
		(-0.224)
Chemistry * Much teaching experience		0.0651
		(0.551)
Social sciences * Much third-party funding		0.181
		(1.497)
Chemistry * Much third-party funding		0.528***
		(4.666)
Social sciences * PhD gained abroad		0.174
		(1.645)
Chemistry * PhD gained abroad		0.222*
		(2.213)
Social sciences * Postdoc gained abroad		0.00362
		(0.032)

Dependent variable: Suitability for a full professorship	M1	M2
Chemistry * Postdoc gained abroad		0.420***
		(3.785)
Social sciences * Contact with many scientists abroad		0.0846
		(0.764)
Chemistry * Contact with many scientists abroad		-0.000951
		(-0.009)
Social sciences * High number of citations in German publications		-0.0833
		(-0.811)
Chemistry * High number of citations in German publications		-0.240*
		(-2.451)
Social sciences * High number of citations in international publications		0.346**
		(2.925)
Chemistry * High number of citations in international publications		0.461***
		(4.057)
Constant	0.900**	0.995**
	(2.672)	(2.809)
σ_u	1.127	1.121
σ_e	1.700	1.674
ρ	0.305	0.310
R^2	0.323	0.337
$R^2_{between}$	0.148	0.150
R^2_{within}	0.393	0.414
Wald χ^2	3181.6***	3550.6***
$N_{vignettes}$	6354	6354
$N_{respondents}$	874	874

Random effects regression with covariates at respondents' level (see section 3.2 for details)
b-coefficients, robust standard errors, *t* values in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Data source: SciMo Survey of Professors (2018).

Table A3 Robustness checks (estimations with covariates, fixed effects, and reduced sample)

Dependent variable: Suitability for a full professorship	M1	M2	M3	M4
Qualification				
Junior professorship (evaluated) (ref. none)	0.999***	0.999***	0.992***	1.022***
	(14.857)	(14.826)	(14.696)	(14.107)
Habilitation (postdoctoral qualification) (ref. none)	1.419***	1.417***	1.423***	1.436***
	(19.877)	(19.818)	(19.887)	(18.606)
Non-tenured associate (W2) professorship (ref. none)	1.441***	1.441***	1.439***	1.474***
	(19.377)	(19.343)	(19.251)	(18.261)
High number of German publications (ref. low number)	0.340***	0.343***	0.333***	0.351***
	(8.441)	(8.474)	(8.239)	(8.183)
High number of international publications (ref. low number)	1.024***	1.026***	1.027***	1.067***
	(20.502)	(20.487)	(20.450)	(19.836)
Much teaching experience (ref. little)	1.157***	1.155***	1.159***	1.192***
	(23.797)	(23.720)	(23.767)	(22.695)
Much third-party funding (ref. little)	1.091***	1.092***	1.090***	1.093***
	(22.872)	(22.808)	(22.735)	(21.086)
PhD gained abroad (ref. in Germany)	0.0473	0.0475	0.0505	0.0685
	(1.145)	(1.149)	(1.219)	(1.547)
Postdoc gained abroad (ref. in Germany)	-0.108*	-0.109*	-0.101*	-0.0750
	(-2.325)	(-2.347)	(-2.171)	(-1.489)
Contact with many scientists abroad (ref. few)	0.451***	0.449***	0.456***	0.453***
	(10.214)	(10.145)	(10.317)	(9.530)
High number of citations in German publications (ref. low number)	0.420***	0.419***	0.420***	0.418***
	(10.523)	(10.446)	(10.492)	(9.794)
High number of citations in international publications (ref. low number)	0.981***	0.982***	0.984***	1.047***
	(20.031)	(19.986)	(20.020)	(19.770)
Constant	1.052***	0.900**	1.053***	0.923***
	(11.197)	(2.672)	(13.219)	(9.233)
σ_u	1.222	1.127	1.430	1.181
σ_e	1.700	1.700	1.700	1.710
ρ	0.341	0.305	0.414	0.323
R^2	0.273	0.323	0.273	0.289
$R^2_{between}$	0.029	0.148	0.028	0.010
R^2_{within}	0.393	0.393	0.393	0.404
Wald χ^2 / F	2828.6***	3181.6***	233.2***	2646.9***
$N_{vignettes}$	6354	6354	6354	5528
$N_{respondents}$	874	874	874	691

M1: Random effects regression without covariates
M2: Random effects regression with covariates at respondents' level (see section 3.2 for details)
M3: Fixed effects regression (Hausman test: $\chi^2 = 23.84$, p = 0.0214)
M4: Random effects regression without dropouts at respondents' level
b-coefficients, robust standard errors, *t* values in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Data source: SciMo Survey of Professors (2018).