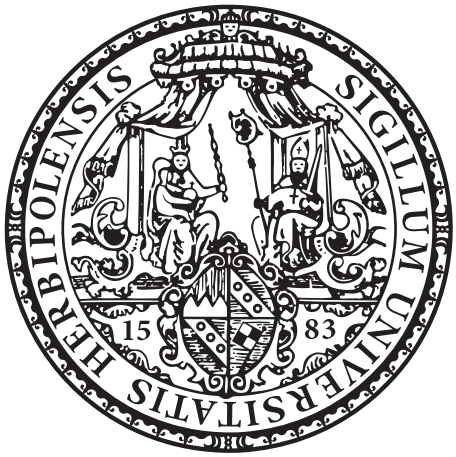
Occupational destinations and professional success among doctoral graduates in Germany

Inaugural-Dissertation

zur Erlangung der Doktorwürde (Dr. rer. soc.)

der Fakultät für Humanwissenschaften

der Julius-Maximilians-Universität Würzburg



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Hannover, 2023

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Tag der Abgabe:	02. Januar 2023
Tag der Disputation:	24. Juli 2023

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Acknowledgements

First of all, I thank my “doctoral mother” and supervisor, Professor Dr. Christiane Gross. Not only did she give me the opportunity to do my doctorate in the first place, but she also supported my doctoral project from the very beginning and mentored, encouraged, and challenged me throughout the years, professionally, methodically, and personally. I would also like to thank my second supervisor, Professor Dr. Corinna Kleinert, for reviewing my doctoral thesis and for providing me with advice and feedback whenever I needed it, but otherwise giving me free rein in conducting my research. Further thanks go to Professor Dr. Frank Schwab who was my first choice as third supervisor and happily agreed to meet my wish. I also thank Junior Professor Dr. Ulrike Zeigermann for agreeing to write an additional review of my dissertation at short notice, Professor Dr. Elke Wagner for chairing my disputation, and Dr. Theresa Stawski for writing the report of my disputation.

In addition, I would like to thank my co-authors: Aaron Bohlen, and especially Dr. Steffen Jaksztat, with whom I have worked and researched particularly closely during my doctorate, who always had an open ear for my questions and concerns, and who was always happy to give me feedback and food for thought on my research.

Besides Professor Dr. Christiane Gross, I also thank all other current and past colleagues at the Chair of Quantitative Methods of Empirical Social Research for such supportive teamwork over all the years: Dr. Andreea Baier-Klenkert, Annemarie Betz, Jürgen Deniffel, Bärbel Janietz, PD Dr. Jan Künzler, Dr. Gerd Pfister, and Laura Zapfe. Special thanks go to Bärbel Janietz for always having watched my back with regard to bureaucratic matters and to Laura Zapfe, my office partner and “fellow sufferer” on the way to the doctorate, with whom I have often worked very productively. I would also like to thank all the student assistants I have had over the years and Micha Pastuschka in particular because he has supported my research with a high level of motivation as well as reliable, fast, and flawless work results.

I would also like to thank Fine Cordua and Dr. Martina Kroher for both their emotional support and their professional advice on different aspects related to my research as well as many others at the German Centre for Higher Education Research and Science Studies (DZHW), at the University of Würzburg’s Institute of Political Science and Sociology, and at the university’s Faculty of Human Sciences who have helped me over the years through helpful advice, feedback on research results, collaboration, or cooperation beyond the doctorate.

Moreover, my doctorate would not have been possible without the data from the DZHW PhD Panel 2014. Therefore, I would like to thank the team of the PhD Panel at the DZHW for data collection and the team of the DZHW’s Research Data Centre (FDZ-DZHW) for providing the data and for always being eager to respond to my requests.

For a long time, the funding of my doctorate was uncertain. A doctoral scholarship from the German Academic Scholarship Foundation (German: *’Studienstiftung des deutschen Volkes’*) gave me security for the first time and thus the freedom and peace of mind to conduct my research. I would therefore like to thank the German Academic Scholarship Foundation as well as the Free State of Bavaria for additional funding in the Marianne Plehn Programme. Over the years, I have also repeatedly received further financial support from the Faculty of Human Sciences, the Faculty’s Human Dynamics Centre, and the Faculty’s Equal Opportunities Commission in the form of cost subsidies for conference travels and

English language editing. These subsidies have also made an important contribution to my research. The same holds for the “Subjective and objective professional success of PhD holders in Germany” research project (German: *’Subjektiver und objektiver Berufserfolg von Promovierten in Deutschland’*), which is funded by the German Research Foundation (DFG) and provided me with monetary resources for conference visits, further training, and support by a student assistant.

Further thanks go to my friend Matze for his emotional support and for being a role model in resilience.

Last but not least, I would like to thank with all my heart my partner, Paul, who has supported me throughout the whole doctorate, picked me up after setbacks, and celebrated the successes and progress with me.

Summaries

English summary

The starting point of the present doctoral thesis is that, as opposed to general expectation and perception, doctoral graduates do not necessarily strive for or realize the ideal-typical academic career. In many Western countries, career opportunities and paths for doctoral graduates have diversified, and academia is not their only occupational destination, with a large proportion leaving academia to work in public service, in companies' research and development departments, or in non-profit organizations. Against this background, this thesis examines postdoctoral careers by means of the mid-term occupational destinations and professional success among doctoral graduates in the academic and non-academic labour markets in Germany. With regard to occupational destinations, I investigate where doctoral graduates are employed following graduation and how their occupational destinations can be explained. With regard to professional success, I investigate various objective and subjective success indicators related to the returns to doctoral degrees — such as earnings, management positions, and job satisfaction — and systematically include the graduates' occupational destinations in the analyses. I also consider social inequalities regarding both research topics.

The employment situation and career prospects for doctoral graduates in Germany are particularly interesting because here a considerable number of doctoral candidates complete their training each year, due to the fact that most of them find employment beyond the ideal-typical academic career, and because they also encounter good career prospects outside academia and so doctoral training seems to pay off both inside and outside academia. However, so far, the employment situation among doctoral graduates outside academia, i.e., in the private and non-academic public sectors, has barely been comprehensively studied. In addition, the professional success among doctoral graduates has typically only been examined in comparison to other higher education graduates, but differences in the professional success within the group of doctoral graduates have not yet been studied.

With the PhD Panel 2014 from the German Centre for Higher Education Research and Science Studies (DZHW), new panel survey data is available on the careers of recent doctoral graduates in Germany. The data is representative of the 2014 doctoral graduation cohort, includes doctoral graduates from all subject groups and formal types of doctoral training, and comprises five annual survey waves covering the initial five years following doctoral graduation. The DZHW PhD Panel 2014 is the data basis for all analyses and allows me to shed new light on postdoctoral careers in Germany within the framework of various research questions.

Within the scope of the overall research topics, this thesis examines a wide range of illustrative and relevant subtopics across five individual papers: 1) social inequalities in postdoctoral dropout from academia, 2) determinants of doctoral graduates' employment sector choices, 3) differences in various professional success indicators by their employment sectors, 4) the effect of obtaining a permanent employment contract on doctoral graduates' job satisfaction inside and outside academia, and 5) determinants of the gender pay gap among doctoral graduates. Depending on the papers' research interests, I use different theoretical approaches — for example, the intersectionality approach, rational choice theory, human capital theory, and traditional gender roles and beliefs — as well as different cross-sectional or longitudinal methods of analysis — for example, log-linear ordinary least squares regression, Cox proportional hazards models, and panel fixed-effects regression.

The papers provide both new insights into their specific research questions and general insights into doctoral graduates' occupational destinations and professional success. Overall, the analyses regarding doctoral graduates' occupational destinations confirm a diversification of postdoctoral career paths as most doctoral graduates find employment outside academia (*papers 1, 2, 3*) where they are employed in different sectors but still often engaged in research activities (*papers 2, 3*). The analyses also indicate that doctoral graduates' occupational destinations seem to depend less on social characteristics (*paper 1*) than on individual preferences and restrictions imposed by external conditions and characteristics of their doctorates (*papers 2, 3*). The analyses regarding doctoral graduates' professional success indicate inter-individual differences in the various indicators of success within the group of doctoral graduates. Their professional success largely varies by their occupational destinations (*papers 3, 4, 5*). I also find that doctoral graduates' contract type and job satisfaction are associated and that this association is strongly moderated by their employment sectors (*paper 4*). There are also gender differences in earnings five years following graduation that are driven by a substantive wage premium for male doctoral graduates outside academia and mediated by several doctoral and occupational characteristics (*paper 5*).

German summary

Der Ausgangspunkt der vorliegenden Doktorarbeit ist, dass Promovierte entgegen der allgemeinen Wahrnehmung und Erwartung, die idealtypische akademische Laufbahn weder zwangsläufig anstreben noch zwangsläufig realisieren. In vielen westlichen Ländern haben sich die Karrieremöglichkeiten und -wege für Promovierte diversifiziert. Die Wissenschaft ist nicht ihr einziges Berufsziel und viele von ihnen verlassen die Wissenschaft, um im öffentlichen Dienst, in Forschung- und Entwicklungsabteilungen von Unternehmen oder in Non-Profit-Organisationen zu arbeiten. Vor diesem Hintergrund untersucht diese Doktorarbeit die Karrierewege von Promovierten in Deutschland anhand ihres beruflichen Verbleibs und Erfolgs auf dem wissenschaftlichen und nicht-wissenschaftlichen Arbeitsmarkt. Hinsichtlich des beruflichen Verbleibs wird untersucht, wo Promovierte nach ihrem Abschluss beschäftigt sind und wie ihr beruflicher Verbleib erklärt werden kann. Hinsichtlich des beruflichen Erfolgs werden verschiedene objektive und subjektive Erfolgsindikatoren untersucht, die mit den Erträgen von Promotionen zusammenhängen — wie z.B. Einkommen, Führungspositionen und Berufszufriedenheit — wobei der berufliche Verbleib der Promovierten in die Analysen systematisch miteinbezogen wird. Bei beiden Forschungsthemen werden auch soziale Ungleichheiten berücksichtigt.

Die Beschäftigungssituation und die Karriereperspektiven von Promovierten sind in Deutschland besonders interessant, da hier jedes Jahr besonders viele Promotionen abgeschlossen werden, da hier die meisten Promovierten jenseits der idealtypischen akademischen Laufbahn tätig werden und da sie gleichzeitig außerhalb der Wissenschaft gute Beschäftigungsaussichten vorfinden, so dass sich eine Promotion sowohl innerhalb als auch außerhalb der Wissenschaft zu lohnen scheint. Allerdings ist die Beschäftigungssituation von Promovierten außerhalb der Wissenschaft, d.h. in der Privatwirtschaft und im nicht-wissenschaftlichen öffentlichen Dienst, bisher kaum untersucht worden. Zudem ist der Berufserfolg von Promovierten in der Regel nur im Vergleich zu anderen Hochschulabsolvent*innen bestimmt worden, Analysen zu Unterschieden im Berufserfolg innerhalb der Gruppe der Promovierten fehlen bisher jedoch weitestgehend.

Mit dem DZHW-Promoviertenpanel 2014 liegen neue längsschnittliche Befragungsdaten zu den Karrierewegen von Promovierten vor, die kürzlich ihre Promotion abgeschlossen haben. Die Daten sind repräsentativ für die Promotionsabschlusskohorte 2014, umfassen Promovierte aller Fächergruppen und Promotionskontexte und enthalten fünf jährliche Befragungswellen, die den Zeitraum bis fünf Jahre nach Promotionsabschluss abdecken. Das DZHW-Promoviertenpanel 2014 ist die Datengrundlage für alle Analysen und ermöglicht es mir, im Rahmen verschiedener Forschungsfragen neue Einblicke in die Karrierewege von Promovierten in Deutschland zu gewinnen.

Im Rahmen der übergeordneten Forschungsthemen wird in dieser Arbeit exemplarisch anhand von fünf Einzelbeiträgen ein breites Spektrum an relevanten Unterthemen untersucht: 1) soziale Ungleichheiten beim Ausscheiden aus der Wissenschaft nach Promotionsabschluss, 2) Determinanten der Tätigkeitsbereiche von Promovierten, 3) Unterschiede in verschiedenen Indikatoren des Berufserfolgs von Promovierten in Abhängigkeit ihrer konkreten Tätigkeitsbereiche, 4) der Effekt von Entfristungen auf die Berufszufriedenheit von Promovierten inner- und außerhalb der Wissenschaft und 5) Determinanten des Gender Pay Gaps bei Promovierten. Je nach Forschungsinteresse der Einzelbeiträge verwende ich unterschiedliche theoretische Ansätze — wie z.B. den Intersektionalitätsansatz, die Rational-Choice-Theorie, die Humankapitaltheorie sowie traditionelle Geschlechterrollen und -überzeugungen — sowie unterschiedliche quer- oder längsschnittliche Analysemethoden — wie z.B. Ordinary-Least-Squares-Regression, Cox-Proportional-Hazard-Regression und Fixed-Effects-Panel-Regression.

Die fünf Einzelbeiträge liefern sowohl neue Erkenntnisse zu ihren jeweiligen Forschungsfragen als auch allgemeine Einblicke in den beruflichen Verbleib und Erfolg von Promovierten. Insgesamt bestätigen die Analysen zum beruflichen Verbleib von Promovierten eine Diversifizierung ihrer Karrierewege, da die meisten Promovierten außerhalb der Wissenschaft beruflich tätig werden (*Beiträge 1, 2, 3*), hier sind sie in verschiedenen Bereichen tätig, gehen aber dennoch häufig forschungsbezogenen Tätigkeiten nach (*Beiträge 2, 3*). Die Analysen deuten auch darauf hin, dass der berufliche Verbleib von Promovierten weniger von sozialen Merkmalen (*Beitrag 1*) als von individuellen Präferenzen, Promotionsmerkmalen und äußeren Bedingungen abzuhängen scheint (*Beiträge 2, 3*). Die Analysen zum beruflichen Erfolg weisen für verschiedene Erfolgsindikatoren auf interindividuelle Unterschiede innerhalb der Gruppe der Promovierten hin, da sich diese je nach beruflichem Verbleib unterscheiden (*Beiträge 3, 4, 5*). Außerdem zeigt sich, dass die Art des Arbeitsvertrags mit der Berufszufriedenheit Promovierter zusammenhängt und dass dieser Zusammenhang von ihren Tätigkeitsbereichen moderiert wird (*Beitrag 4*). Zudem bestehen fünf Jahre nach Promotionsabschluss geschlechtsspezifische Einkommensunterschiede, die auf einen erheblichen Lohnaufschlag für männliche Promovierte außerhalb der Wissenschaft zurückzuführen sind und durch verschiedene Promotions- und Beschäftigungsmerkmale der Promovierten vermittelt werden (*Beitrag 5*).

1 Introduction

The present doctoral thesis examines the occupational destinations and the professional success among doctoral graduates in Germany. On the one hand, it investigates where doctoral graduates are employed inside and outside academia following doctoral graduation and how their occupational destinations can be explained. On the other hand, it examines the professional success among doctoral graduates by means of different success indicators and against the background of their occupational destinations. The thesis also investigates social inequalities in doctoral graduates' occupational destinations and professional success. Within the scope of these overall research topics, this thesis comprises five scientific and peer-reviewed papers.

In the following introductory sections, I first describe the framework conditions of doctoral training in Germany, then the importance of doctoral graduates in knowledge societies, before presenting the overall topics and aims of this thesis. Finally, I introduce the conception of the individual papers before locating them in the overall research topics.

1.1 Facts and figures on doctoral training in Germany

In Germany, generally speaking, doctoral training aims at preparing junior researchers for an academic career. Therefore, doctoral training mainly consists of conducting scientific in-depth research by which the doctoral candidates are expected to make an original contribution to their respective field of research. Thus, a doctoral degree attests to its holder's ability to independently carry out in-depth scientific work (Hochschulrektorenkonferenz, 2012, p. 2; Schneijderberg & Teichler, 2018; Wissenschaftsrat, 2002, p. 48). However, since those pursuing an ideal-typical academic career with the goal of becoming a professor need to acquire further academic qualifications beyond doctoral graduation — typically a habilitation or junior professorship — a doctoral degree is a necessary, but not sufficient, requirement for an academic career.

The prerequisite for taking up doctoral training is usually the completion of a master's degree, state examination, or traditional pre-Bologna higher education degree with (very) good final grades. Doctoral candidates do not need to be — or only temporarily need to be — enrolled at university and are therefore typically considered as junior or early-career researchers in Germany, as opposed to the Anglo-American science system where doctoral candidates are considered as doctoral students (Schneijderberg & Teichler, 2018; Shin, Kehm, & Jones, 2018). In Germany, doctoral training is often described as a traditional 'apprenticeship model' because doctoral candidates are typically subordinated to one university professor, who is also their main supervisor, and therefore, they largely depend on their supervisor's favour and support.[1] Doctoral training usually takes several years and is completed by submitting a written doctoral thesis and defending it in an oral examination. Depending on universities' formal guidelines and disciplinary traditions, the dissertation can be either a monograph or a collection of scientific and peer-reviewed journal articles. Despite recent reform efforts, traditionally, only universities have the right to award doctoral degrees in contrast to universities of applied sciences.

Doctoral training can take place in different institutional settings and can be funded in different ways. The institutional settings or rather formal types of doctoral training (German: *'Promotionskontexte'*) are,

[1] On a side note, in some cases, this strong dependence on a single person and the associated power imbalance entails disadvantages and potential for conflict and is therefore currently the subject of criticism.

generally speaking, either internal, external, or structured doctorates (Federal Statistical Office, 2016, pp. 35–36; de Vogel, 2020, pp. 48–63). *Internal doctorates* are the most common formal type of doctoral training and mean employment at the university at which the graduates also intend to submit their doctoral thesis and pass their oral examination. The German law on academic employment (German: '*Wissenschaftszeitvertragsgesetz*') stipulates that researchers can be temporarily employed inside academia for a maximum of six years prior to doctoral graduation and another six years thereafter (nine for medicine). This can be extended for parents by two years for each child born within this period. Continued employment beyond the maximum period is only possible if the position is third-party funded; in this case, the maximum duration of temporary employment corresponds to the duration of the project. *External doctorates* mean that the candidates have a university professor as supervisor but are not employed at the university at which they aim to submit their thesis. External doctoral candidates may fund their doctoral training through employment at another university, a non-university research institution, or outside academia, as well as through doctoral scholarships or private means. *Structured doctorates* have only recently been introduced in Germany and refer to structured or rather standardized doctoral programmes following the US model of doctoral training. Inter alia, these include compulsory lectures and classes on research-related topics and scientific methods. However, the range of different structured doctorates in Germany is quite broad. Previous research has shown that the formal type of doctoral training affects the candidates' conditions and experiences during doctoral training and the quality of their supervision (de Vogel, 2020, pp. 216–268), which in turn is likely to affect their doctoral progress and performance (de Vogel, 2022).

The conditions in which doctoral candidates complete their doctoral training and conduct their research also vary by subject group — for example, regarding the ratio of doctoral candidates supervised per professor (BuWiN, 2013, pp. 221–222; BuWiN, 2021, p. 137; Federal Statistical Office, 2016, p. 23), the most common institutional settings and funding channels of doctoral training (BuWiN, 2021, p. 131; Federal Statistical Office, 2016, pp. 32–38), the dissertation type (Federal Statistical Office, 2016, pp. 33–34), the duration of doctoral training (BuWiN, 2021, p. 138), and the risk of dropout from doctoral training (BuWiN, 2017, p. 156; Jaksztat, Neugebauer, & Brandt, 2021). Note that medical doctorates fundamentally differ from those in all other subject groups for a number of reasons; because most medical graduates acquire a doctoral degree in the first place, because they usually earn it alongside undergraduate studies, because their research activities are often limited in scope, and because the doctorate serves mainly as an additional professional qualification rather than a scientific qualification (Berning & Falk, 2006, pp. 123–140; Epstein, 2016, pp. 39–44).

Nationally as well as internationally, there has been an ongoing debate about the necessity of reforming doctoral training (for Germany see: König et al., 2019, pp. 140–141; U. Schwabe and Jungbauer-Gans, 2021, pp. 112–113; for international debate see: Hayter and Parker, 2019, p. 558; Kehm, 2020; Melin and Janson, 2006; Shin, Kehm, and Jones, 2018, pp. 6–7). So far, doctoral training primarily prepares candidates for an academic career. Yet, as most doctoral graduates do not stay inside academia, some scholars suggest providing opportunities during doctoral training to also acquire qualifications needed outside academia as well as making the requirements, advantages, and disadvantages of both academic and non-academic careers transparent from the outset in order to allow doctoral candidates to judge their own suitability (e.g., Bloch, Graversen, & Pedersen, 2015, p. 179; Di Paolo, 2016, p. 525; König et al., 2019, pp. 140–141; U. Schwabe & Jungbauer-Gans, 2021, p. 113; Teelken & van der Weijden, 2018). Counterarguments against doctoral training imparting broader skills are that this would undermine the doctoral degree as a scientific qualification (e.g., Balaban, 2020) and that doctoral graduates already have good career opportunities outside academia anyway.

In official statistics in Germany, doctoral candidates have been systematically underrepresented (BuWiN, 2013, pp. 219–220, 325) because doctoral regulations either do not require doctoral candidates to enrol at university or require them to do so only for a few terms, which does not correspond to the real duration of doctoral training. Therefore, in 2016, the German law on higher education statistics (German: *'Hochschulstatistikgesetz'*) was amended with the purpose of capturing doctoral candidates more accurately (BuWiN, 2017, pp. 22, 277–281). However, the resulting statistics are still in parts insufficient (BuWiN, 2021, pp. 36, 69–70; Federal Statistical Office, 2019b; Vollmar, 2019).

While there are only partially reliable statistics on the number of doctoral *candidates* in Germany, statistics on the number of doctoral *graduates* are reliable. As in other countries, the number of higher education graduations — and therefore also the number of doctoral graduations — has increased in Germany in recent decades due to educational expansion. Figure 1.1 illustrates the development of higher education graduations since 1980. The figure shows the increase in the absolute number of higher education degrees awarded in Germany between 1981 and 2020 as a percentage compared to the reference year 1980. For the purposes of better comparability and a better overview of the dimension, it captures both doctoral and all other higher education degrees. Overall, we find that the number of all degrees has increased since 1980, but the increase of other higher education degrees is more pronounced than that of doctoral degrees. In 1980, 111,458 other higher education degrees were awarded. By 2020, this figure has quadrupled, increasing to 450,693, which corresponds to an increase of 304 %. Over the same period, the number of doctoral degrees doubled from 12,222 to 26,220, which corresponds to an increase of 115 %. By international comparison, the absolute numbers of doctoral degrees awarded in Germany are particularly high (BuWiN, 2013; Eurostat, 2020; OECD, 2021a, p. 210).

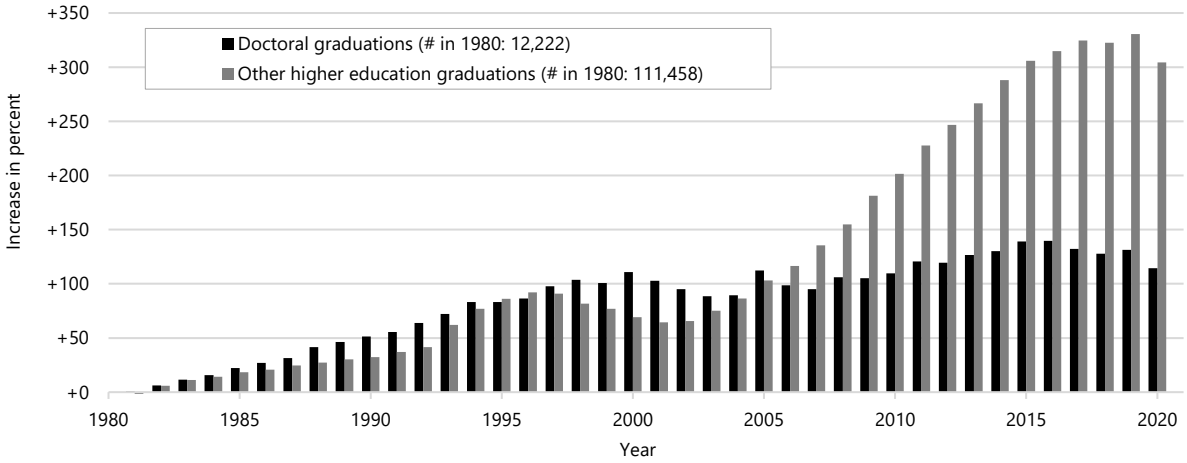

Figure 1.1: **Increase in the absolute number of doctoral degrees and other higher education degrees awarded in Germany between 1981 and 2020 given in percent compared to 1980.**
Note: from 1980 to 1992 without degrees awarded in former East Germany;
Source: Federal Statistical Office, 1998, 2021b.

Not only is the absolute number of doctoral degrees awarded in Germany high and increasing, but the doctoral graduation rate is also high. Approximately 20 % of all higher education graduates who have earned a degree qualifying for doctoral training also take up and complete doctoral training in the following years (BuWiN, 2017, p. 96; BuWiN, 2021, p. 141). Taking into account an assumed average doctorate duration of four years (BuWiN, 2017, pp. 32, 152–154), Table 1.1 shows an approximation of the doctoral graduation rate by subject group for the five most recent doctoral graduation cohorts, i.e.,

the 2016 to 2020 cohorts. It is calculated as the number of doctoral degrees awarded between 2016 and 2020 divided by the number of university degrees qualifying for doctoral training awarded between 2012 and 2016. Across all subjects, the doctoral graduation rate is 19.9 %. The rate is highest in medicine (53.8 %), but in absolute terms the most doctoral degrees awarded over the five-year period were in mathematics and natural sciences, with 42,087 graduations. The lowest doctoral graduation cohort is in art (4.3 %).

Table 1.1: Doctoral graduation rate by subject group in Germany over a period of five years

	University degrees[a] (2012–2016)	**Doctoral degrees** (2016–2020)	**Doctoral graduation rate**[b] (in %)
Humanities	9,890	93,623	10.6
Sports	606	5,488	11.0
Legal, economic, social sciences	21,503	234,788	9.2
Mathematics, natural sciences	42,087	107,015	39.3
Medicine	36,811	68,472	53.8
Agriculture, forestry, nutrition sciences, veterinary medicine	4,835	21,761	22.2
Engineering	22,876	166,778	13.7
Art	1,416	32,638	4.3
Total	138,608	697,925	19.9

[a] All university degrees qualifying for doctoral training (master's degree, state examination, traditional degree prior to Bologna),
[b] Number of doctoral degrees awarded 2016–2020 divided by the number of university degrees awarded 2012–2016
Source: Federal Statistical Office, 2021b; author's calculations

Compared to other European countries, the overall percentage of doctoral graduates in the total population of higher education graduates is high in Germany – outnumbered only by Switzerland and Austria (Auriol, 2010, p. 8). Compared to other member countries of the Organisation for Economic Co-operation and Development (OECD), the percentage of doctoral graduates in various reference populations is also particularly high in Germany, namely in the total population of the same age cohort, in the total labour force, and in the total population in general (Auriol, Misu, & Freeman, 2013, pp. 8–9; OECD, 2019).

1.2 Importance of doctoral graduates in knowledge societies

Modern knowledge societies rely largely on a high-performance science system to solve social and technological problems on scientific and research-based grounds, to overcome present and future global challenges, and to secure jobs and prosperity. In this regard, highly qualified graduates and especially doctoral graduates are a key human resource. The workforce of doctoral graduates is crucial for knowledge production, dissemination, and transfer, and for innovation, as well as for technological progress – both inside and outside academia. This has resulted in an increasing demand for doctoral graduates outside academia and thereby in a diversification of postdoctoral career paths (Bogle et al., 2010; Diamond et al., 2014; Enders & Kaulisch, 2006; Hnatkova et al., 2022; H.-f. Lee, Miozzo, & Laredo, 2010; Shin, Kehm, & Jones, 2018). Although doctoral training primarily prepares candidates for an academic career, more and more doctoral graduates find employment beyond the traditional academic career and go on to use the research qualification gained during doctoral training in the non-academic public or private sectors. Bogle et al. (2010, p. 5) explain this as follows:

> "*Employers in the public sector, charities, industry and commerce seek trained researchers who can apply their research skills to new areas necessary for their business development in industry and commerce, or where social change drives the public and charitable sector to change its focus. The need for rigorous, well-informed, painstakingly executed research*

> *is strong in the light of increased public scrutiny resulting from greater disclosure and the explosion of information in the public domain*."

Doctoral training offers many advantages for society — more precisely, for academia, economy, politics, and the individual graduates. For the *academic system*, doctoral training is beneficial as doctoral candidates' research enhances scientific knowledge production and their workforce allows universities and non-university research institutions to fulfil their teaching and research tasks. Doctoral training also provides permanent supplies of early-career researchers with, ideally, the best of them realizing an academic career and becoming a professor or senior scientist. As such they contribute to further expanding scientific knowledge and methods as well as to the training of students and future scientists.

Doctoral graduates promote *economic growth* by fostering innovations and technological progress – especially when working in private research and development departments where they transfer their scientific knowledge and apply scientific methods to find innovative solutions to business problems and to develop new products (e.g., Buenstorf & Heinisch, 2020a, 2020b; Buenstorf, Heinisch, & Kapa, 2022). Non-academic employers appreciate doctoral graduates' critical thinking, creativity, problem-solving abilities, and analytical skills in this regard (Diamond et al., 2014, pp. 66–78). Doctoral graduates introduce these abilities and skills in the workplace in general, which may also result in spillover effects on colleagues by strengthening their respective abilities and skills (Diamond et al., 2014, pp. 95–119).

Politics often require scientific knowledge for political decision-making and its justification. Therefore, scientific experts, who usually hold a doctoral degree, are key policy advisers. One example of such scientific policy advice is the newly introduced COVID-19 expert council of the German federal government (German: *'Corona-ExpertInnenrat der Bundesregierung'*). Another, older example is the German Council of Economic Experts (German: *'Sachverständigenrat zur Begutachtung der gesamtwirtschaftlichen Entwicklung'*) — most frequently referred to as the "Five Sages of Economy" (German: *'Fünf Wirtschaftsweise'*). This council is an official and institutionalized group of five economists, founded in the 1960s; all of its current and recent members are/were graduated university professors.

Previous research indicates that *doctoral graduates* themselves directly benefit from their high educational attainment as they get additional returns in the labour market compared to other higher education graduates. Doctoral graduates are less often unemployed, achieve higher earnings, more often hold management positions, and are more frequently adequately employed (BuWiN, 2013, pp. 270–288; Engelage & Hadjar, 2008; Falk & Küpper, 2013; Heineck & Matthes, 2012; König et al., 2019, pp. 36–62; Trennt & Euler, 2019).

Taken together, besides benefits for the individual, doctoral graduates also have a benefit to society as a whole by generating knowledge for civil society actors, innovation processes, economic growth, and political decision-making processes. Therefore, political institutions — both at national and EU level — usually legitimize their investments in academia and in the training of young scientists with the resulting potential for innovation and creativity for society as a whole and with the importance of scientists as economic and social functionaries (König et al., 2019, p. 134).

1.3 Overall research topics and aims of the thesis

As we have seen so far, doctoral graduates are a large group in Germany and they are acknowledged as key players in today's knowledge societies as they undertake important and responsible scientific,

social, and economic tasks. Although most doctoral graduates in Germany find employment beyond the ideal-typical academic career, their employment situation outside academia has up to this point barely been comprehensively studied. In addition, the professional success among doctoral graduates has typically only been examined in comparison to other higher education graduates, and differences in the professional success *within* the group of doctoral graduates have only occasionally been studied; yet this seems a worthwhile endeavour because doctoral graduates are not a homogeneous group — for example, their professional success demonstrably varies by doctoral subject and formal type of doctoral training (e.g., de Vogel, 2020, pp. 269–321; Enders & Bornmann, 2001, pp. 179–233; Enders & Kottmann, 2009, pp. 101, 127–128; Engelage & Hadjar, 2008; Falk & Küpper, 2013; Flöther, 2015; Jaksztat et al., 2017; König et al., 2019, pp. 62–73; Mertens & Röbken, 2013). As working conditions and career prospects differ strongly between the academic, the non-academic public, and the private sectors, it is likely and suggested in the BuWiN (2013, p. 293) and by König et al. (2019, pp. 36–59) that their level of professional success also depends on their occupational destinations. Therefore, this thesis examines:

(1) the *occupational destinations* among doctoral graduates in Germany in the initial years following graduation and

(2) their *professional success* by means of different success indicators and against the background of their occupational destinations.

I consider occupational destinations and professional success as connected, but distinct, aspects of postdoctoral careers. The term *occupational destination* refers to the differentiated sectors in which doctoral graduates are employed, with a special focus on the differentiation between the academic sector and several non-academic sectors. With regard to occupational destinations, I examine where doctoral graduates are employed following their graduation and how their occupational destinations can be explained. I define *professional success* according to Judge and Bretz (1994) and Judge et al. (1995) as "*positive psychological or work-related outcomes or achievements one has accumulated as a result of one's work experiences*" (Judge et al., 1995, p. 486). I use the term synonymously with returns to (doctoral) education in the labour market. Professional success is a multidimensional construct, and in previous research on educational returns in the labour market, a differentiation between subjective and objective professional success has proven useful (for a general overview see: Abele, Spurk, and Volmer, 2011; Judge et al., 1995; Spurk, 2019; for example studies see: Abele and Spurk, 2009; Enders and Bornmann, 2001; Engelage and Hadjar, 2008; Engelage and Schubert, 2009; Falk and Küpper, 2013; Flöther, 2015; Kühne, 2009; Ng et al., 2005). Objective indicators are externally observable metrics on job characteristics and returns to education that can be assessed by researchers. They are said to be directly comparable and therefore relatively objective, such as earnings or whether individuals hold a management position. In contrast, subjective indicators take into account the individuals' perception of their own job characteristics and returns to education, such as their job satisfaction or subjective assessment of their job adequacy. Although this subjective perspective is linked to the individuals' objective professional success, it is not necessarily coincident; therefore, it is important to differentiate between both types of indicators. In this thesis, I examine professional success by means of various objective and subjective success indicators related to the returns to doctoral education in the labour market and against the background of the graduates' occupational destinations. In addition, I also investigate examples of *social inequality* in doctoral graduates' occupational destinations and professional success.

I focus on doctoral graduates specifically in Germany because here postdoctoral career opportunities and paths differ in several regards from those in other countries. To begin with, the German academic system "produces" a particularly high number of doctoral graduates in the first place in international comparison (Eurostat, 2020; OECD, 2021a, p. 210). Therefore, German academia does not provide enough jobs to absorb all doctoral graduates. Approximately seven out of ten doctoral graduates — a particularly large number — leave academia in the years following doctoral graduation (Flöther, 2015; Jaksztat et al., 2017; König et al., 2019). Both as a result and as a precondition, the doctorate is not only valued in the academic but also in the non-academic German labour market. Thus, doctoral degrees fulfil a dual function in Germany (BuWiN, 2013, p. 252); on the one hand, they are a necessary requirement for an academic career; on the other hand, they qualify a candidate for jobs outside academia with research-related and/or responsible tasks. In addition, with the DZHW PhD Panel 2014, new panel survey data is available on the careers of recent doctoral graduates in Germany. This survey data is unique as it is the first data in Germany that combines nationally representative survey data of doctoral graduates with a medium-term observation period. Yet a perennial observation period is expedient when studying postdoctoral careers as Nerad (2020, p. 44) points out:

> "*Surveys assessing careers immediately after degree completion are only partially useful, as many PhDs will be in post-doctoral positions or other temporary jobs. Astonishingly little knowledge exists concerning the employment of doctorate recipients five to ten years after degree completion*."

Against the background of its overall research topics and interests, this thesis' research agenda is located within higher education research and has intersections with both labour market and inequality research. Higher education research is an interdisciplinary field of research, but my access to it is through the lens of sociology. In general, *sociology* is concerned with explaining social phenomena, processes, and inequality by examining and explaining the (inter-)actions of actors within social contexts. The specific social phenomena under study in this thesis are inequality in dropout from academia, employment sector choices, the relationship between working conditions and job satisfaction, and the gender pay gap. The actors that I am focusing on are doctoral graduates in Germany in the initial five years following graduation. Based on the individual graduates at the micro-level, I try to provide insights on postdoctoral careers in general at the macro-level.

This thesis aims to take a closer look at differences in occupational destinations and professional success within the group of doctoral graduates; thereby shedding new light on postdoctoral careers, a goal which also complies with one of the concluding expert recommendations of a 2019 conference on doctoral education worldwide[2]:

> "*Support more research on doctoral education for evidence-based decision-making on doctoral education around the globe. We recommend to [. . .] track careers transparently and comprehensively to establish an evidence base for change in doctoral education, to encourage and involve alumni as agents of change, and to illustrate the value of doctoral education to society at large, especially in the face of recent political curbs on higher education and research [...].*" (Nerad et al., 2019, p. 3)

Because doctoral graduates are ascribed important roles in several areas of society and because many of them will eventually undertake responsible tasks in one way or another, it is essential to understand and learn about their career paths, their returns in the labour market, and potential social

[2] Please note that I have myself attended the conference, which was entitled "Revisiting Forces and Forms of Doctoral Education Worldwide" and took place in Hanover, Germany, in September 2019.

inequalities. This knowledge is necessary to prepare doctoral candidates for these careers, irrespective of whether pursued inside or outside academia, but also to reduce possibly existing social inequalities in postdoctoral careers. In addition, by generating new insights into postdoctoral careers, this thesis also provides an empirical basis that can possibly further enrich the ongoing debate about the necessity of reforming doctoral training and thereby may allow the drawing of conclusions and implications for doctoral training. In general, quality assurance in doctoral training can only succeed if there is enough knowledge on postdoctoral career paths — to which this work aims to contribute. On a side note, the focus on a homogeneous educational group brings with it the methodological advantage of eliminating differences in educational attainment; therefore, the latter are excluded as an explanation of differences in the outcomes under study.

1.4 Conception of the individual papers

Within the scope of the overall research topics, this thesis comprises five scientific and peer-reviewed papers.[3] The papers provide insights into their specific research questions, but when combined, they also provide general insights into doctoral graduates' occupational destinations and professional success. Figure 1.2 gives an overview of the individual papers. It shows how they relate to the overall research topics of doctoral graduates' occupational destinations and professional success, whether their research question is cross-sectional or longitudinal, and whether they take into account social inequalities.

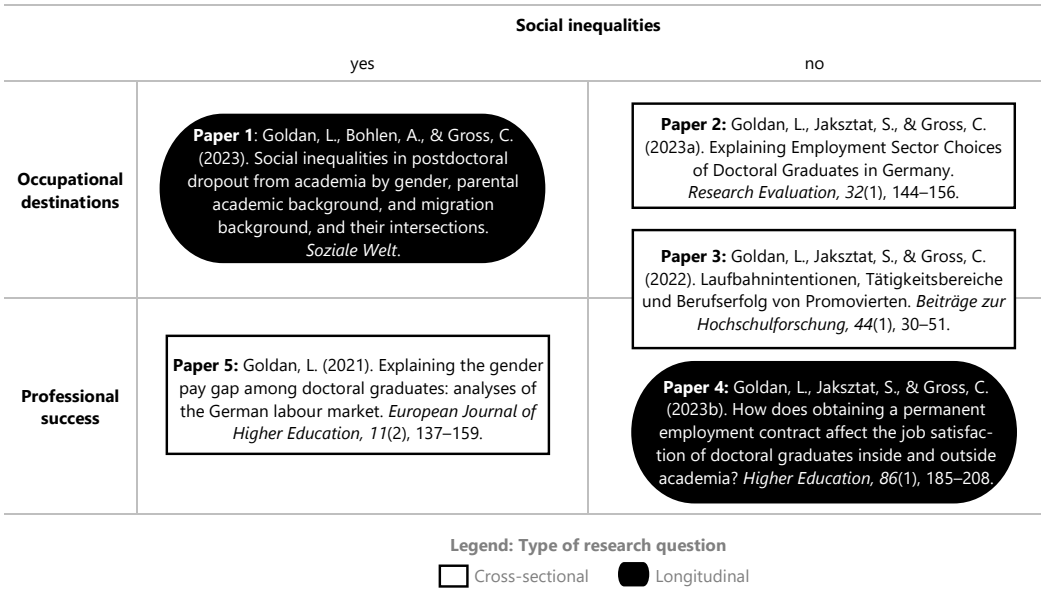

Figure 1.2: **Overview of the individual papers' research questions.**

As I assume that doctoral graduates' occupational destinations and professional success are connected, the starting point of my analyses and groundwork for the subsequent analyses are *doctoral graduates'*

[3]The papers were realized within the framework of the "Subjective and objective professional success of PhD holders in Germany" research project (German: *'Subjektiver und objektiver Berufserfolg von Promovierten in Deutschland'*), which is a joint project between Christiane Gross (University of Würzburg) and Steffen Jaksztat (DZHW) and funded by the German Research Foundation (DFG) under project number: 433155285. Although my doctorate was not funded by the DFG-project, but in large parts by a doctoral scholarship by the German Academic Scholarship Foundation, the DFG-project was a driving force for my close and very productive cooperation with Steffen Jaksztat and provided me with monetary resources for conference visits, further training, and support by a student assistant.

occupational destinations. Thus, the first two papers examine outcomes related to occupational destinations — once with a focus on social inequalities, once without an inequality perspective. The *first paper* (Goldan, Bohlen, & Gross, 2023) examines potential social inequalities in postdoctoral dropout from academia in the five years following doctoral graduation from an intersectional perspective and in a longitudinal research design, with dropout from or rather survival inside academia being one dimension of doctoral graduates' occupational destinations. The paper's research question is: *are there social inequalities by gender, parental academic background, and migration background, and their intersections in postdoctoral dropout from academia?* The paper is a joint work with Aaron Bohlen and Christiane Gross[4] and is scheduled to be published in the "Career Paths Inside and Outside Academia" special issue of the German *'Soziale Welt'* journal in October 2023. The *second paper* (Goldan, Jaksztat, & Gross, 2023a) investigates the occupational destinations in more depth than the first as it differentiates between five distinct employment sectors. More precisely, it differentiates between employment in the academic sector and four types of employment outside academia. The paper aims at explaining doctoral graduates' employment sector choices and identifying their underlying determinants. Its research question is: *what are the determinants of doctoral graduates' employment sector choices?* Because of its cross-sectional research interest, it focuses on the employment sectors at a particular point in time, namely at the time five years following doctoral graduation. It is a joint work with Steffen Jaksztat and Christiane Gross[5] and was published in *Research Evaluation* in 2023.

The *third paper* (Goldan, Jaksztat, & Gross, 2022) links the overall research topics as it focuses on the *intersection between doctoral graduates' occupational destinations and their professional success*. The paper explores and describes the associations between doctoral graduates' academic career intentions, employment sectors — using the same categorization of employment sectors as *paper 2* — and various objective and subjective indicators of professional success. The main research question is: *what are the differences in doctoral graduates' professional success by employment sector?* Thus, the paper has a cross-sectional research interest and it mainly focuses on the time five years following graduation. It is a joint work with Steffen Jaksztat and Christiane Gross[6] and was published in the German *'Beiträge zur Hochschulforschung'* journal in 2022.

The last two papers each investigate a specific indicator of *doctoral graduates' professional success* in more detail — again, once from an inequality perspective and once not. The outcome studied in the *fourth paper* (Goldan, Jaksztat, & Gross, 2023b) is doctoral graduates' job satisfaction, which is a subjective success indicator. The paper examines the association between the graduates' contract type and their job satisfaction and whether this association is moderated by the graduates' labour market sector. More specifically, the underlying research questions are: 1) *What effect does obtaining a permanent employment contract have on recent doctoral graduates' job satisfaction?* and 2) *Is the effect different for doctoral graduates inside and outside academia?* With a focus on intra-individual variation in contract type, the paper has a longitudinal research interest, which is implemented by including the graduates' employment trajectories from doctoral graduation until five years later. The graduates' occupational destinations are also taken into account as the paper allows the treatment

[4] Aaron Bohlen has done the conceptual and statistical groundwork for the paper as part of his Master's thesis. I have refined his groundwork and have written the first draft of the manuscript, performed all data preparations and statistical analyses, and was primarily responsible for the revisions of the manuscript. Christiane Gross has supervised the whole research process and has consulted in all key decisions.

[5] This paper was initiated by Steffen Jaksztat. Steffen Jaksztat and I were equally involved in the theoretical and methodological conceptualization, literature research, data analysis, and in both writing and revising the manuscript. Christiane Gross was responsible for supervision and has consulted in all key decisions.

[6] I have written large parts of the first manuscript version. Steffen Jaksztat has complemented and revised the first manuscript version, supported me with the data preparations and analyses, and helped to sharpen the analytical strategy. Again, Christiane Gross has supervised the research process and has consulted in all key decisions.

effect to differ between doctoral graduates in the academic, non-academic public, and private sectors. For this paper, published in *Higher Education* in 2023, I have again collaborated with Steffen Jaksztat and Christiane Gross[7]. The *fifth paper* (Goldan, 2021) studies an objective indicator of professional success in terms of earnings. It adopts an inequality perspective with a focus on gender inequalities as it tries to identify the determinants of the gender pay gap among doctoral graduates. The paper's research question is: *what are the determinants of the gender pay gap among doctoral graduates?* Aiming at quantifying and explaining the gender pay gap, the paper has a cross-sectional research interest and focuses on the time five years following graduation. Like *paper 4*, it also takes into account the graduates' occupational destinations as it tests whether the gender pay gap differs between doctoral graduates inside and outside academia. The paper was written in sole authorship and published in the *European Journal of Higher Education* in 2021.

The remainder of this thesis is structured as follows. In the next section, I present previous research on doctoral graduates' occupational destinations and professional success as well as the thesis' and papers' contributions to research (section 2). In section 3, I position the thesis theoretically and briefly describe the papers' theoretical approaches and expectations. Afterwards, I introduce the DZHW PhD Panel 2014, which is the data basis for all papers, how I handle missing data in all papers, as well as the papers' methodological similarities and differences (section 4). Sections 5 to 9 include the individual papers, and in section 10, I summarize and discuss the results of the papers against the background of the overall research interest, elaborate on policy implications, describe the limitations of my research, and point out directions for future research.

[7] We have equally contributed to the study conception and design and to revisions of the manuscript. I have performed all data preparations and statistical analyses and have written the first draft of the manuscript, except for the discussion and conclusions, the first draft of which was written by Steffen Jaksztat. Christiane Gross again had the supervising and consulting role.

2 State of research

In the following, I review previous research on doctoral graduates' occupational destinations and professional success. Wherever pertinent, I include studies from national contexts other than Germany, but because of my research interest and large differences in academic systems and postdoctoral employment between countries, I place a special focus on previous research specifically on doctoral graduates in Germany — and to some extent also in Austria and Switzerland. I start with the state of research on doctoral graduates' occupational destinations, then continue with the state of research on their professional success, and end by elaborating on this thesis' contributions to narrowing existing research gaps.

2.1 Occupational destinations among doctoral graduates

In Germany, previous research has regularly examined doctoral graduates' occupational destinations in one way or another. In general, only a minority of doctoral graduates stay inside academia in the long-term and realize the ideal-typical academic career. On the one hand, some doctoral graduates have never truly been inside academia in the first place because they have completed their doctoral training without employment inside academia or another institutional integration into academia. On the other hand, the majority of doctoral candidates in Germany are employed inside academia during their doctoral training (e.g., Federal Statistical Office, 2016, p. 36; Flöther, 2015; Hüther & Krücken, 2018, p. 198), but many of them leave academia at some point following graduation (König et al., 2019, pp. 99–101). In fact, doctoral graduation is an important moment of decision for or against an academic career.

There are various and sometimes very individual *reasons for doctoral graduates leaving academia* that are given in the following list. It is not meant to be exhaustive but summarizes some major and more general reasons, which are also mutually related:

(1) A substantial proportion of doctoral candidates have never had an academic career intention (e.g., Berweger & Keller, 2005; Hauss, Kaulisch, & Tesch, 2015; Krempkow, Sembritzki, & Schürmann, 2016, p. 32) but have taken up doctoral training to deliberately improve their career opportunities in the non-academic labour market. In some disciplines, such as medicine and chemistry, a doctoral degree is even considered as standard degree for a non-academic career.

(2) Some doctoral candidates' academic career intentions decline in the course of their doctoral training. This pattern has been found among doctoral candidates in Germany (Kaiser, 2020) and in the US (Roach & Sauermann, 2017), and it seems to be particularly prevalent in engineering, mathematics, and natural sciences.

(3) Doctoral graduates encounter good career prospects in the German non-academic labour market (see section 2.2) and may leave academia due to attractive job opportunities outside academia.

(4) Working conditions inside German academia below professorship level are highly insecure and precarious (e.g., Borgwardt, 2010; BuWiN, 2017, 2021; Dörre & Neis, 2008; Kreckel, 2016; Waaijer, 2015). There are only a few permanent positions available and the lack of permanent positions is even intensified, given the high number of doctoral graduations in Germany each year as well as provisions by the German law on academic employment. Recently, precarious working conditions

of doctoral candidates and postdocs have been — and continue to be — much debated around the Twitter hashtag *'#IchBinHanna'* ('#IamHanna') (Bahr et al., 2021; Bahr, Eichhorn, & Kubon, 2022; Dirnagl, 2022). Because of these precarious working conditions and few permanent positions, some doctoral graduates may voluntarily leave academia following graduation, while others, trying to realize an academic career, will find themselves forced to leave academia once their employment contract expires or has reached the maximum period of temporary employment of six years if they have not obtained one of the few permanent positions by then (referred to as 'up or out' policy). Only a few doctoral graduates eventually succeed in realizing an academic career and are appointed to a professorship or obtain some other kind of permanent position inside academia.

There is a large and mostly descriptive body of research on *doctoral graduates' employment sectors* using very different employment sector categorizations and considering different postdoctoral career stages (BuWiN, 2013, p. 290; BuWiN, 2017, p. 185; Briedis et al., 2014, pp. 51–56; Enders & Bornmann, 2001; Enders & Kottmann, 2009; Flöther, 2015, 2017; Jaksztat et al., 2017; König et al., 2019; M. Schwabe, 2011). Overall, the studies indicate that the proportion of doctoral graduates employed inside academia declines in the course of their postdoctoral employment trajectories. König et al. (2019, p. 99) have focused on the employment sectors of the 2005 doctoral graduation cohort over the period between two years prior to graduation to ten years following graduation. They find that two years prior to their graduation, 61 % of doctoral graduates were employed at a university or non-university research institution. By the time of graduation this proportion had declined to 43 %, and one year later it had further decreased to 30 %. In the following years, the proportion continues to decrease, and ten years following graduation, only 22 % of doctoral graduates are still employed inside academia. Other studies considering the time approximately one to two years following graduation report similar proportions with between 19 % and 34 % of doctoral graduates still being employed inside academia (BuWiN, 2013, p. 290; Flöther, 2015, 2017; Jaksztat et al., 2017). Regarding the graduates' specific sectors of non-academic employment, these studies uniformly indicate that 17 % of all graduates have research-related jobs in the private or non-academic public labour market sectors at that time and that 52 % to 64 % work in non-research jobs in these sectors. In total, approximately one half of doctoral graduates seem to have an academic or at least a research-related job in the initial years following graduation, and the other half seem to have non-research jobs outside academia.

Studies have also regularly described the employment sectors of doctoral graduates in other countries than Germany — but again using different employment sector categorizations and considering different postdoctoral career stages (Agarwal & Ohyama, 2013; Alfano et al., 2021; Auriol, 2010; Auriol, Misu, & Freeman, 2013; Ballarino & Colombo, 2010; Bloch, Graversen, & Pedersen, 2015; Kyvik & Olsen, 2012; H.-f. Lee, Miozzo, & Laredo, 2010; Mangematin, 2000; Neumann & Tan, 2011; Passaretta, Trivellato, & Triventi, 2019; Stephan et al., 2004; Waaijer, 2017). Studies using data of the international comparative 'Careers of Doctorate Holders' survey among all doctoral graduates residing in one of the surveyed OECD countries in a given year find that the proportion of doctoral graduates working in different employment sectors varies largely by country (Auriol, 2010; Auriol, Misu, & Freeman, 2013). At one end of the scale, there are Poland and Portugal where the vast majority of doctoral graduates are employed inside academia (approximately 90 %) and only a few graduates are employed in non-academic sectors. At the other end of the scale, there are doctoral graduates in Denmark and in the Netherlands; with a proportion of approximately 30 % here, the least doctoral graduates of all countries studied are employed inside academia. In both countries, approximately every third doctoral graduate is working in the business sector. However, studies exclusively on doctoral graduates in Denmark

(Bloch, Graversen, & Pedersen, 2015) and the Netherlands (Waaijer, 2017) report larger proportions of graduates employed inside academia with 40 % and 60 %, respectively. Regarding doctoral graduates in Italy, recent findings on their academic employment are more consistent with approximately 40 % working inside academia approximately five years following graduation (Alfano et al., 2021; Passaretta, Trivellato, & Triventi, 2019). Because of different categorizations of the non-academic employment sectors, it is difficult to summarize results in this regard.

In addition, both international research and research in Germany suggest differences in doctoral graduates' employment sectors by discipline (Briedis et al., 2014; BuWiN, 2013, p. 290; BuWiN, 2021, pp. 214–215; Enders, 2002; Enders & Bornmann, 2001; Flöther, 2015, 2017; König et al., 2019, pp. 96–101; Kyvik & Olsen, 2012; Passaretta, Trivellato, & Triventi, 2019; M. Schwabe, 2011; Stephan et al., 2004). The studies referring to Germany suggest the following pattern: doctoral graduates from humanities tend to be particularly frequently employed inside academia following graduation and those from law and medicine particularly seldom. Some studies also find differences in employment sectors by formal type of doctoral training with doctoral graduates having completed an internal doctorate being *more* likely and those having completed an external doctorates being *less* likely to be employed inside academia than outside (Enders & Bornmann, 2001, p. 101; Flöther, 2017; Jaksztat et al., 2017).

Occasionally, studies have also tried to explain doctoral graduates' occupational destinations (Agarwal & Ohyama, 2013; Balsmeier & Pellens, 2014; Bloch, Graversen, & Pedersen, 2015; Briedis et al., 2014, pp. 51–56; Flöther, 2017; Herrera & Nieto, 2016; Waaijer, 2017; Wenqin et al., 2018). These studies have shown that the sector choices made by doctoral graduates are shaped by individual preferences for certain job attributes, by the number of awarded doctoral degrees within a subject group, by the graduates having been externally encouraged to pursue a specific career path, and by their subjective perceptions of academic career prospects. The most comprehensive study so far is Bloch, Graversen, and Pedersen (2015), which refers to doctoral graduates in Denmark, but similar results are available for the United States (Agarwal & Ohyama, 2013) and the Netherlands (Waaijer, 2017). For Germany, there is little research on the determinants of doctoral graduates' employment sectors (Briedis et al., 2014, pp. 51–56; Flöther, 2017).

In the case of doctoral graduates, another dimension of their occupational destinations concerns their *chances of being appointed to a professorship*, as some graduates do strive for an academic career. Against this background, some studies focus on university faculty members (Lutter & Schröder, 2016; Schröder, Lutter, & Habicht, 2021), on several doctoral graduation cohorts (Lang & Neyer, 2004), or on specific subgroups of doctoral graduates pursuing academic careers (Jungbauer-Gans & Gross, 2013; G. G. Schulze, Warning, & Wiermann, 2008; Zimmer, 2018) and examine the determinants of their chances of being appointed to a full professorship. For example, G. G. Schulze, Warning, and Wiermann (2008) have studied doctoral graduates from economics and business administration in Germany, Austria, and the German-speaking part of Switzerland who have additionally also completed a *'Habilitation'*, i.e., the next traditional academic qualification after the doctorate that qualifies for a teaching career in higher education and that is typically another necessary requirement for being appointed besides the doctorate. They found that the age at completion of the habilitation, some habilitation characteristics, the number of journal articles, and marital status are all associated with the chances of becoming a professor. Another study on doctoral graduates with a habilitation and their chances of being appointed to a professorship is by Jungbauer-Gans and Gross (2013). They have focused only on Germany and compared three different disciplines: sociology, law, and mathematics. They found that the determinants of being appointed professor vary by discipline with the number of publications in indexed journals and gender being important in sociology; the parents' years of

education and the mentor's reputation being important in law; and the parents' occupational prestige, marital status, time spent doing research, a specialization in applied mathematics, and the mentor's reputation being important in mathematics. Age at habilitation is negatively associated across all disciplines with the chances of appointment.

Besides the habilitation, another — only recently introduced — academic postdoctoral qualification for a lifetime professorship is the junior professorship. Zimmer (2018, pp. 258–266) has investigated the chances of being appointed to a full professorship within that special group of junior professors. Using survey data of junior professors at universities in three federal states in Germany, Zimmer found that their chances of being appointed depend on whether they have given advisory services for politics and companies, on their age when taking up the junior professorship, on subjective career prospects inside academia, and on whether their junior professorship includes academic tenure in the first place. In contrast, the number of publications, the subject group, and support received from a mentor with a high reputation are not associated with junior professors' chances of being appointed to a full professorship.

In addition, there has also been research on social inequalities in academic careers in Germany. However, findings are ambiguous. While most studies find no inequalities by either gender, parental academic background, or migration background once individuals have completed their doctorate (e.g., Auspurg, Hinz, & Schneck, 2017; Enders & Bornmann, 2001; König et al., 2019; Leemann, Keck, & Boes, 2010; Lörz & Mühleck, 2019; Lörz & Schindler, 2016; G. G. Schulze, Warning, & Wiermann, 2008), some studies do find inequalities by one of these social categories (Buche & Gottburgsen, 2012; Flöther, 2017; Jungbauer-Gans & Gross, 2013; Möller, 2017, 2018; Zimmer, 2018), and a few studies even suggest intersectional inequalities (Bakshi-Hamm & Lind, 2008; Löther, 2012; Möller, 2017, 2018; Neusel et al., 2014; Shinozaki, 2017).

2.2 Professional success among doctoral graduates

In Germany, doctoral graduates' professional success has occasionally been studied — typically by comparing various occupational characteristics between doctoral graduates and other higher education graduates. In terms of several subjective and objective professional success indicators, such studies have found that doctoral degrees are associated with additional monetary and non-monetary returns.

First, doctoral graduates have a *higher employment rate* than other higher education graduates. According to Enders and Bornmann (2001, pp. 201–205), doctoral graduates generally find employment following graduation more quickly, with these differences by academic degree varying by subject group. Other studies have shown that doctoral graduates are more often employed and less often unemployed (BuWiN, 2013, pp. 254–255; Engelage & Hadjar, 2008). For example, the 2009 microcensus indicates that 95 % of doctoral graduates in the age group of 35 to 45 years were gainfully employed compared to 89 % among other higher education graduates and 83 % among the general working population, respectively in the same age group (BuWiN, 2013, p. 255). However, among both doctoral graduates and other higher education graduates, men are generally more often employed than women.

Second, doctoral graduates achieve *higher earnings* than other higher education graduates (BuWiN, 2013, pp. 261, 285; Enders & Bornmann, 2001, pp. 209–217; Engelage & Hadjar, 2008; Falk & Küpper, 2013; Flöther, 2015; Heineck & Matthes, 2012; König et al., 2019, pp. 38–49; Mertens & Röbken, 2013; Trennt & Euler, 2019). König et al. (2019, p. 38) have shown across several graduation cohorts that doctoral graduates earn substantially and statistically significantly more than other higher education

graduates, both five and ten years following graduation. For example, in the 2005 graduation cohort, doctoral graduates earned 88,250 € gross per year ten years following graduation as opposed to other higher education graduates' gross annual earnings of 65,300 €. Measured in terms of hourly wages, the same pattern appears with doctoral graduates earning more than other higher education graduates (Mertens & Röbken, 2013; Trennt & Euler, 2019). However, findings are ambiguous regarding the association between the labour market sector and these earning differences. According to Falk and Küpper (2013) and König et al. (2019, p. 48), earning differences by academic degree are moderated by the overall labour market sector with earning differences between doctoral graduates and other higher education graduates being more pronounced in the private than in the public sector. By contrast, Trennt and Euler (2019) find no such moderation effect but state that these earning differences exist both in the private and in the public sectors. Yet, some of the studies suggest earning differences by subject group (BuWiN, 2013, p. 262; Engelage & Hadjar, 2008; König et al., 2019, p. 40; Mertens & Röbken, 2013) and by gender with female doctoral graduates earning less than male doctoral graduates (BuWiN, 2013, p. 262; Engelage & Hadjar, 2008; Falk & Küpper, 2013; Flöther, 2015; König et al., 2019, p. 39; Mertens & Röbken, 2013).

Third, doctoral graduates *more often hold management positions* than other higher education graduates (BuWiN, 2013, p. 286; Enders & Bornmann, 2001, pp. 217–223; Falk & Küpper, 2013; König et al., 2019, pp. 55–59; Trennt & Euler, 2019). Studies using survey data on several graduation cohorts have shown that the proportion of individuals holding a management position is approximately 15 percentage points higher among doctoral graduates than among other higher education graduates ten years following graduation (BuWiN, 2013, p. 286; König et al., 2019, pp. 55–59; Trennt & Euler, 2019). Falk and Küpper (2013) find a similar pattern in descriptive analyses. Yet, there is some evidence for these differences varying by gender, subject group, and labour market sector (Enders & Bornmann, 2001; König et al., 2019, pp. 57–59).

Fourth, doctoral graduates subjectively assess themselves to be *more frequently adequately employed* in one way or another than other higher education graduates (BuWiN, 2013, p. 285; Enders & Bornmann, 2001, p. 226; Engelage & Hadjar, 2008; Falk & Küpper, 2013; Flöther, 2015; Heineck & Matthes, 2012; König et al., 2019, pp. 49–55; Trennt & Euler, 2019). Studies have shown for several graduation cohorts that doctoral graduates more frequently assess their jobs to be completely adequate and less frequently to be completely inadequate than other higher education graduates (BuWiN, 2013, p. 285; König et al., 2019, p. 51; Trennt & Euler, 2019). Some studies differentiate between various dimensions of job adequacy and find that doctoral graduates assess their jobs to be more adequate regarding their job position, task level, and subject qualification (Flöther, 2015; Heineck & Matthes, 2012). Yet again, there seem to be small differences by subject group (Enders & Bornmann, 2001, p. 226; Engelage & Hadjar, 2008; Falk & Küpper, 2013; König et al., 2019, p. 53).

Fifth, doctoral graduates tend to be *slightly more satisfied with their jobs* than other higher education graduates (BuWiN, 2013, p. 287; Enders & Bornmann, 2001, pp. 228–229; Falk & Küpper, 2013; Flöther, 2015; Heineck & Matthes, 2012; König et al., 2019, pp. 59–62). These studies examine either job satisfaction in general or facet satisfactions, such as satisfaction with career prospects or with further training opportunities, and find that doctoral graduates seem to be slightly more satisfied with their jobs and/or specific job characteristics. For example, in the 2009 graduation cohort, 74 % of the doctoral graduates are (very) satisfied with their jobs compared to 68 % of the other higher education graduates (König et al., 2019, p. 60).

However, note that all of these studies do not provide any causal analyses and therefore only indicate associative relations rather than causal relations between academic degrees and their various returns in the labour market (Auer et al., 2016; BuWiN, 2017, p. 227). Alternative explanations of increased returns to doctoral degrees could also be that certain skills, such as a high level of personal commitment and motivation, make it more likely that an individual takes up and completes doctoral training, and they may also have a positive impact on professional success indicators, such as earnings and the chances of holding management positions.

Besides studies that compare the professional success between doctoral graduates and other higher education graduates, some studies have also examined the *determinants of doctoral graduates' professional success* in terms of some of the afore-mentioned indicators (de Vogel, 2020; Enders & Bornmann, 2001; Enders & Kottmann, 2009; Engelage & Schubert, 2009; Goldan, 2019, 2020; Hartmann & Kopp, 2001). Enders and Kottmann (2009, pp. 127–128), Hartmann and Kopp (2001), and de Vogel (2020, pp. 269–321) have investigated the determinants of doctoral graduates' chances of holding a management position, Engelage and Schubert (2009) have investigated the determinants of three dimensions of job adequacy, and Enders and Bornmann (2001, pp. 179–198) have investigated the determinants of doctoral graduates' earnings, job position, and career satisfaction. Although considering different outcomes and using different data, operationalizations, and methods, most of these studies consistently find that the graduates' subject group, age, professional experience gained following graduation, and their labour market sector are somewhat important determinants. In addition, Goldan (2019, 2020) has studied the gender pay gap and its determinants among doctoral graduates in Germany, i.e., gender inequalities in postdoctoral earnings. Both studies use different data and samples and consider partly different determinants. Therefore, the studies come to slightly different conclusions, but they consistently find a substantial gender pay gap, which is mediated by the doctoral subject group and professional experience.

Descriptive analyses in the BuWiN (2013, p. 293) juxtapose various subjective and objective indicators of doctoral graduates' professional success against their labour market sector one-and-a-half years following graduation and also suggest the labour market sector to be important for doctoral graduates' professional success. More precisely, doctoral graduates inside academia are the least likely to be permanently employed (13 %), they receive the lowest gross monthly earnings (approximately 3,200 €), quite regularly hold management positions (43 %), and assess their job adequacy across various dimensions as exceptionally high (81 % to 95 %). By contrast, doctoral graduates in the private sector are particularly often full-time (91 %) and permanently employed (81 %), earn the most (approximately 4,500 € gross per month), quite regularly hold management positions (42 %), but assess their job adequacy in terms of the same dimensions as before slightly less frequently as high (69 % to 85 %). Doctoral graduates in the non-academic public sector lie mostly between doctoral graduates in the two other sectors except that the proportion holding a management position is lower (27 %).

2.3 Contribution to research

The above-mentioned research landscape on doctoral graduates' occupational destinations and professional success has provided important insights into postdoctoral careers but also left some blind spots that serve as a starting point for this thesis. With regard to *doctoral graduates' occupational destinations*, one strand of research concerns social inequalities in academic careers in Germany, which has produced ambiguous findings. While some studies have found no social inequalities (e.g.,

Auspurg, Hinz, & Schneck, 2017; Enders & Bornmann, 2001; König et al., 2019; Leemann, Keck, & Boes, 2010; Lörz & Mühleck, 2019; Lörz & Schindler, 2016; G. G. Schulze, Warning, & Wiermann, 2008), others did find some (Buche & Gottburgsen, 2012; Flöther, 2017; Jungbauer-Gans & Gross, 2013; Möller, 2017, 2018; Zimmer, 2018), and still others even suggested intersectional intertwinings of different social categories (Bakshi-Hamm & Lind, 2008; Löther, 2012; Möller, 2017, 2018; Neusel et al., 2014; Shinozaki, 2017). However, in Germany, research specifically on intersectional inequalities in academic careers is scarce (exceptions: Buche & Gottburgsen, 2012; Shinozaki, 2017). Against the background of the intersectionality approach, *paper 1* contributes to narrowing this gap in research by studying social inequalities by gender, parental academic background, and migration background, and their intersections in postdoctoral dropout from academia. In contrast to previous research among specific subgroups of doctoral graduates clearly pursuing an academic career (Jungbauer-Gans & Gross, 2013; G. G. Schulze, Warning, & Wiermann, 2008; Zimmer, 2018), the focus on doctoral graduates regardless of their career intentions and further academic qualifications allows me to consider a larger and more general group and chances for an academic career at an earlier career stage. The paper aims at providing new insights into the empirically-contested question of whether there are social inequalities in academic careers.

Another strand of research regarding doctoral graduates' occupational destinations concerns their employment sectors in general. There is a large body of research that has described doctoral graduates' employment sectors in different national contexts (for Germany: BuWiN, 2013, p. 290; BuWiN, 2017, p. 185; Enders & Bornmann, 2001; Enders & Kottmann, 2009; Flöther, 2015; König et al., 2019) but only relatively little research on the determinants of their employment sector choices (Agarwal & Ohyama, 2013; Balsmeier & Pellens, 2014; Bloch, Graversen, & Pedersen, 2015; Briedis et al., 2014, pp. 51–56; Flöther, 2017; Herrera & Nieto, 2016; Waaijer, 2017; Wenqin et al., 2018). These studies have been able to identify several determinants, but they have not or have hardly derived the determinants from theory, their data have not been representative of a full doctoral graduation cohort, and they have only used a rough differentiation of employment sectors. For Germany, research on the determinants of doctoral graduates' sector choices is scarce (Briedis et al., 2014, pp. 51–56; Flöther, 2017). However, because of the high number of awarded doctorates in Germany and because postdoctoral employment is characterized by few tenured and precarious positions below professorship level inside academia and relatively good career prospects outside academia, resulting in high incentives to leave academia following doctoral graduation, Germany is an interesting case study. Therefore, *paper 2* examines the determinants of the employment sector choices among doctoral graduates in Germany. The paper's strengths are that it derives all determinants from theory, uses a particularly appropriate employment sector categorization that combines the graduates' overall labour market sector and their jobs' research reference, and that it uses panel instead of cross-sectional data, which allows us to measure the determinants prior (i.e., in wave 1 or 2) to the employment sectors (wave 5).

Previous research on *doctoral graduates' professional success* has typically examined one or several success indicators in comparison to other higher education graduates (BuWiN, 2013, pp. 252–288; Enders & Bornmann, 2001, pp. 199–233; Engelage & Hadjar, 2008; Falk & Küpper, 2013; Flöther, 2015; Heineck & Matthes, 2012; König et al., 2019, pp. 36–73; Mertens & Röbken, 2013; Trennt & Euler, 2019). Although it has been occasionally shown that doctoral graduates' professional success varies within doctoral graduates (e.g., de Vogel, 2020, pp. 269–321; Enders & Bornmann, 2001, pp. 179–198; Falk & Küpper, 2013; Flöther, 2015; Jaksztat et al., 2017; König et al., 2019, pp. 62–73), few studies have explicitly examined differences *in* and determinants *of* the professional success within the group of doctoral graduates (de Vogel, 2020; Enders & Bornmann, 2001; Enders & Kottmann,

2009; Engelage & Schubert, 2009; Goldan, 2019, 2020; Hartmann & Kopp, 2001) — and if so then often only the determinants of their chances of holding a management position. Therefore, with doctoral graduates' job satisfaction, this thesis studies, on the one hand, a subjective indicator of their professional success and how it is associated with their contract type (*paper 4*). The paper links previous research on temporary employment, job satisfaction, and doctoral graduates. The only previous study on the association between doctoral graduates' contract type and their job satisfaction found that temporary employment is negatively associated with the graduates' job satisfaction (Waaijer et al., 2017); however, the study was only cross-sectional. By contrast, by using panel data on the employment trajectories of a recent doctoral graduation cohort and employing panel analyses that rely on within-variation, *paper 4* better approximates the effect of obtaining a permanent employment contract on doctoral graduates' job satisfaction.

On the other hand, with the gender pay gap among doctoral graduates, the thesis also investigates an objective indicator and earning differences within the group of doctoral graduates (*paper 5*). Previous research has regularly shown that in many countries female doctoral graduates earn less than male doctoral graduates (Amilon & Persson, 2013; Ballarino & Colombo, 2010; Bornmann & Enders, 2004; Christie & Shannon, 2001; Desjardins & King, 2011; Enders & Bornmann, 2001; Engelage & Hadjar, 2008; Goldan, 2019, 2020; U. Schulze, 2015; Waite, 2017). However, few of these studies have also tried to explain the reasons for this gender pay gap and there is disagreement about to what extent the gender pay gap is caused by gender differences in doctoral and occupational characteristics (Ballarino & Colombo, 2010; Goldan, 2019, 2020; U. Schulze, 2015). Therefore, *paper 5* aims at providing new insights into the determinants of the gender pay gap among doctoral graduates.

In addition, a few studies suggest that doctoral graduates' professional success depends on their occupational destinations and varies by labour market sector (BuWiN, 2013, p. 293; de Vogel, 2020, p. 283; Enders & Bornmann, 2001, p. 119; Enders, 2002; Engelage & Schubert, 2009; Falk & Küpper, 2013; Flöther, 2015; König et al., 2019, pp. 36–59; M. Schwabe, 2011). Although doctoral graduates' working conditions and career prospects presumably differ strongly between the academic, the non-academic public, and the private sectors, the association between their occupational destinations and professional success has not been systematically studied so far. Therefore, *paper 3* contributes to expanding the literature by examining doctoral graduates' professional success in terms of various objective and subjective indicators of success as a function of their employment sectors. Similarly, *papers 4* and *5* take into account the graduates' occupational destinations when examining the two individual success indicators in more detail.

Another contribution to research concerns *social inequalities in postdoctoral careers*, which have rather been briefly touched than systematically studied. In this thesis, I examine two examples of such social inequalities — one regarding doctoral graduates' occupational destinations and the other regarding their professional success; namely social inequalities in postdoctoral dropout from academia (*paper 1*) and gender inequalities in postdoctoral earnings (*paper 5*).

Furthermore, the DZHW PhD Panel 2014 allows me to remove some methodological limitations of previous research. Most previous studies have used survey data that is not representative of a full and recent doctoral graduation cohort, is only cross-sectional, and only covers the first one to two years following graduation. In contrast, the DZHW PhD Panel 2014 is panel survey data covering the initial five years following graduation and is representative of a recent doctoral graduation cohort in Germany. The panel design is also a major advantage as it allows both longitudinal analyses (*papers 1, 4*) and measurement of predictors prior to the outcomes in cross-sectional analyses (*papers 2, 3, 5*).

3 Theoretical considerations

In this theory section, I position the thesis theoretically and give an overview of the theories used in the individual papers and the expectations derived from them.

3.1 Theoretical positioning of the thesis

This thesis aims at narrowing the research gaps from section 2 with a clearly theory-guided approach in the sense of analytical-empirical sociology. Analytical-empirical sociology (Hedström, 2005; Hedström & Swedberg, 1996; Kron & Grund, 2010; Manzo, 2021, 2022) is characterized by a theory-driven approach and controlled methods using empirical data in order to examine social phenomena and their underlying mechanisms. At the core of analytical sociology are mechanism-based explanations of social phenomena. Therefore, it is crucial not only to describe the social phenomena under study but also to identify their mechanisms from theory and to test these with appropriate methods. For these purposes, analytical-empirical sociology allows for integrating pluralistic theories and methods (Manzo, 2022) and is not restricted to a specific theory or method. In line with analytical-empirical sociology, my approach is to examine and explain the social phenomena under study on the basis of empirical data and by means of testing assumptions that have been carefully derived from theory.

In this context, I would like to emphasize two key points regarding this thesis' theoretical framework. The first point is that this thesis is located within higher education research and that it has intersections with both labour market and inequality research. However, there are no immanent theories to higher education research (Tight, 2004, 2014). Instead, higher education researchers typically apply classical theories from other disciplines to their own research topics. The same holds for this thesis as it applies theories established in sociology and labour market research to address the individual research questions.

The other point relates to the fact that all of the individual papers examine very different research questions and social phenomena. Therefore, there is no overarching theoretical framework or one-size-fits-all theory. Instead, depending on their respective research interest, I use different but particularly productive actor-centred theoretical approaches for each paper. In the sense of Ockham's razor, I am as parsimonious as possible in the choice of theories and select only the most suitable ones. They serve both as a lens through which I approach the research topics and as a tool for identifying possible mechanisms of the outcomes under study as well as for deriving testable hypotheses. I assume that postdoctoral careers take place within social contexts and that career paths as well as decisions result in a large part from the graduates' rationality and norm-oriented considerations. These complex interdependences are reasonably reflected by the selected theories, which allow me to capture the reality of postdoctoral careers and their underlying mechanisms appropriately from a micro-sociological perspective. Nevertheless, I am aware that this is only one side of the coin. On the other side of the coin are other actors and structures, i.e., employers and external circumstances in both the academic and the non-academic labour market. Postdoctoral careers are obviously not only the result of the graduates' deliberate career planning and choices, but they also depend on coincidences, luck, path dependencies, opportunity structures, and constraints. Not all of these factors can be examined in this thesis.

Taken together, this thesis does not aim at testing existing theories but rather at testing theoretically derived assumptions, or at least at empirically enriching them. Therefore, it does not constitute a theoretical but an empirical contribution to the literature. It follows scientific standards to promote theory-guided and evidence-based knowledge production in the sense of analytical-empirical sociology.

3.2 Overview of the theoretical expectations

In the following, I elaborate on the applied theories and derived expectations in the individual papers. *Paper 1* investigates social inequalities in postdoctoral dropout from academia from a multidimensional and intersectional perspective to accurately depict the complex social situatedness of doctoral graduates. The theoretical concept of intersectionality assumes that an individual's different social categories may be intertwined and cause specific and additional inequalities in certain contexts (P. H. Collins & Chepp, 2013; Crenshaw, 1989; Davis, 2011; McCall, 2005). The intersectionality approach is a rather vague and ambiguous theoretical concept that alone does not allow the derivation of concrete hypotheses. To identify groups who have a higher risk for dropout from academia, my co-authors and I combine the intersectionality approach with theories on minority and majority effects in the workplace: taste-based discrimination (G. S. Becker, 1957), statistical discrimination (Arrow, 1973; Phelps, 1972), and tokenism (Kanter, 1977). We expect that female doctoral graduates, graduates with non-academic parents, and those with a migration background are more likely to drop out from academia than their respective reference groups. In addition, we expect that these social categories are intersectionally intertwined and cause specific and additional inequalities in dropout.

Paper 2 examines the determinants of doctoral graduates' employment sector choices. It builds on previous research from countries other than Germany in which various important determinants had already been empirically identified but hardly derived from theory. These determinants include individual preferences for certain job attributes, subjective career prospects, external encouragement, and objective labour market conditions. My co-authors and I are able to locate these empirically-known determinants within the wide version of rational choice theory (Opp, 1999) as we assume that doctoral graduates make rational career decisions between different employment sectors based on their preferences, objective, and subjective constraints. In addition to the empirically known determinants from previous research, we suggest individual career constraints as another determinant. In broad summary, we expect 1) that doctoral graduates self-select into the employment sector that best matches their job preferences, 2) that doctoral subject groups provide different objective conditions for taking up employment in a particular sector, 3) that a more favourable perception of the career prospects in a particular employment sector increases the likelihood of employment in that sector, 4) that external encouragement to pursue a specific career path increases their likelihood of employment in the according sector, 5) that doctoral graduates who have worked inside academia during their doctoral training are more likely to be employed in the academic sector, 6) those with the top final grade are more likely to be employed in the academic sector following graduation, and 7) that a higher age at graduation decreases the likelihood of employment in the private sector.

Please note that *paper 3* is an exception with regard to theory and testing assumptions because it uses no theory given its exploratory and descriptive research interest.

Paper 4 investigates the effect of obtaining a permanent employment contract on doctoral graduates' job satisfaction. My co-authors and I expect that obtaining a permanent contract increases their job satisfaction, which we derive consistently from both the effort-reward imbalance model (Siegrist, 1996,

2017) and rational choice theory (e.g., Lindenberg, 1985; Opp, 1999; Simon, 1955). Although both theoretical approaches postulate different mechanisms, they suggest the same conclusion. According to the effort-reward imbalance model, obtaining a permanent employment contract acts as a reward to the graduates, which positively affects the ratio of job-related efforts and rewards, and thereby increases their job satisfaction. From a rational choice perspective, doctoral graduates obtaining a permanent contract can make decisions about their jobs and private lives with more certainty and therefore should be more satisfied with their job compared to when they were only temporarily employed. In addition, we also expect that the graduates' labour market sector moderates the effect or rather that obtaining a permanent employment contract increases the doctoral graduates' job satisfaction more inside than outside academia. Following social comparison theory (Festinger, 1954), doctoral graduates may compare their employment conditions with other doctoral graduates in the same labour market sector, and because permanent employment is less common inside academia, those graduates inside academia who are permanently employed may appreciate this privilege and be particularly satisfied with their job.

Paper 5 examines the gender pay gap among doctoral graduates and its determinants. I derive all determinants from a combination of human capital theory (G. S. Becker, 1964; Mincer, 1958, 1962), traditional gender roles and beliefs (Acker, 1990; Correll & Ridgeway, 2003; Eagly, 1987; Ridgeway, 2011), and empirical findings from previous research. The derivation of hypotheses is only possible through the combination of these theoretical approaches and previous empirical findings. I consider several doctoral and occupational characteristics as potential determinants mediating the gender pay gap. *First*, I expect doctoral subjects to mediate the gender pay gap. Gender-typical preferences for certain subjects and the anticipation of gender-specific labour market participation prior to university may result in a gender-specific choice of (doctoral) subjects that leads to differences in the acquired types of human capital, which, in turn, causes gender differences in productivity and earnings. *Second*, because of path dependency, gender differences in doctoral subjects may translate in the labour market into gender differences in industries that additionally mediate the gender pay gap. *Third*, high doctoral performance may signal high productivity to employers (Arrow, 1973; Spence, 1973) and may positively affect postdoctoral job opportunities and remuneration. Yet, previous research has shown that female doctoral graduates tend to have a lower doctoral performance than male doctoral graduates, which may also explain the gender pay gap. *Fourth*, the gender pay gap may also result from gender differences in labour market participation and, thus, in human capital gained through professional experience or rather on-the-job-training. Previous research suggests that female doctoral graduates gain less professional experience both during and following doctoral training and that they work fewer hours than male doctoral graduates. As a result, women acquire less human capital and may also earn less. *Fifth*, because of path dependency, their lower labour market participation may also lower female doctoral graduates' chances of holding a management position and prevent them from the associated pay raise. *Finally*, in line with previous research (Amilon & Persson, 2013; U. Schulze, 2015), I also expect that academic employment moderates the gender pay gap with it being smaller inside than outside academia.

4 Data and methods

In this section, I first describe the data that I have used for all the individual papers. Afterwards, I explain how I have handled missing data and elaborate on methodological similarities and differences between the individual papers.

4.1 Description of the dataset

The individual papers in this thesis are all based on the same data: the scientific use file of the DZHW PhD Panel 2014, which is an ongoing panel survey study that monitors the postdoctoral careers of one doctoral graduation cohort in Germany and is conducted by the DZHW. The panel study is designed as a complete survey of the 2014 graduation cohort as its population is all 28,147 persons (Federal Statistical Office, 2021b) who have earned a doctoral degree in the 2013/14 winter semester or in the 2014 summer semester at a university with the right to award doctorates in the Federal Republic of Germany (Brandt, de Vogel, Jaksztat, et al., 2020; Brandt et al., 2018; Vietgen, de Vogel, & Brandt, 2020).[1] According to Vietgen, de Vogel, and Brandt (2020), the data corresponds well to the population of the 2014 doctoral graduation cohort. So far, only the initial five survey waves are included in the scientific use file (Brandt, Briedis, et al., 2020b).

Figure 4.1 gives details on the data collection of the DZHW PhD Panel 2014. The first wave was realized as standardized postal survey approximately half a year to one-and-a-half years following doctoral graduation. For data protection reasons and because there is no central register of all doctoral graduates in Germany, the initial contact with the doctoral graduates and the shipment of the questionnaires had to be carried out via the universities. In the run-up to the survey, the DZHW informed the administrations of all (at that time) 146 universities with the right to award doctorates about the planned survey and asked them to support the research project. If the universities did not refuse, their administrations were asked to send the questionnaires to all of their doctoral graduates of the 2014 graduation cohort. As a result of university bureaucratic processes, the survey period of the first wave took more than one year, i.e., from mid-December 2014 to mid-February 2016. In total, 19,916 doctoral graduates were able to be contacted and received the questionnaire[2], and 5,408 of them participated in the survey, which corresponds to a response rate of 27.2 %.

In the questionnaire, the graduates were asked to indicate their email address if they were willing to participate in follow-up surveys. This allowed the DZHW to directly contact those graduates from the second survey wave onwards. The second to fifth survey waves were realized as standardized online surveys at approximately one-year intervals. In these waves, those graduates who had participated in the first wave, agreed to take part in the follow-up surveys, and given valid contact information constitute the initial survey sample (4,816 doctoral graduates). The response rates and case numbers vary over survey waves, but 56.2 % of the realized wave 1 sample still participated in the fifth survey wave. For more detailed information on the data, see the official data and method reports (Brandt, de Vogel, Jaksztat, et al., 2020; Brandt et al., 2018).

[1] Note that only universities and higher education institutions of equivalent status have the right to award doctorates in Germany. Typically, universities of applied sciences do not have this right.

[2] Unfortunately, some universities and faculties did not support the data collection in the first place; therefore, the total number of successfully sent questionnaires and contacted doctoral graduates was reduced to 19,916.

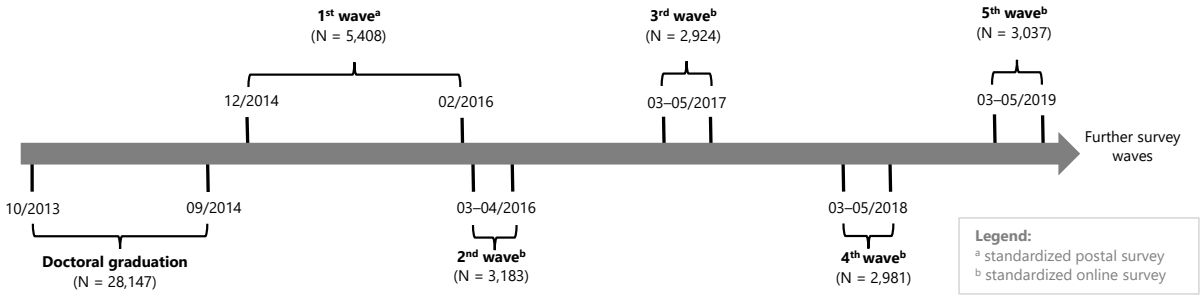

Figure 4.1: **Overview of the data collection, survey waves, and realized sample sizes of the DZHW PhD Panel 2014 (version 4.0.0).**

The DZHW PhD panel 2014 is well suited for investigating the occupational destinations and professional success among doctoral graduates in Germany. On the one hand, it is a nationally representative sample of a recent doctoral graduation cohort that includes graduates from all subject groups and formal types of doctoral training. As it includes only graduates of one graduation cohort who have completed their doctorates under similar structural conditions in the academic system and under similar labour market conditions, cohort effects are largely excluded (Vietgen, de Vogel, & Brandt, 2020, p. 519). On the other hand, the surveys' questionnaires cover a wide range of topics: the graduates' educational and professional biography prior to the doctorate, their experiences during doctoral training, their employment trajectories following doctoral graduation, academic activities, further scientific and professional qualifications, personal characteristics, and demographics. Furthermore, the survey is a panel study with detailed information on the graduates' career paths and employment trajectories both inside and outside academia. The panel design enables event history and "true" panel analyses but also takes into account the temporal order in measurement of the predictors and outcomes in cross-sectional analyses.

Nevertheless, the data is subject to some limitations. One such limitation is that with persons who have successfully completed their doctorate the sample is still selective. As a result, experiences during doctoral training are only measured retrospectively and can therefore be biased due to difficulties in remembering and rationalization processes (Vietgen, de Vogel, & Brandt, 2020, p. 520). In addition, these experiences are not representative of doctoral candidates in general because students who did not complete their doctorate — and probably had negative experiences more frequently — are not part of the sample. Another limitation is that the change from a postal survey in wave 1 to an online survey in wave 2 may have resulted in the systematic loss of respondents and in changes in their response behaviour (Vietgen, de Vogel, & Brandt, 2020, p. 520). In addition, the currently available scientific use file only includes the initial five waves of the survey, i.e., the period until approximately five years following doctoral graduation. This observation period indicates the graduates' mid-term rather than their long-term careers. Against the background of the German law on academic employment, a longer observation period would have been preferable but will only be available with the publication of later survey waves as scientific use files in the future. Because of this law, many doctoral graduates are likely to leave academia six years following doctoral graduation, which affects not only their long-term occupational destination but also their professional success; this is therefore not covered in the current scientific use file.

4.2 Handling of missing data

As usual with survey data, there are missing values for various variables and cases. To handle missing data due to item non-response and to achieve estimates and standard errors that are as unbiased as possible, I multiply impute missing values in the relevant variables prior to analyses in all papers — a procedure that was developed by Rubin (1976, 1987). In the following, I describe the general procedure and its area of application (Allison, 2001; Carpenter & Kenward, 2013; Rubin, 1987; van Buuren, 2018).

Whether certain statistical methods are admissible or not depends on the missingness mechanism in the data. Most statistical procedures presume and require complete data and simply exclude cases with missing values from the analysis. This strategy is known as complete case analysis, listwise deletion, or casewise deletion. As long as missing values are *missing completely at random* (MCAR), this strategy produces unbiased estimations. MCAR is a rather strong assumption and means that the probability of missing data in a given variable *Y* "*is unrelated to the value of Y itself or to the values of any other variables in the data set. When this assumption is satisfied for all variables, the set of individuals with complete data can be regarded as a simple random subsample from the original set of observations.*" (Allison, 2001, p. 3). However, if the data is not MCAR, complete case analysis produces biased results and is therefore impermissible. A weaker and often more plausible assumption is that the data is *missing at random* (MAR). MAR means that the probability of missing data is independent of the unobserved data conditional on the observed data (Carpenter & Kenward, 2013, p. 12). If the missing data is neither MCAR nor MAR, it is *missing not at random* (MNAR), i.e., the probability of missing data depends on unknown reasons or rather unobserved data. In contrast to complete case analysis, multiple imputation "*produces estimates that are consistent, asymptotically efficient, and asymptotically normal when the data are MAR*" (Allison, 2001, p. 27). Thus, under the MAR assumption, multiple imputation is preferable to complete case analysis. Note that in most cases, we should still expect some deviations from the MAR assumption, but these typically introduce only minor bias to estimates and standard errors (L. M. Collins, Schafer, & Kam, 2001).

Unfortunately, as we do not know the missing values, there is no way of definitely identifying the missingness mechanism in a given dataset. Yet, there are statistical procedures using the observed data that hint at violations of the MCAR assumption, which then in turn suggest that the data are MAR or MNAR. One can run logistic regressions of the dependent variable on dummy variables indicating whether a specific variable of interest is missing (coded as 1) or observed (coded as 0). A statistically significant regression coefficient suggests a violation of the MCAR assumption. A more global test is Little's (1988) test, which is a significance test of the null hypothesis that the missing data is MCAR in the whole dataset or rather in all variables of interest. The test evaluates whether there are statistically significant differences between subgroups of cases that share the same missing data pattern. A statistically significant test result indicates that the data is not MCAR. In all sub-analyses for the individual papers, I have initially checked potential violations of the MCAR assumption and found in each case hints of such violations.

In general, multiple imputation estimates plausible values for missing values in the variables of interest prior to analyses. Using the observed values in the variables of interest, $m > 1$ complete datasets are iteratively estimated with plausible values replacing the previously missing values. After these estimations, the results of each of the m completed datasets are combined into a pooled result following Rubin's rules (van Buuren, 2018). As a result, the imputed plausible values can be included in analyses alongside with the observed values, and no cases have to be excluded due to missing values, as opposed to complete case analysis. There are different multiple imputation techniques and I

use the method of fully conditional specification, or more precisely, *multiple imputation via chained equations* (MICE). This allows for different estimation techniques to impute variables with different scale levels and is particularly suitable for the imputation of categorical variables (van Buuren, 2018; White, Royston, & Wood, 2011). Following von Hippel's (2007) MID approach ("multiple imputation, then deletion"), I always exclude cases with imputed values in the respective outcome variable from the analyses.

4.3 Methodological similarities and differences between the papers

Besides the general data basis and multiple imputation, another similarity of the individual papers is that they all pay attention to occupational destinations, but depending on their specific research question and the method necessary to answer it, the papers measure occupational destinations differently — i.e., in two (*papers 1, 5*), three (*paper 4*), or five categories (papers 2, 3) — but always in the most differentiated way possible. Another common feature is that all papers investigate the latest available observation time in the graduates' careers, which is the fifth wave at approximately five years following doctoral graduation. Accordingly, the analyses of the longitudinal papers (*papers 1, 4*) refer to the time between doctoral graduation and the fifth survey wave, and in the cross-sectional papers (*papers 2, 3, 5*) the outcomes are measured at the time of the fifth survey wave. Furthermore and according with open science policies, each paper's Stata code used for data preparation, imputation, and analyses is archived at the Research Data Centre for Higher Education Research and Science Studies (FDZ-DZHW), DOI registered, and as such accessible to the scientific community.

However, the papers differ with regard to *sample restrictions* and *analysis samples*. The cross-sectional papers (*papers 2, 3, 5*) are restricted to those doctoral graduates who had participated in the fifth survey wave. Because the pathways to and after doctorate in medicine differ from those in other subject groups (see section 1.1), the three cross-sectional papers consistently exclude graduates who have earned their doctoral degree in medicine. *Papers 2* and *3* also exclude a small number of graduates who have never been gainfully employed since their doctoral graduation. Note that both papers use the same analysis sample but, as they take into account different predictor variables, they have been multiply imputed separately. In addition, *paper 5* also excludes graduates who are self-employed or working outside Germany at the time of the fifth wave.

The longitudinal papers (*papers 1, 4*) take into account all available information from the first to the fifth survey wave. Because of its longitudinal research interest in a time-varying treatment effect, *paper 4* is restricted to doctoral graduates who have participated in at least two survey waves and have been temporarily employed when first observed. Like *paper 5*, self-employed graduates are excluded from analyses. As *paper 1* examines dropout from academia, its analysis sample is restricted to those graduates who are at risk of leaving academia in the first place, i.e., graduates who have completed their doctoral training inside academia. Because this information relates to the paper's outcome variable, i.e., the timing and occurrence of dropout from academia, incomplete information on the postdoctoral employment trajectories could not be multiply imputed in a meaningful way. Therefore, it was necessary to exclude graduates with missing values in the according variables from analyses.

Due to their different research interests, the papers cover a wide range of *analysis methods*. *Paper 3* is the most basic from a methodological point of view because it only reports descriptive statistics, i.e., proportional and mean values, of doctoral graduates' academic career intention, employment sectors, and indicators of professional success. To test whether and how the theoretically derived

determinants in *paper 2* are associated with doctoral graduates' employment sectors, we estimate a cross-sectional multinomial logit model (Long & Freese, 2014) with average marginal effects of the probability of being employed in each of the five employment sectors five years following doctoral graduation. Note that *papers 2* and *3* use the same five-level categorization of employment sectors: 1) the academic sector, 2) research jobs in the non-academic public sector, 3) research jobs in the private sector, 4) non-research jobs in the non-academic public sector, and 5) non-research jobs in the private sector.

In the third cross-sectional paper (*paper 5*), I estimate stepwise log-linear regression models on the log gross monthly earnings five years following graduation to test whether the hypothesized determinants mediate the gender pay gap. I start with a baseline model including only gender as predictor and indicating the unadjusted gender gap. In each subsequent model step, I add another potential determinant. The extent to which the gender pay gap decreases across models, indicates whether the determinants mediate it. I examine the expected moderating effect of academic employment in the gender pay gap by including an interaction between gender and academic employment (yes vs. no) in the final regression model.

With Cox proportional hazards models (Allison, 2014; Cleves, Gould, & Marchenko, 2016; Cox, 1972), *paper 1* uses an event history technique to examine if and when a dropout from academia occurs and to test the main "effects" of gender, parental academic background, migration background, and their intersections on the risk of experiencing a dropout from academia, while controlling for discipline and academic performance. *Paper 4* uses panel fixed-effects regression (Allison, 2009; Brüderl & Ludwig, 2015) to estimate the effect of obtaining a permanent contract on doctoral graduates' job satisfaction. Obtaining a permanent contract is the treatment, and job satisfaction is the outcome. Fixed-effects regression has the advantage that it eliminates all time-constant heterogeneity by design and that it allows the estimation of the treatment effect net of observed potential confounders by controlling for observed time-varying confounders, those being various person- and job-related characteristics. By including an interaction term between the treatment and graduates' labour market sector, we also examine whether the treatment effect differs by labour market sector.

5 Social inequalities in postdoctoral dropout from academia (*Paper 1*)

Goldan, L., Bohlen, A., & Gross, C. (2023). Social inequalities in postdoctoral dropout from academia by gender, parental academic background, and migration background, and their intersections. *Soziale Welt*.[1, 2, 3, 4, 5, 6]

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.

5.1 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., R. Becker, 2009; de Vogel, 2017; Jaksztat, 2014; Jaksztat, Neugebauer, & Brandt, 2021; Lörz, 2019; Lörz & Mühleck, 2019; Lörz & Schindler, 2016; Müller & Pollak, 2016; Müller et al., 2011; Watermann, Daniel, & Maaz, 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., 2019; Lörz & Mühleck, 2019; Lörz & Schindler,

[1] This is an Accepted Manuscript of an article that will be published in the 'Career Paths Inside and Outside Academia' Special Issue of Soziale Welt by Nomos Publishing in 2023.

[2] Acknowledgements: We thank the anonymous reviewers for their helpful suggestions that have contributed to improving the manuscript.

[3] Funding: This work was supported by the German Research Foundation (DFG, Deutsche Forschungsgemeinschaft) [433155285] and a doctoral scholarship by the German Academic Scholarship Foundation (Studienstiftung des deutschen Volkes) to Lea Goldan.

[4] Conflicts of interest/Competing interests: The authors declare that they have no conflicts of interest or competing interests.

[5] Availability of data: The dataset analysed in the current study is available at the Research Data Centre for Higher Education Research and Science Studies (FDZ-DZHW) as scientific use file (DOI: 10.21249/DZHW:phd2014:4.0.0).

[6] 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.

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, Jaksztat, & Gross, 2023a; 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 individuals' 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"[7] 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 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.

[7] We put the word in inverted commas to emphasize that we cannot guarantee causal relationships. See section 5.4.3 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.

5.2 Literature review

5.2.1 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, Kaulisch, & Tesch, 2015) and parental academic background (Briedis et al., 2014). By contrast, with regard to migration background, Hauss, Kaulisch, and Tesch (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, G. G. Schulze, Warning, and Wiermann (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, Hinz, and Schneck (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, Lutter, & Habicht, 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, Keck, & Boes, 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, 2021a, pp. 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, Keck, and Boes (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 (three 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, 2019; König et al., 2019, pp. 64, 72; Leemann, Keck, & Boes, 2010; Lörz & Mühleck, 2019; Lörz & Schindler, 2016) but to be less frequently employed in the private sector (BuWiN, 2013, p. 256; Flöther, 2017; Goldan, Jaksztat, & Gross, 2023a; König et al., 2019, p. 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, 2019; König et al., 2019; Leemann, Keck, & Boes, 2010; Lörz & Mühleck, 2019; Lörz & Schindler, 2016). Only few studies consider doctoral graduates' migration background. Among doctoral graduates in Switzerland, Leemann, Keck, and Boes (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.

5.2.2 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, Lind, & Löther, 2008; Baur, 2016; Buche & Gottburgsen, 2012; BuWiN, 2013, pp. 352–353; 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.

5.3 Theoretical background & hypotheses

We use the intersectionality approach (section 5.3.1) 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 5.3.2).

5.3.1 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 (P. H. 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, p. 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, p. 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, p. 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, Gottburgsen, & Phoenix, 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, p. 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.

5.3.2 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 (G. S. Becker, 1957) and statistical discrimination (Arrow, 1973; Phelps, 1972). For the employees' perspective, we refer to Kanter's (1977) tokenism.

G. S. 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, p. 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 5.1 summarizes all expectations.

Table 5.1: 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	+

5.4 Data & methods

5.4.1 Data & sample

We use data from the DZHW PhD Panel 2014 (Brandt, Briedis, et al., 2020b; Brandt, de Vogel, Jaksztat, 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 (χ^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 5.2 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.

5.4.2 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, Gottburgsen, & Phoenix, 2016). See Table 5.3 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, 2019; Goldan, Jaksztat, & Gross, 2023a; Jungbauer-Gans & Gross, 2013; König et al., 2019; Leemann, Keck, & Boes, 2010; G. G. Schulze, Warning, & Wiermann, 2008; de Vogel, 2020, pp. 312–313). 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.

5.4.3 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, pp. 33–51; Cleves, Gould, & Marchenko, 2016, pp. 131–178). 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 j^{th} individual as

$$h(t|x_j) = h_0(t)\exp(x_j\beta_x) \tag{5.1}$$

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, Gould, & Marchenko, 2016, pp. 205–230) indicated no problems[8] except for a violation of the proportional hazards assumptions for the final grade of the 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 behaviour/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.

[8] 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, pp. 15–17). 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 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 5.5 in the appendix), which indicates that the models are not sensitive to violations of the non-informative assumption.

5.5 Results

In the following, we *first* nonparametrically describe survival inside academia (section 5.5.1). 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 5.5.2). *Third*, we discuss our findings (section 5.5.3).

5.5.1 Description of postdoctoral survival inside academia

Figure 5.1 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, Gould, & Marchenko, 2016, pp. 93–107). 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.[9]

The survivor function drastically decreases in the first month after graduation (the probability of survival beyond $t = 1$ is 71.3 percent)[10] 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.[11] 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.

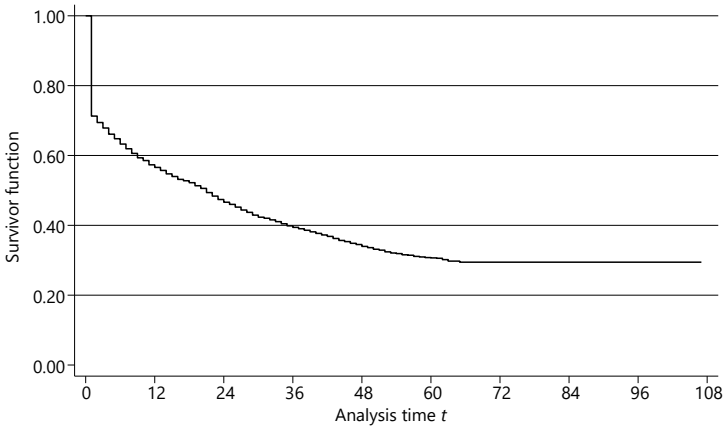

Figure 5.1: **Kaplan-Meier survival estimates.**
Note: multiply imputed data, results reported for $m = 1$, N = 2,549.
Source: DZHW PhD Panel 2014 (4-0-0).

[9] See Table 5.4 in the appendix for more detailed statistics on survival inside academia. See Figures 5.4a–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 migration background drop out from academia after graduation as quickly as their respective reference groups.

[10] 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.

[11] 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 5.4 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.

5.5.2 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 5.5 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, Gould, & Marchenko, 2016, pp. 132–134, 176–177).

Figure 5.2 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).

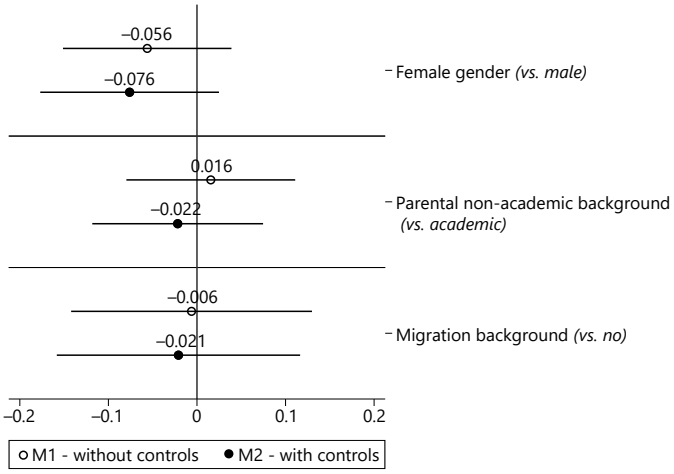

Figure 5.2: **Cox regression on postdoctoral dropout from academia — main effects of all social categories.**
Note: point estimators and 95 percent confidence intervals presented, multiply imputed data, N = 2,549, M2 controls for doctoral subject group, final grade of the doctorate, numbers of publications 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 5.3 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.[12]

[12] With regard to the control variables (see Table 5.5 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.

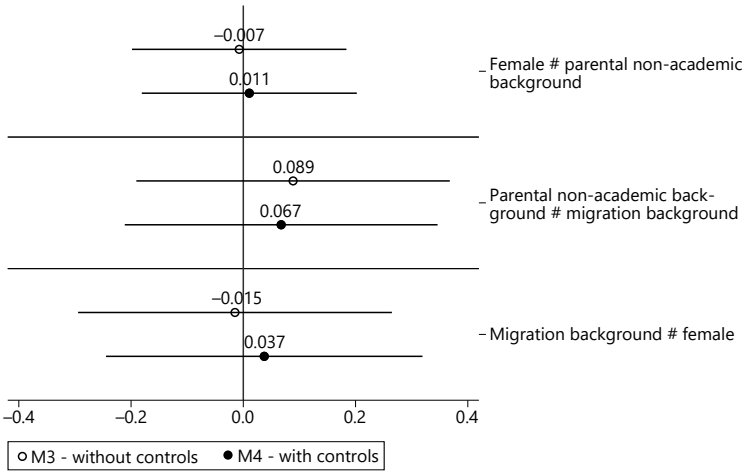

Figure 5.3: **Cox regression on postdoctoral dropout from academia — interaction effects of all social categories.**
Note: point estimators and 95 percent confidence intervals presented, multiply imputed data, N = 2,549, M4 controls for doctoral subject group, final grade of the doctorate, numbers of publications and conference contributions, and age at graduation.
Source: DZHW PhD Panel 2014 (4-0-0).

5.5.3 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.[13]

5.6 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 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

[13] 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.

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 fulfil 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 afore-mentioned 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.

Appendix

Table 5.2: 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
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 5.3: Description of variables

Variables	Description	Categories	Percent/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 5.4: 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).

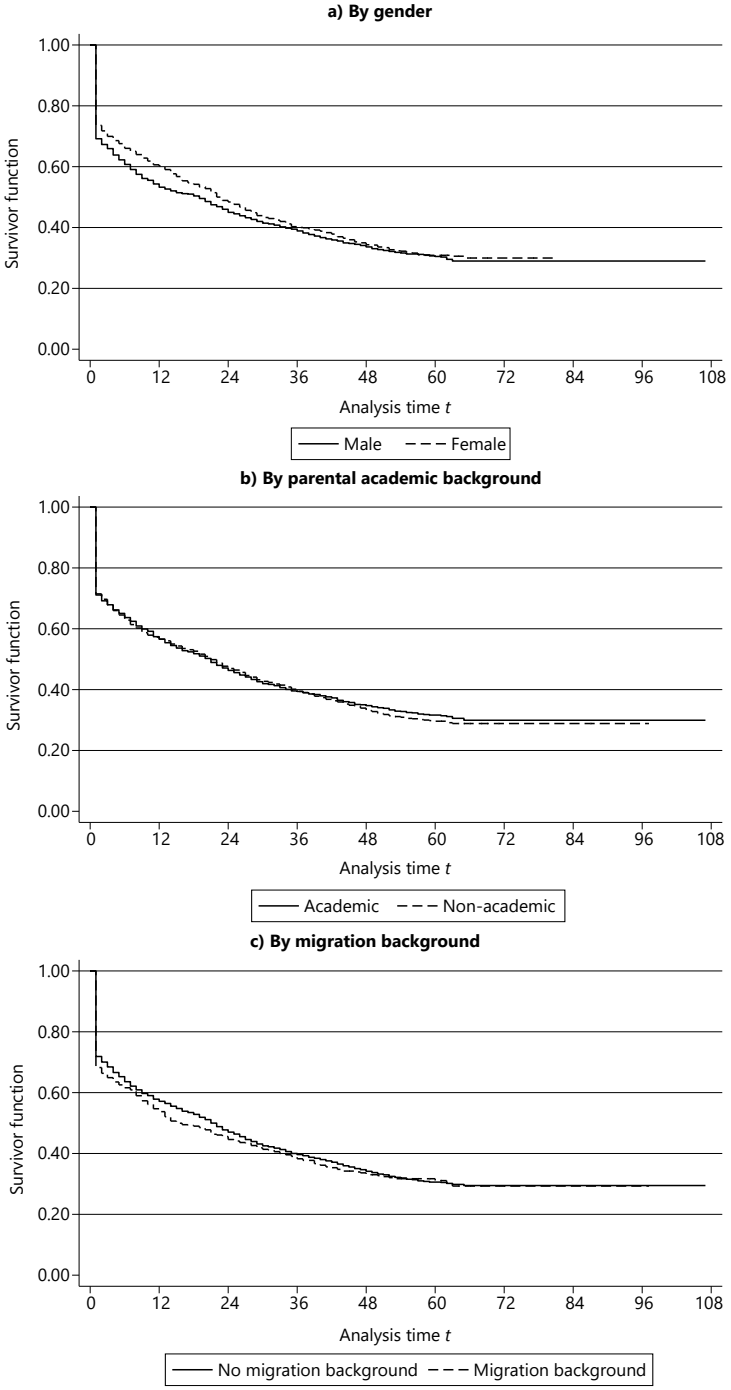

Figure 5.4: **Kaplan-Meier survival estimates by social categories.**
Note: multiply imputed data, results reported for m = 1, N = 2,549.
Source: DZHW PhD Panel 2014 (4-0-0).

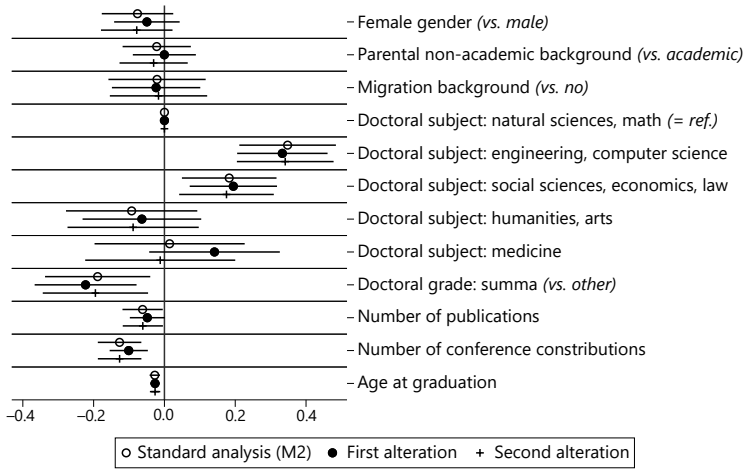

Figure 5.5: **Cox proportional hazards models on dropout from academia — illustration of whether analyses are sensitive to violations of the non-informative assumption.**
Note: point estimators and 95 percent confidence intervals presented, multiply imputed data, N = 2,549.
Source: DZHW PhD Panel 2014 (4-0-0).

Table 5.5: Cox proportional hazards models on dropout from academia

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

Note: point estimators in coefficient metric, 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

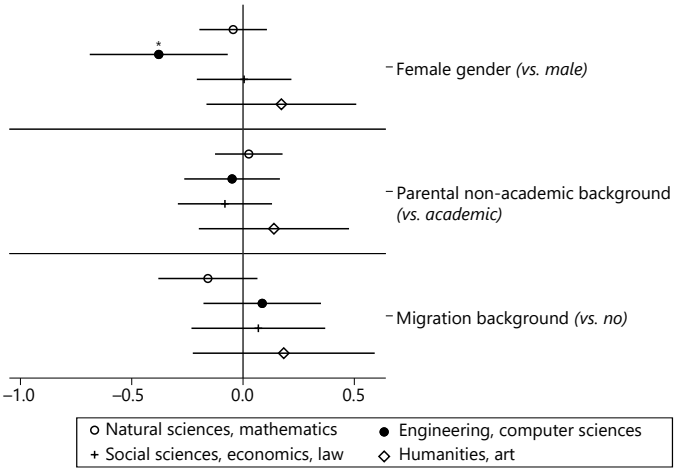

Figure 5.6: **Cox regression on postdoctoral dropout from academia — main effects of all social categories by doctoral subject group.**
Note: point estimators and 95 percent confidence intervals presented, multiply imputed data, N = 2,549.
Source: DZHW PhD Panel 2014 (4-0-0).

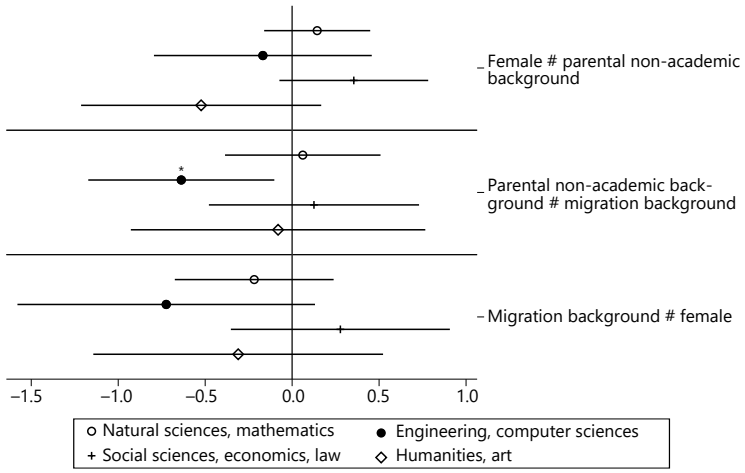

Figure 5.7: **Cox regression on postdoctoral dropout from academia — interaction effects of all social categories by doctoral subject group.**
Note: point estimators and 95 percent confidence intervals presented, multiply imputed data, N = 2,549.
Source: DZHW PhD Panel 2014 (4-0-0).

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 Figure 5.8 and Figure 5.9 for the key results of Cox regression and Table 5.6 for the detailed regression models these plots refer to. We again find no social inequalities in transition to the non-academic labor market.[14]

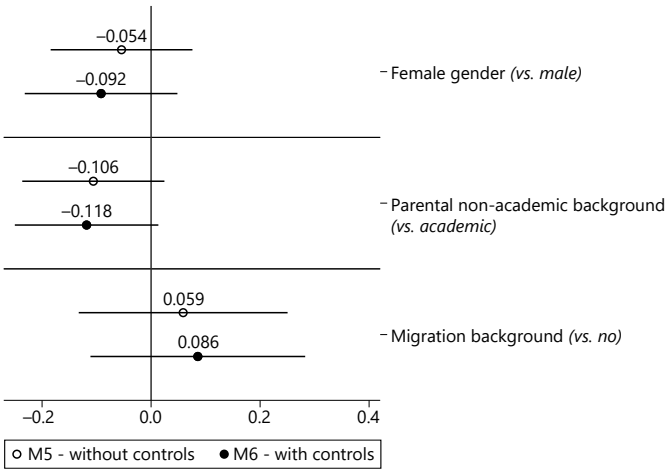

Figure 5.8: **Cox regression on difficult transition to the non-academic labour market — main effects of all social categories.**

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).

[14] 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.

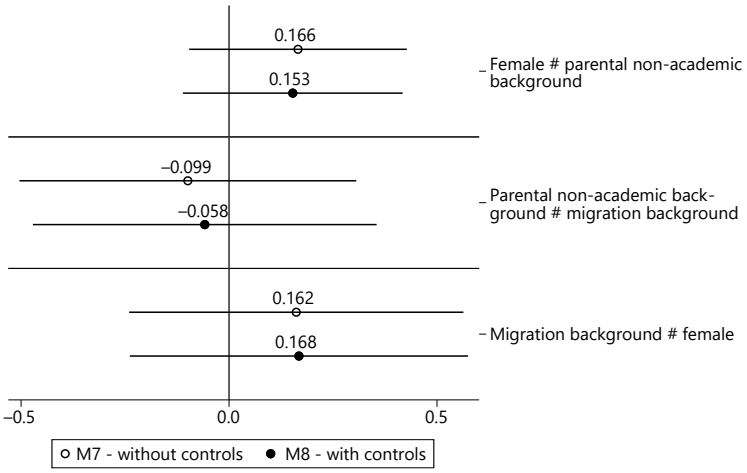

Figure 5.9: **Cox regression on difficult transition to the non-academic labour market — interaction effects of all social categories.**
Note: point estimators and 95 percent confidence intervals presented, multiply imputed data, N = 1,500, M8 controls for doctoral subject group, final grade of the doctorate, numbers of publications and conference contributions, and age at graduation.
Source: DZHW PhD Panel 2014 (4-0-0).

Table 5.6: Cox proportional hazards model on difficult transition to the non-academic labour market

Variables	**Bivariate**	**M5**	**M6**	**M7**	**M8**
Gender: female *(ref.: male)*	–.052	–.054	–.092	–.162	–.191
	(.066)	(.066)	(.071)	(.099)	(.102)
Parental academic background: non-academic *(ref.: academic)*	–.104	–.106	–.118	–.167	–.179
	(.066)	(.067)	(.067)	(.099)	(.099)
Migration background: yes *(ref.: no)*	.064	.059	.086	.039	.043
	(.097)	(.098)	(.100)	(.173)	(.176)
Female gender # non-academic parental background				.166	.153
				(.134)	(.135)
Non-academic parental background # migration background				–.099	–.058
				(.206)	(.210)
Migration background # female gender				.162	.168
				(.205)	(.207)
Doctoral subject group *(ref.: natural sciences, mathematics)*					
Engineering, computer sciences			.025		.030
			(.098)		(.098)
Social sciences, economics, law			.220*		.205*
			(.094)		(.095)
Humanities, art			–.005		–.008
			(.125)		(.125)
Medicine			.209		.205
			(.159)		(.161)
Other			.129		.126
			(.149)		(.149)
Final grade of the doctorate: summa *(ref.: other)*			.182		.185
			(.115)		(.115)
Number of publications			–.028		–.028
			(.037)		(.037)
Number of conference contributions			–.033		–.033
			(.033)		(.033)
Age at graduation			–.035**		–.036**
			(.011)		(.012)
Interactions with analysis time *t*					
# Final grade of the doctorate: summa			.000		.001
			(.005)		(.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, standard errors in parentheses, multiply imputed data; significance: * p < .05, ** p < .01, *** p < .001.
Source: DZHW PhD Panel 2014 (4-0-0).

6 Determinants of doctoral graduates' employment sector choices (*Paper 2*)

Goldan, L., Jaksztat, S., & Gross, C. (2023a). Explaining Employment Sector Choices of Doctoral Graduates in Germany. *Research Evaluation, 32*(1), 144–156.[1, 2, 3, 4, 5]

Abstract: Previous research in different national contexts has shown that individual preferences for certain job attributes, objective labour market conditions, subjective career prospects, and external encouragement shape doctoral graduates' career decisions. For Germany, where the number of awarded doctoral degrees is highest within the European Union and where no established academic tenure-track system exists, the determinants of doctoral graduates' sector choices are still largely unexplored. This paper aims to shed light on the determinants of sector choices of doctoral graduates in Germany. By deriving the determinants from the wide version of rational choice theory and by measuring the determinants prior to employment sectors, we overcome conceptual and methodological limitations of previous research. Using data from a nationally representative panel survey with doctoral graduates of the 2014 cohort in Germany, we differentiate between five distinct employment sectors and carry out multinomial logistic regression analysis. As expected, and in line with previous research from other countries, the results confirm that the sector choices of doctoral graduates in Germany depend on their preferences as well as various objective and subjective constraints. The paper helps to better understand how doctoral graduates select into different employment sectors and thus provides important insights into postdoctoral career trajectories.

6.1 Introduction

Doctoral graduates strongly contribute to modern economies' ability to innovate and societies' ability to solve current and future problems (Auriol, Misu, & Freeman, 2013; Barge-Gil, D'Este, & Herrera, 2021; Bogle et al., 2010; Diamond et al., 2014; European Commission, 2009). Therefore, a doctoral degree qualifies an individual for jobs both inside and outside academia. In fact, there is a huge variation in postdoctoral career paths and employment sectors. Many doctoral graduates leave academia to work in public service, in companies' research and development departments, or in non-profit organizations.

Inside academia, working conditions are changing in many countries. Differentiation and stratification, competition for resources, and the rigour of evaluations of achievements are increasing in institutions of higher education. Working conditions inside academia largely depend on national higher education systems. While Anglo-American higher education systems have both tenure-track systems and tenured positions other than professorships, such as lecturers, the academic labour market in Germany is characterized by precarious working conditions and a declining proportion of full or associate professorships and other tenured positions (Cummings & Bain, 2018; Kreckel, 2016; Waaijer, 2015). Thus, in Germany, academic careers require even more flexibility and perseverance than in many other

[1]This is an Accepted Manuscript of an article published by Oxford University Press in Research Evaluation following peer review. The version of record is available online at: https://doi.org/10.1093/reseval/rvac030.
[2]Funding: This work was supported by the German Research Foundation (DFG, Deutsche Forschungsgemeinschaft) [433155285] and a doctoral scholarship by the German Academic Scholarship Foundation (Studienstiftung des deutschen Volkes) to Lea Goldan.
[3]Conflicts of interest/Competing interests: The authors declare that they have no conflicts of interest or competing interests.
[4]Availability of data: The dataset analysed in the current study is available at the Research Data Centre for Higher Education Research and Science Studies (FDZ-DZHW) as scientific use file (DOI: 10.21249/DZHW:phd2014:4.0.0).
[5]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:goldan2022b:1.0.0.

countries. Generally, doctoral graduation and the subsequent years represent a crucial period for the decision to leave academia or to stay and try to realize an academic career.

While research careers inside academia have become increasingly competitive, accelerating technological changes and increasing societal complexity have increased the demand for scientifically trained staff outside academia. The demand for doctoral graduates outside academia is currently high and is likely to continue to grow in the future.

Understanding how doctoral graduates select into different employment sectors is key for policy makers, employers inside and outside academia, career advisors, and doctoral graduates themselves. This understanding may help to improve the competitiveness and attractiveness of both academic and non-academic jobs for doctoral graduates, to achieve a good match between individual characteristics and preferences on the one hand and job requirements on the other hand, and to support doctoral graduates in making sustainable career decisions.

A large body of research has described the employment sectors of doctoral graduates in different national contexts, and a smaller body of research has examined the determinants of their sector choices. However, there is still insufficient knowledge on the decision-making processes underlying doctoral graduates' career decisions. Why do doctoral graduates choose certain employment sectors over others? What factors underlie their sector choices? Previous research has shown that individual preferences for certain job attributes, subjective career prospects, and objective labour market conditions shape doctoral graduates' career decisions. The most comprehensive study is by Bloch, Graversen, and Pedersen (2015) on doctoral graduates in Denmark, but similar results are available for the United States (Agarwal & Ohyama, 2013) and the Netherlands (Waaijer, 2017). For Germany, where the number of awarded doctoral degrees is highest within the European Union (Eurostat, 2021) and where no established academic tenure-track system exists, these questions remain largely unanswered. However, because of national differences in higher education systems, the number of doctoral graduates, and economic structures, it is unclear to what extent results from previous studies on doctoral graduates' sector choices in other countries can be applied to doctoral graduates in Germany.

Against this background, our paper builds on previous research on the determinants of doctoral graduates' sector choices and focuses on the German context. We examine whether the determinants of doctoral graduates' sector choices that have been identified in previous research also apply to doctoral graduates in Germany. Moreover, we seek to overcome certain methodological and conceptual limitations of previous research. First, using panel data instead of cross-sectional data, we are able to measure the determinants prior to sector choices and to test their predictive power. Second, we derive all determinants under study in this paper from theory – more precisely, from the wide version of rational choice theory (RCT). This enables us to examine sector choices using precise theoretical terms and to systematise previous findings, which will help to improve our understanding of postdoctoral career trajectories.

6.2 Previous research

A large body of research has described *doctoral graduates' employment sectors* in different national contexts, including Japan (Misu & Horoiwa, 2016), Australia (Neumann & Tan, 2011), the US (Agarwal & Ohyama, 2013), the UK (Diamond et al., 2014; H.-f. Lee, Miozzo, & Laredo, 2010), Italy (Alfano et al., 2021; Ballarino & Colombo, 2010; Passaretta, Trivellato, & Triventi, 2019), the Netherlands (Waaijer, 2017), Denmark (Bloch, Graversen, & Pedersen, 2015), Norway (Kyvik & Olsen, 2012), Austria (M.

Schwabe, 2011), Germany (Briedis et al., 2014; BuWiN, 2021; Flöther, 2017; Goldan, Jaksztat, & Gross, 2022), and across the OECD (Auriol, Misu, & Freeman, 2013). Because these studies use different employment sector classifications and focus on different career stages, their results are difficult to compare in detail. However, they show that in most countries, the majority of doctoral graduates leave academia for other employment sectors. Specifically, in Germany, only a relatively small proportion of doctoral graduates stay inside academia. According to Goldan, Jaksztat, and Gross (2022), five years after graduation, only three out of ten doctoral graduates are employed inside academia.

Previous studies have also tried to explain *doctoral students' career intentions* (Ateş et al., 2011; Gemme & Gingras, 2012; Hauss, Kaulisch, & Tesch, 2015; Kim, Benson, & Alhaddab, 2018; Li & Horta, 2021; Seo et al., 2020; Vuolanto, Pasanen, & Aittola, 2006). Roach and Sauermann (2010) find that career intentions largely depend on preferences for certain job attributes based on an US sample of science and engineering doctoral students. In addition, doctoral students with a strong preference for science prefer an academic career to a career in industry, whereas those with strong preferences for salary, access to resources, and applied research and development prefer industry employment. According to that study, the perceived availability of jobs in different employment sectors is not associated with career intentions. In a later panel study of doctoral students from 39 research universities in the US, Roach and Sauermann (2017) find that academic career intentions tend to decline over the course of doctoral training. According to the authors, this decline is primarily due to a change in doctoral students' preferences for specific job attributes but not to a change in the perceived career prospects inside and outside academia.

Previous studies on the *determinants of doctoral graduates' actual sector choices* have been conducted in European countries, the US, and China. Agarwal and Ohyama (2013) find in a cross-sectional US study that preferences for challenges, responsibility, and independence increase the likelihood of employment inside academia, while preferences for salary and benefits increase the likelihood of employment in industry referring to matching and human capital theory. Wenqin et al. (2018) find that male graduates are less likely to be employed at universities and research institutions and more likely to be employed outside academia than female graduates in a cross-sectional study among doctoral graduates from 13 universities in China.

Balsmeier and Pellens (2014) retrospectively study survival inside academia among doctoral graduates in Belgium. Like Roach and Sauermann (2010) and Agarwal and Ohyama (2013), they find that doctoral graduates with preferences for salary, benefits, career progression, and job security are more likely to leave academia. In contrast, they do not find an association between doctoral graduates' preference for science and their likelihood of staying inside academia.

However, a more recent cross-sectional study by Waaijer (2017) with doctoral graduates from several universities in the Netherlands confirms that doctoral graduates inside academia value intellectual challenges, independence, and creativity more highly, whereas doctoral graduates in non-academic research have stronger preferences for salary, benefits, and job opportunities. Doctoral graduates with strong preferences for job security are more likely to be employed outside of research – this basic pattern is confirmed by Flöther (2017) in a cross-sectional study of doctoral graduates in Germany as well. In contrast to Roach and Sauermann (2010), Waaijer's (2017) study suggests that sector choices largely depend on subjective perceptions of career prospects inside academia. Doctoral graduates outside academia perceive the long-term career prospects inside academia as poorer than outside academia; for doctoral graduates inside academia, the opposite holds true.

In a cross-sectional study among doctoral graduates in Spain, Herrera and Nieto (2016) find that selection into the private sector is associated with graduates' subject group, the funding and duration of their doctoral training, experiences of unemployment after doctoral graduation, and their age.

For Denmark, Bloch, Graversen, and Pedersen (2015) confirm that doctoral graduates' sector choices depend on their individual preferences for certain job attributes and objective labour market conditions. The authors find that the number of awarded doctoral degrees within a subject group slightly increases the likelihood of employment outside academia. However, both the effects of the number of new assistant professor positions within a subject group and the share of new positions with at least three qualified applicants were mainly insignificant. In addition, the study finds that being encouraged to pursue an academic career increases the likelihood of employment inside academia. Of all the studies cited here, Bloch, Graversen, and Pedersen (2015) is the most extensive study and the one that uses the most convincing and selective categorization of employment sectors because they combine the overall labour market sector (academic, non-academic public, private) with the jobs' reference to research into five distinct employment sectors. Nevertheless, their study also only uses cross-sectional data.

In summary, most previous studies have indicated that doctoral graduates' sector choices depend on their individual preferences. Some of them also found subjective career prospects, objective labour market conditions, and external encouragement to be important. However, the above-mentioned studies are limited for two reasons. First, with the exception of Balsmeier and Pellens (2014), previous studies use only cross-sectional data; i.e. they measure the determinants and the employment sectors at the same time. Second, they do not or hardly derive the determinants from theory.

Against this background, this paper's contribution to the international literature on the determinants of doctoral graduates' sector choices is fourfold. *First*, we examine how individual preferences, external encouragement, objective labour market conditions, and subjective career prospects *simultaneously* affect sector choices.

Second, we focus specifically on doctoral graduates in *Germany*. There are substantial differences between countries regarding their higher education systems, number of doctoral degrees, postdoctoral employment rates inside academia, and economic structures (Auriol, Misu, & Freeman, 2013). Therefore, it is unclear, to what extent results from the afore-mentioned previous studies on doctoral graduates' sector choices in other countries can be applied to doctoral graduates in Germany.

Third, by using panel data, we are able to measure the predictors *prior* to sector choices and to test their predictive power. We thus overcome a major methodological limitation of previous research, which is mostly based on cross-sectional data.

Fourth, in contrast to most previous research, we apply a theory of social action to explain individual sector choices. We locate the empirically known determinants of these choices in wide RCT and theoretically derive their associations with the respective employment sectors.

6.3 Theory

We suggest that doctoral graduates' employment sector choices can be explained by the wide version of rational choice theory (RCT) (Opp, 1999). The classic version of RCT includes three core assumptions. First, individual preferences determine the actions that are suitable for satisfying these preferences (*preference assumption*). Second, any factor that increases or decreases individuals' ability (i.e.

opportunities or constraints) to satisfy their preferences by performing certain actions determines the performance of those actions (*constraints assumption*). Third, individuals choose the actions that best allow them to satisfy their preferences under the given constraints (*utility maximization assumption*). The wide version of RCT specifies these core assumptions as follows (Opp, 1999):

(1) All kinds of preferences may explain an individual's actions.

(2) All kinds of constraints may explain an individual's actions.

(3) Individuals do not necessarily need to be fully informed about their environment to take action (bounded rationality).

(4) Both objective and subjective constraints may be relevant for an individual's actions.

(5) Only preferences, only constraints, or both together may be relevant for an individual's actions.

We assume that doctoral graduates make rational career decisions between different employment sectors based on their preferences (individual preferences) and objective and subjective constraints (objective labour market conditions, subjective career prospects, external encouragement, individual career constraints). Thus, the empirically known determinants can be located within the wide RCT. We take into consideration individual career constraints as an additional determinant. Figure 6.1 illustrates the theoretical model.

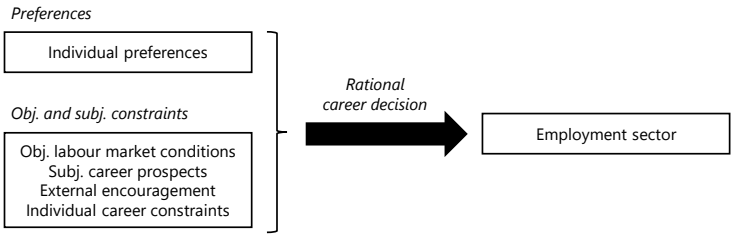

Figure 6.1: **Theoretical model for doctoral graduates' employment sector choices.**

6.3.1 Individual preferences

From the perspective of the wide RCT, doctoral graduates strive to find jobs in employment sectors where their individual preferences are likely to match job tasks and working conditions. Thus, their preferences may cause them to self-select into particular employment sectors. Previous research has repeatedly shown that doctoral graduates' preferences are associated with their employment sectors (Agarwal & Ohyama, 2013; Balsmeier & Pellens, 2014; Bloch, Graversen, & Pedersen, 2015; Flöther, 2017; Waaijer, 2017). Studies also suggest that doctoral graduates are heterogeneous in the job attributes they value (Roach & Sauermann, 2010; Stern, 2004). Some doctoral graduates tend to have a strong preference for science and attach particular importance to autonomy and intellectual challenges. Others tend to have a strong preference for business and value salary and career advancement.

At the same time, reward structures, social norms, and working conditions differ between labour market sectors (Agarwal & Ohyama, 2013; Bloch, Graversen, & Pedersen, 2015; Goldan, Jaksztat, & Gross, 2022; Stephan, 1996). Inside *academia*, the primary goal is research itself or, more precisely, the creation of knowledge using scientific methods and following scientific norms, such as objectivity and independence of non-scientific interests (Merton, 1974). Although the daily working tasks of senior

researchers and professors considerably deviate from this ideal conception, academic jobs typically match the skills and qualifications acquired during doctoral training and provide a relatively high level of autonomy in choosing research topics. However, the proportion of permanent positions below the professorship level is low (Auriol, Misu, & Freeman, 2013; BuWiN, 2021; Waaijer, 2015). As a result, doctoral graduates striving for an academic career are often confronted with prolonged periods of job insecurity. Rewards inside academia are usually nonmonetary, e.g. recognition by the scientific community or research awards, or they provide access to resources for further research, e.g. research funds.

In contrast, in the *private sector*, the primary goal is economic growth. Innovation and technological advancement are used as means to increase profit. The private sector demands that doctoral graduates "transform[. . .] scientific knowledge into commercially valuable outputs and appropriat[e] economic value in the form of profits" (Agarwal & Ohyama, 2013). The private sector includes many different occupations, some research-related and others non-research-related. In research-related jobs, research is often applied, and researchers have less autonomy to choose their own research topics because these topics are frequently subordinated to strategic and economic goals. In the private sector, rewards usually relate to status, salary, and promotion. Wages and job security are typically higher than in the academic sector (Goldan, Jaksztat, & Gross, 2022).

In the *non-academic public sector* (henceforth, the public sector), the primary goal is to fulfil the organizational mission, and research is – inter alia – a means to do so. This sector also includes many different occupations, some research-related and others non-research-related. The public sector "is often less interested in research results on their own, but more on their use to perform tasks or to fulfil the missions and goals of the organization" (Bloch, Graversen, & Pedersen, 2015). Therefore, researchers in the public sector are assumed to be less autonomous than researchers inside academia. In the public sector, promotion structures often comply with seniority, and remuneration complies with collective wage agreements. In general, the rewards and working conditions in the public sector lie somewhere between those in the academic and private sectors. While wages are comparable to those inside academia, job security (i.e. the proportion of permanent positions) is higher in the public sector (Goldan, Jaksztat, & Gross, 2022).

Because of their different characteristics, employment sectors may attract different types of doctoral graduates. In line with the wide RCT, we assume that doctoral graduates make rational career decisions based on their individual preferences. As a result, they self-select into the employment sector that best matches their preferences. *We expect that (1) doctoral graduates with strong preferences for innovation and autonomy are more likely to be employed inside academia, (2) those with strong preferences for career are more likely to be employed in the private sector, and (3) those with strong preferences for security are more likely to be employed in the public sector*.

6.3.2 Objective labour market conditions

Doctoral graduates' sector choices are constrained by objective labour market conditions. Basically, the supply of doctoral graduates and the availability of suitable jobs in different employment sectors form the objective background against which doctoral graduates make career decisions. Accordingly, Bloch, Graversen, and Pedersen (2015) find that the number of doctoral degrees awarded within a subject group is associated with doctoral graduates' employment sector. The more doctoral degrees

are awarded, the higher the likelihood of employment in most non-academic sectors compared to employment inside academia.

However, we suggest that doctoral subjects are more suitable for capturing labour market conditions in general, as they reflect both the subject-specific supply of and the demand for doctoral graduates as well as their interplay. The number of doctoral degrees – i.e. the supply of doctoral graduates – differs across subjects. Official statistics indicate for the doctoral graduation cohort 2014 in Germany that most doctorates were earned in mathematics and natural sciences (36 %), followed by medicine (28 %); law, economics, and social sciences (14 %); engineering (12 %); and humanities (12 %) – a pattern that is relatively stable over time (Federal Statistical Office, 2021b).

The demand for doctoral graduates in the labour market is also associated with doctoral subjects. Depending on their doctoral subject, graduates have acquired different qualifications or, rather, different types of human capital (G. S. Becker, 1964), which are assumed to be in different demand in different employment sectors. Some subjects, such as humanities and social sciences (excluding economics and law), provide general training and impart more general human capital, while others, such as science, technology, engineering, and mathematics (STEM) and economics, provide specific training and impart more specific human capital. In principle, compared to the humanities and social sciences, STEM subjects and economics are likely to be more closely linked to the private sector since qualifications are usually more practically oriented and can be used more directly for the development and marketing of products and services. In Germany, with its strong technology sector, these qualifications are in great demand. However, the general human capital acquired in the humanities and social sciences should be more useful in both the academic and the public sectors. Legal qualifications should be in high demand in higher positions in public administration, prosecutors, and courts on the one hand and companies' legal departments on the other hand, i.e. in the non-research public and private sectors. In short, the supply of doctoral graduates from different subjects and the sector-specific demand for certain qualifications cause objective opportunity structures and constraints.

Finally, the supply of and demand for doctoral graduates may also interact with each other and cause subject-specific opportunity structures and constraints. For example, good career prospects and high remuneration outside academia are incentives to leave academia after doctoral graduation. These incentives possibly reduce the number of postdoctoral researchers competing for academic positions improving the career prospects of those who stay inside academia.

In summary, *we expect that (1) doctoral graduates from STEM subjects and economics are more likely to be employed in the private sector, (2) those from other social sciences and the humanities are more likely to be employed in the academic or public sectors, and (3) those from law are more likely to be employed in non-research jobs outside academia*.

6.3.3 Subjective career prospects

The wide RCT suggests that subjective constraints may be as crucial for rational decision-making processes as objective constraints, and doctoral graduates' subjective perception of career prospects may be one such subjective constraint. From an RCT perspective, doctoral graduates self-select into the employment sector where they perceive that they have the best career prospects. Accordingly, Waaijer (2017) finds that doctoral graduates' subjective career prospects influence their sector of employment. The accuracy of subjective career prospects depends on the degree of information about the objective

labour market conditions and on the evaluation of individual capabilities and other relevant resources. However, from the perspective of the wide RCT, the accuracy of subjective career prospects is not crucial because individuals do not necessarily need to be fully informed. *We expect that the more favourably doctoral graduates perceive their career prospects inside (or outside) academia, the higher their likelihood of employment inside (or outside) academia*.

6.3.4 External encouragement

Following the wide RCT, we assume that external encouragement to pursue a specific career path may influence the subjective constraints on doctoral graduates' sector choices, which is also in line with Bloch et al.'s (2015) findings. External encouragement is a form of positive feedback regarding individual capabilities and competencies; therefore, it is likely to increase self-confidence and motivation. In addition, external encouragement may be perceived as a normative expectation regarding the 'right' career path. In our analysis, we test the impact of external encouragement by former doctoral supervisors on doctoral graduates' employment sectors. *We expect that if doctoral graduates have been encouraged to pursue a specific career path, their likelihood of employment in the corresponding sector will be higher*.

6.3.5 Individual career constraints

We assume that sector choices are also influenced by individual career constraints that relate to educational biographies and achievements. The formal type of doctoral training, the final doctoral grade, and age at graduation are likely to be relevant constraints in this context.

Employment as a research assistant inside academia is the most common way of funding doctoral training. Other funding sources are employment outside academia, doctoral scholarships, and other or private means. In particular, doctoral graduates who have worked as research assistants may have advantages in recruitment processes inside academia after graduation because they have gained specific professional experience during their doctoral training that is particularly rewarded inside academia (e.g., collaboration in research projects, teaching activities, academic self-administration, supervision of students). In addition, such professional experience may have also helped them to build up academic networks, which can make it easier for them to find out about vacancies inside academia and ultimately to get them. In contrast, doctoral graduates who have been employed outside academia may have advantages in the private and public sectors for the same reasons. Accordingly, Flöther (2017) found that employment inside academia during doctoral training increases the likelihood of employment inside academia after graduation. *We expect that if doctoral graduates have worked inside (or outside) academia during their doctoral training, the higher their likelihood of employment inside (or outside) academia*.

The final grade is a proxy for academic ability. In Germany, an academic career is possible only if doctoral graduates have completed their doctorate with a (very) good final grade; therefore, a moderate or poor grade usually prevents graduates from pursuing an academic career. Flöther (2017) has also shown this pattern. *We expect that doctoral graduates with the top final grade are more likely to be employed inside academia*.

The completion of a doctorate at a young age is likely to be perceived as a signal of ability, self-motivation, and determination. Hence, a young age at graduation in general should be an advantage

in recruitment processes for positions in all sectors of employment. However, we expect that a young age is valued, especially by employers in the private sector, because it typically means a shorter professional socialization process inside academia, which in turn should make it easier for doctoral graduates to adapt to non-academic workplaces.[6] Previous research suggests a negative association with employment in the private sector compared to academia (Balsmeier & Pellens, 2014; Bloch, Graversen, & Pedersen, 2015; Herrera & Nieto, 2016). *We expect that doctoral graduates with a higher age at graduation are less likely to be employed in the private sector*.

6.4 Data and methods

6.4.1 Data and sample

We use data from the PhD Panel 2014 (Brandt, Briedis, et al., 2020b; Brandt, de Vogel, Jaksztat, et al., 2020), which was conducted by the German Centre for Higher Education Research and Science Studies (DZHW). The target population of the survey was persons who had earned a doctoral degree at a German university in the winter semester of 2013/14 or the summer semester of 2014. The panel data were collected in five waves conducted annually from 2015 to 2019, i.e. approximately one to five years after participants had graduated. The first wave was realized as a standardized postal survey, and the subsequent waves were realized as standardized online surveys. To account for panel attrition (i.e. unit-nonresponse), we use probability weights provided by the DZHW. These weights comprise the respondents' individual probability of participation in Wave 5, and they are calibrated to the characteristics of the target population.

In our analyses, we confine ourselves to doctoral graduates who participated in Wave 5 and had earned a doctoral degree in a subject other than medicine (2,343 cases).[7] We exclude doctoral graduates who had never been gainfully employed since graduation (–11 cases) and those who did not have a calibrated attrition weight in Wave 5 (–29 cases). Little's (1988) test indicates that missing values are not missing completely at random (χ^2: 2,501.51; 2,139 degrees of freedom; p: 0.00). Therefore, we multiply impute missing values, which only requires missing values to be missing at random and compensates for item nonresponse. We apply multiple imputation by chained equations with 10 imputations and 70 iterations to replace the missing values in all relevant variables (see Supplementary Table 6.4 for details on imputation). Following von Hippel's (2007) MID approach ("multiple imputation, then deletion"), we exclude cases with imputed values in the dependent variable (–344 cases). Thus, the final analysis sample consists of 1,959 cases.

6.4.2 Variables

Our dependent variable is the current or last *employment sector* in five categories in Wave 5. Similar to Bloch, Graversen, and Pedersen (2015), we differentiate (1) the academic sector[8], (2) research jobs in the public sector[9], (3) research jobs in the private sector, (4) non-research jobs in the public sector,

[6] At the same time, a very old age at graduation can formally prevent future appointments to professorships. In Germany, professors are usually civil servants, and one can enter that status only up to a certain age (up to the age of 47 to 55 depending on the federal state). However, the analysis of appointments to professorships would require longer panel data and is not the subject of this study.

[7] In medicine, a doctoral degree is acquired by the majority of graduates and serves mainly as an additional professional qualification rather than as a scientific qualification. In many cases, dissertation work takes place during studies and is limited in scope.

[8] Including universities, universities of applied sciences, and non-university research institutions.

[9] Including jobs in associations, parties, foundations, religious communities, arts, and culture.

and (5) non-research jobs in the private sector. We define jobs as research jobs if respondents indicate that they are (very) intensively involved in designing or coordinating research or development projects or if they (very) intensively apply scientific methods, procedures, or techniques.

We operationalize *individual preferences* by four distinct factors: career, security, innovation, and autonomy. The corresponding items were included in Wave 1. Respondents were asked to rate the importance of various job-related life goals on a 5-point scale from 1 'very unimportant' to 5 'very important'. We conducted a principal component analysis with varimax rotation to identify the preference factors (see Table 6.1).[10] The sum scores for each factor are calculated based on the items indicated in the table. Because the factors consist of different numbers of items, we z-standardize all factors to be able to compare their effect sizes in the regression analyses.

Table 6.1: Results of principal component analysis (varimax rotation) on job-related life goals to identify preference factors

	Factors				Cronbach's alpha
Items	Career	Security	Innovation	Autonomy	
Having good opportunities for career advancement	**0.51**	0.06	0.03	–0.05	0.77
Working in a managerial position	**0.55**	–0.07	–0.01	0.06	
Managing and leading other people	**0.43**	–0.09	0.04	0.13	
Earning a lot of money	**0.45**	0.17	–0.04	–0.24	
Having a secure job	0.02	**0.59**	–0.04	–0.03	0.74
Being sure of always having a job	0.03	**0.60**	–0.02	0.01	
Having a boss who treats me fairly	–0.08	**0.48**	0.11	0.16	
Having a job that contributes to innovation	0.03	0.03	**0.73**	–0.10	0.75
Developing new ideas	–0.03	–0.04	**0.67**	0.10	
Independently organizing my work	–0.07	0.06	–0.02	**0.76**	0.64
Having a position that gives me the authority to make my own decisions	0.21	–0.07	–0.01	**0.54**	

Note: Factor loadings greater than 0.4 are marked in bold; *data:* DZHW PhD Panel 2014 (phd2014_p_o_4-0-0); N=1,959; weighted data; using first imputation

Objective labour market conditions are captured by the doctoral subject group. We differentiate seven categories: (1) natural sciences, mathematics; (2) engineering, computer sciences; (3) social sciences (excluding economics and law); (4) humanities, arts; (5) economics; (6) law; and (7) others. These categories correspond to the official subject classification of the German Federal Statistical Office – with two exceptions: because of few cases in arts, we combined them with humanities; and because of our theoretical expectations, we split law, economics, and other social sciences into separate subject groups.

Subjective career prospects are measured by respondents' evaluation of their personal employment prospects inside and outside academia on a 5-point scale from 1 'very bad' to 5 'very good'. Both items were first observed in Wave 2 and then each year thereafter. The Wave 2 items are highly correlated with the respective items in subsequent waves (inside academia $r_{wave2+3}$: 0.61, $r_{wave2+4}$: 0.56; outside academia $r_{wave2+3}$: 0.66, $r_{wave2+4}$: 0.62); therefore, prior to imputation, we replace missing values in both Wave 2 items with those from Waves 3 or 4 if the latter are non-missing. We z-standardize both variables.

External encouragement comprises three dummy variables from Wave 1 that indicate whether the respondents had been encouraged by their doctoral supervisor to pursue a research career inside academia, a research career outside academia, or a non-research career. [11]

[10] The survey contains further items on life goals that were also included in the imputation model and in a previous principal component analysis. For our analysis, however, we use only items that form factors that fit our theoretical expectations.

[11] Question text: At the end of your doctoral training, did your supervisor make any recommendations with regard to your professional future?

Individual career constraints are captured by respondents' main funding source during the doctorate in four categories (research assistant position, scholarship, employment outside academia, other funding source), their final doctorate grade (summa cum laude vs. other), and their age at graduation.

In the regression analysis, we control for respondents' gender and whether they are parents at the time of Wave 5. Table 6.2 shows the descriptive statistics by employment sector.

Table 6.2: Variable description by employment sector

	Academic sector (n=614) [a]	**Research in public sector (n=194) [a]**	**Research in private sector (n=506) [a]**	**Non-research in public sector (n=231) [a]**	**Non-research in private sector (n=414) [a]**	***Total (N=1,959)***	**Sig.[b]**
Dependent variable: Employment sector (%)	29.2	9.1	28.9	10.6	22.2	*100.0*	
Preferences							
Career *(z-stand.)*	–0.26 (0.93)	–0.11 (1.01)	0.20 (1.01)	–0.07 (0.97)	0.15 (1.00)	*–0.00* *(1.00)*	***
Security *(z-stand.)*	–0.03 (1.00)	0.06 (1.04)	–0.03 (1.00)	0.11 (0.92)	0.00 (1.02)	*–0.00* *(1.00)*	n.s.
Innovation *(z-stand.)*	0.09 (0.92)	–0.11 (1.06)	0.29 (0.88)	–0.29 (1.07)	–0.31 (1.06)	*0.00* *(1.00)*	***
Autonomy *(z-stand.)*	0.05 (1.00)	0.04 (1.07)	–0.05 (0.98)	0.01 (1.02)	–0.02 (0.99)	*–0.00* *(1.00)*	n.s.
Objective labour market conditions							
Subject group (%)							
Natural sciences, mathematics	39.8	38.0	47.9	25.6	46.1	*41.9*	***
Engineering, computer sciences	14.5	9.9	35.0	2.4	18.2	*19.6*	
Social sciences	14.1	12.5	3.4	14.4	3.5	*8.5*	
Humanities, arts	17.8	18.9	2.5	24.4	6.0	*11.6*	
Economics	6.0	5.0	5.4	3.4	9.5	*6.2*	
Law	2.7	9.9	2.7	24.0	8.5	*6.9*	
Other	5.2	5.8	3.1	6.0	8.3	*5.4*	
Subjective career prospects							
Subjective employment prospects inside academia *(z-stand.)*	0.47 (0.99)	–0.09 (0.91)	–0.04 (0.97)	–0.28 (0.88)	–0.39 (0.90)	*0.00* *(1.00)*	***
Subjective employment prospects outside academia *(z-stand.)*	–0.51 (1.06)	–0.05 (0.99)	0.32 (0.82)	0.10 (0.99)	0.23 (0.87)	*–0.00* *(1.00)*	***
External encouragement							
Encouraged to pursue a research career inside academia: yes (*ref.: no*; %)	45.0	22.1	17.5	15.9	17.5	*25.8*	***
Encouraged to pursue a research career outside academia: yes (*ref.: no*; %)	9.4	8.1	12.0	2.7	7.3	*8.9*	**
Encouraged to pursue a non-research career: yes (*ref.: no*; %)	3.5	5.1	7.9	9.7	7.0	*6.3*	**
Individual career constraints							
Main funding source during the doctorate (%)							
Research assistant position	71.0	59.8	71.4	39.7	64.3	65.3	***
Scholarship	21.5	17.2	14.3	24.8	12.7	*17.4*	
Employment outside academia	4.1	17.7	11.2	24.7	16.3	*12.3*	
Other funding source	3.5	5.4	3.1	10.8	6.8	*5.0*	
Final grade of doctorate: summa cum laude (*ref.: other*; %)	37.6	17.6	22.4	16.4	15.5	*24.2*	***
Age at graduation (%)							
< 30 years	18.5	16.4	25.6	24.4	23.1	*22.0*	***
30 to 34 years	61.4	54.0	60.7	50.9	61.0	*59.3*	
35 to 39 years	14.4	18.2	9.1	13.3	10.3	*12.2*	
>=40 years	5.8	11.5	4.6	11.4	5.6	*6.5*	
Controls							
Gender: female (*ref.: male*; %)	41.4	51.6	24.8	54.4	46.0	*40.0*	***
Parenthood: yes (*ref.: no*; %)	53.0	59.0	54.3	62.2	57.2	*55.8*	n.s.

Note: Mean values for quasi-metric variables (standard deviation in parentheses) and frequencies for categorical variables (column percentages), both by employment sector; *data:* DZHW PhD Panel 2014 (phd2014_p_o_4-0-0); weighted data; using first imputation; [a] unweighted case numbers; [b] one-way analysis of variance in case of quasi-metric variables and Chi^2-test in case of categorical variables

6.4.3 Analytical strategy

To test how individual preferences, objective labour market conditions, subjective career prospects, external encouragement, and individual career constraints correspond with doctoral graduates' sector choices, we estimate a multinomial logit model of the probability of being employed in each of the five employment sectors. Multinomial logit models are used for categorical dependent variables that consist of k exclusive and unordered categories; estimation is based on maximum likelihood (Cameron & Trivedi, 2010; Long & Freese, 2014). Multinomial logit models simultaneously fit binary logits that compare $k - 1$ categories to the dependent variable's remaining category, which serves as an overall reference category. As a result, each binary logit is based on a different subsample, the logit coefficients vary depending on which category of the dependent variable is chosen as the overall reference category, and they can be interpreted only with reference to that category. Therefore, we present the results in terms of average marginal effects rather than logit coefficients. The advantage of average marginal effects is that marginal changes are constant, regardless of which of the dependent variable's categories serves as the reference category; therefore, they can be interpreted in a straightforward manner.[12] In this paper, the average marginal effects indicate a change in the probability of being employed in each employment sector when the predictor variables increase by one unit net of all other covariates.[13]

Although using panel data, our analytical strategy is cross-sectional. There are two reasons for this. *First*, our research interest is to explain *inter*individual differences in doctoral graduates' employment sectors, i.e. our focus is on between-variation in the predictors and employment sectors instead of the within-variation typical in panel analyses. *Second*, most of our predictors are time-constant (e.g. subject group, final grade, external encouragement) or not measured at each wave (e.g. preferences, subjective career prospects). We still make use of the panel data structure because the predictors are measured prior to the dependent variable. Nevertheless, the temporal order in measurement cannot completely rule out endogeneity issues in our analyses. However, the determinants are theoretically derived and mostly exogenous, and the results are not sensitive to model specification (s. section 6.5.3). Therefore, the potential bias should be negligible.

The following results section starts with a brief description of employment sectors over the five survey waves. Afterwards, we present the results of the multinomial logit model predicting employment sectors in Wave 5. The statistical analysis is supplemented by robustness checks to test whether the results are sensitive to model specification.

6.5 Results

6.5.1 Description of employment sectors over waves

In Wave 1, 39 percent of the respondents were employed in the academic sector (Figure 6.2)[14]; 23 percent held research and 22 percent held non-research jobs in the private sector; and smaller proportions held non-research (10 percent) or research (6 percent) jobs in the public sector. Within the first five years after doctoral graduation, the share of individuals inside academia decreases by approximately 10 percentage points (ppts). In addition, the share of graduates in research jobs in the

[12] We use Klein's (2014) 'mimrgns' Stata ado to obtain average marginal effects with multiply imputed data.
[13] Significant coefficients and relative risk ratios for all pairs of outcomes can be found in Supplementary Table 6.6.
[14] Note that Figure 6.2 refers to all respondents who have participated in the corresponding wave (excluding doctoral graduates in medicine).

private sector increases by approximately 6 ppts. The other employment sectors appear relatively stable over time.

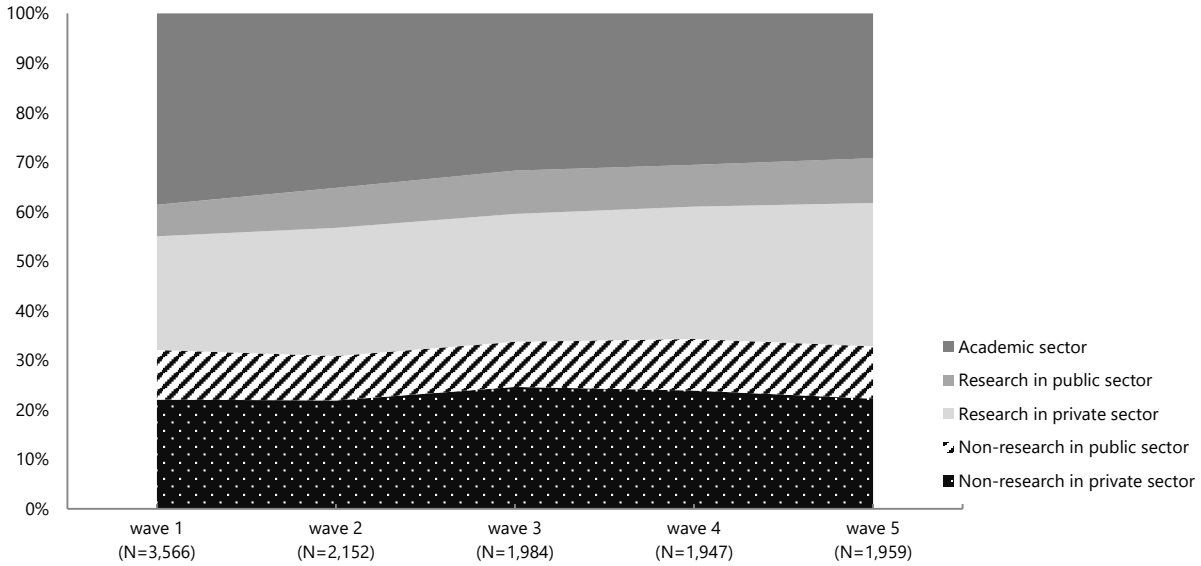

Figure 6.2: **Doctoral graduates' employment sectors over waves.**
Data: DZHW PhD Panel 2014 (phd2014_p_o_4–0–0); weighted data; without imputation.

6.5.2 Determinants of sector choices

Table 6.3 displays the multinomial logit model predicting employment sectors in Wave 5. We find that several *preferences* are associated with the probability of working in specific employment sectors. As expected, an increase in preferences for career by one standard deviation significantly[15] decreases the probability of being employed in the academic sector by 4 ppts and increases the probability of being employed in both private sectors by 3 ppts. In line with expectations, an increase in preferences for security by one standard deviation increases the probability of non-research employment in the public sector by 2 ppts. Moreover, preferences for security decrease the probability of holding a non-research job in the private sector (–3 ppts). Regarding preferences for innovation, an increase of one standard deviation increases the probability of research employment in the private sector by 5 ppts and decreases the probability of non-research employment in this sector by 6 ppts. In line with expectations, an increase in preferences for autonomy increases the probability of being employed in the academic sector by 3 ppts and decreases the probability of holding a research job in the private sector by 2 ppts.

[15]When we refer to the significance of results, we always mean their statistical significance and not their relevance.

Table 6.3: Multinomial logit model (average marginal effects) on doctoral graduates' employment sector

		Academic sector	Research in public sector	Research in private sector	Non-research in public sector	Non-research in private sector
Preferences	Career *(z-stand.)*	–0.04***	–0.01	0.03*	–0.01	0.03**
		(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
	Security *(z-stand.)*	0.02	0.01	–0.02	0.02*	–0.03**
		(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
	Innovation *(z-stand.)*	0.00	–0.00	0.05***	0.00	–0.06***
		(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
	Autonomy *(z-stand.)*	0.03**	0.00	–0.02*	–0.01	0.00
		(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Objective labour market conditions	Subject group *(ref.: natural sciences, mathematics)*					
	Engineering, computer sciences	–0.02	–0.03	0.10**	–0.05***	0.01
		(0.03)	(0.02)	(0.03)	(0.01)	(0.03)
	Social sciences	0.16***	0.04	–0.16***	0.11***	–0.15***
		(0.03)	(0.02)	(0.03)	(0.03)	(0.03)
	Humanities, arts	0.14***	0.07*	–0.24***	0.15***	–0.12***
		(0.04)	(0.03)	(0.03)	(0.03)	(0.03)
	Economics	0.03	–0.00	–0.10*	0.01	0.06
		(0.04)	(0.03)	(0.04)	(0.03)	(0.04)
	Law	–0.07	0.07	–0.22***	0.27***	–0.06
		(0.04)	(0.04)	(0.04)	(0.05)	(0.04)
	Other	0.03	0.01	–0.13**	0.04	0.05
		(0.04)	(0.03)	(0.04)	(0.03)	(0.04)
Subjective career prospects	Subjective employment prospects inside academia *(z-stand.)*	0.10***	0.00	–0.01	–0.01	–0.07***
		(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
	Subjective employment prospects outside academia *(z-stand.)*	–0.09***	–0.00	0.06***	0.01	0.03*
		(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
External encouragement	Encouraged to pursue a research career inside academia: yes *(ref.: no)*	0.12***	–0.01	–0.09***	–0.03	–0.01
		(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
	Encouraged to pursue a research career outside academia: yes *(ref.: no)*	–0.02	0.02	0.03	–0.05*	0.02
		(0.03)	(0.03)	(0.03)	(0.02)	(0.04)
	Encouraged to pursue a non-research career: yes *(ref.: no)*	–0.06	–0.01	0.05	0.04	–0.02
		(0.04)	(0.03)	(0.04)	(0.03)	(0.04)
Individual career constraints	Main funding source during the doctorate *(ref.: Research assistant position)*					
	Scholarship	0.00	-0.01	-0.01	0.05**	-0.04
		(0.03)	(0.02)	(0.03)	(0.02)	(0.02)
	Employment outside academia	-0.17***	0.00	0.05	0.05	0.06
		(0.03)	(0.02)	(0.04)	(0.02)	(0.04)
	Other funding source	-0.16***	-0.04*	0.08	0.03	0.09
		(0.03)	(0.02)	(0.06)	(0.03)	(0.05)
	Final grade of doctorate: summa cum laude *(ref.: other)*	0.08***	–0.02	0.01	–0.02	–0.05*
		(0.02)	(0.02)	(0.03)	(0.02)	(0.02)
	Age at graduation *(ref.: <30 years)*					
	30 to 34 years	0.05*	0.02	–0.06*	–0.02	0.00
		(0.02)	(0.02)	(0.03)	(0.02)	(0.02)
	35 to 39 years	0.11**	0.06*	–0.11**	–0.03	–0.04
		(0.04)	(0.03)	(0.04)	(0.02)	(0.03)
	>=40 years	0.11*	0.08*	–0.14**	0.01	–0.06
		(0.05)	(0.04)	(0.05)	(0.03)	(0.04)
Controls	Gender: female *(ref.: male)*	–0.02	0.03*	–0.10***	0.03*	0.05*
		(0.02)	(0.01)	(0.02)	(0.01)	(0.02)
	Parenthood: yes *(ref.: no)*	–0.02	0.01	–0.02	0.03*	0.00
		(0.02)	(0.01)	(0.02)	(0.01)	(0.02)
	n	614	194	506	231	414

Data: DZHW PhD Panel 2014 (phd2014_p_o_4–0–0); N=1,959; weighted data; standard errors in parentheses; * p < 0.05, ** p < 0.01, *** p < 0.001

Regarding *objective labour market conditions*, our model suggests that compared to doctoral graduates from natural sciences and mathematics, graduates from engineering and computer sciences more frequently hold research jobs in the private sector (10 ppts) and less frequently hold non-research jobs in the public sector (–5 ppts). For graduates from social sciences and from humanities and arts, we find a similar pattern: they are more likely to be employed in the academic sector (16 ppts, 14 ppts) or in non-research jobs in the public sector (11 ppts, 15 ppts) than graduates from natural sciences and mathematics, but they are less likely to be employed in both private sectors. We find that graduates from economics differ from graduates from natural sciences and mathematics only regarding research jobs in the private sector (–10 ppts). Graduates from law are less frequently employed in research jobs in the private sector (–22 ppts) than graduates from natural sciences and mathematics, but they more frequently hold non-research jobs in the public sector (27 ppts).

For *external encouragement*, we find that being encouraged to pursue a research career inside academia increases the probability of working in the academic sector by 12 ppts, which is in line with expectations, and decreases the probability of research employment in the private sector by 9 ppts. Being encouraged to pursue a research career outside academia decreases the probability of holding non-research jobs in the public sector (–5 ppts). Being encouraged to pursue a non-research career is not significantly associated with employment in any sector.

Regarding *individual career constraints*, we find that having funded the doctorate through a scholarship increases the probability of holding non-research jobs in the public sector compared to having funded the doctorate through a research assistant position (5 ppts). In line with expectations, compared to this reference category, employment outside academia during the doctorate decreases the probability of subsequent employment in the academic sector (–17 ppts). Having completed a doctorate with the top grade increases the probability of working inside academia by 8 ppts, which is in line with expectations, and decreases the probability of holding a non-research job in the private sector by 5 ppts. Compared to individuals who completed their doctorate before the age of 30, a higher age tends to increase the probability of working in the academic sector and the research-related public sector. In line with expectations, the probability of research employment in the private sector decreases as age at graduation increases.

Our model also confirms the relevance of our *control variables*. On average, being female decreases the probability of research employment in the private sector by 10 ppts but increases the probability of both research and non-research employment in the public sector (3 ppts) and non-research employment in the private sector (5 ppts). Having children increases the probability of holding non-research jobs in the public sector (3 ppts).

6.5.3 Robustness check

Interrelationships between the predictors might lead to biased estimates in our fully specified model (overcontrol bias). For example, a high academic ability may increase preferences for job attributes that are associated with employment inside academia and subjective career prospects inside academia. Moreover, doctoral students who have been encouraged to pursue an academic career are likely to be a selective group in terms of their academic ability. However, these determinants may also affect their academic performance. For example, doctoral students with strong academic career intentions and according preferences may work particularly hard during their doctoral training to complete their doctorate with the top final grade.

To check whether our results are biased by such interrelations between the predictors, we calculated bivariate correlations (see Supplementary Table 6.5) and the variance inflation factor. Bivariate correlations were inconspicuous, with few and minor exceptions ($0.3 < r < 0.4$). However, the variance inflation factor indicated that there was no problem with multicollinearity among the predictors (mean VIF: 1.25).

As a further robustness check, we additionally calculated models with each theoretical component separately and compared the coefficients with those in the full model for each employment sector. Overall, the robustness checks confirmed that the effects of the predictors are basically robust to the model specification.

6.6 Discussion

Building on previous research, this paper aimed to examine how individual preferences, objective labour market conditions, subjective career prospects, external encouragement, and individual career constraints affect doctoral graduates' employment sector choices in Germany. The determinants were theoretically derived from a rational choice framework and tested on a nationally representative sample of doctoral graduates who completed their doctorate at German universities in 2014, which allowed us to closely reproduce Bloch et al.'s (2015) categorization of employment sectors.

The *results* mainly align with both the wide version of the RCT and previous research. In line with expectations and previous studies (Agarwal & Ohyama, 2013; Balsmeier & Pellens, 2014; Bloch, Graversen, & Pedersen, 2015; Flöther, 2017; Waaijer, 2017), we found that preferences for certain job attributes are associated with employment sectors. Preferences for career decrease the probability of being employed in the academic sector and increase the probability of being employed in the private sector. Conversely, doctoral graduates with strong preferences for autonomy are more likely to hold jobs inside academia and less likely to hold research jobs in the private sector. Preferences for innovation increase the probability of research employment in the private sector and decrease the probability of non-research employment in this sector. Preferences for security slightly increase the probability of non-research employment in the public sector and decrease the probability of non-research employment in the private sector.

In addition to individual preferences, the other theoretical constructs have also been shown to be decisive factors. We have measured objective labour market conditions using subject groups, and in line with our expectations, we found that graduates from STEM subjects are especially often employed in research jobs in the private sector, whereas graduates from social sciences (excluding economics and law) and from humanities and arts are more often employed in the academic or public sectors. As with Waaijer (2017), the results also confirm that sector choices depend on subjective career prospects regarding careers inside and outside academia. In accordance with Bloch, Graversen, and Pedersen (2015), external encouragement to pursue a particular career path appears highly relevant for subsequent sector choices. We were also able to partly confirm our expectations on individual career constraints. In line with expectations, funding the doctorate by employment outside academia compared to a research assistant position strongly decreases the probability of subsequent employment inside academia. Having completed a top grade doctorate increases the probability of working inside academia and decreases the probability of holding a non-research job in the private sector. As expected, a higher age decreases the probability of holding a research job in the private sector.

Overall, the empirical results confirm that sector choices depend on their preferences and on objective and subjective constraints, which supports our rational choice framework and confirms the results from previous studies on national contexts other than Germany. Although science systems and labour markets may differ between countries, the determinants of doctoral graduates' sector choices seem to be reasonably comparable across (Western) countries.

In *policy* terms, understanding how doctoral graduates select into different employment sectors is crucial for ensuring a good match between individual characteristics and preferences on the one hand and job requirements on the other. Employers from all sectors could use this knowledge to attract doctoral graduates and to meet their job expectations.

A striking side result was that very few doctoral graduates had been encouraged by their doctoral supervisor to pursue a non-research career. This phenomenon may be explained by the fact that doctoral supervisors are typically professors and are therefore more familiar with academic careers than with other career paths. In addition, they may have a hidden agenda to keep their mentees for rational, i.e. egoistic, reasons since they have invested in training their mentees and may want to benefit from this investment. As a result, they may be unable or unwilling to give non-academic career advice to their doctoral students. However, in reality, most doctoral graduates leave academia. The number of doctoral graduates exceeds the number of positions available inside academia many times over. Therefore, there is high competition, particularly for tenured positions. Doctoral graduates face academic careers with a high risk of unintended dropout at a high age with very specific (i.e. academic) skills. Thus, during doctoral training, they need to be prepared for and informed about the various postdoctoral career options beyond academic careers – independent of their doctoral supervisors.

We would like to point out this paper's *limitations*, some of which offer *directions for future research*. *First*, there are limitations regarding the operationalization of the independent theoretical constructs. With subjective career prospects inside and outside academia, these prospects were not as differentiated as the employment sectors. Similarly, our measures for external encouragement differentiated only between three potential career paths that did not exactly correspond to our five employment sectors. Encouragement measures have also considered encouragement only by doctoral supervisors and not by other advisors or colleagues. In addition, subject groups were a rather broad proxy for objective labour market conditions. The determinants investigated in our study were measured in the first wave at the earliest, i.e. approximately one year after graduation. Therefore, the subjective determinants may already be influenced by experiences gained after graduation and do not necessarily reflect doctoral graduates' expectations and attitudes prior to entering the postdoctoral labour market.

Second, we were unable to directly model the decision-making process of sector choices, e.g. as the product of subjective perceptions of costs, returns, and probabilities of success differentiated by each employment sector, because this information was not provided by the data we used. Nevertheless, future research on postdoctoral career decisions may take this paper as a starting point for modelling such decisions within a rational choice framework.

Third, despite using panel data, we conducted an interindividual analysis. Future research could instead examine doctoral graduates' transitions between different employment sectors over time from a life course perspective. In this case, it could be valuable to examine how intraindividual changes in the determinants affect employment sectors. Postdoctoral labour force participation could, for example, induce intraindividual changes in preferences or subjective career prospects and consequently affect sector choices.

Fourth, using data five years after graduation, we examined only the medium-term sector choices and could not draw any conclusions about the long-term sector choices – for example, whether doctoral graduates who were employed inside academia in our analysis will stay inside academia and be appointed to a chair. Against the background of the German law on academic employment ("Wissenschaftszeitvertragsgesetz"), it is likely that a substantial part of these doctoral graduates will have to leave academia approximately six years after graduation. Therefore, we encourage further research on doctoral graduates' sector choices at later career stages.

Finally, we focused on the rational career choices of doctoral graduates; however, careers result not only from deliberate career choices but also from coincidences, luck, and path dependencies. In many cases, careers are more a matter of stumbling into jobs than the result of strategic career planning, and they are, of course, also linked with the lives of other people (e.g. partners, friends, or relatives). Another compelling approach would be to investigate employers' perspective, which could be helpful to understand the demand side for doctoral graduates and the constraints they encounter in the labour market.

6.7 Conclusions

A large body of research has described the employment sectors of doctoral graduates in different national contexts, but only relatively few studies have investigated the determinants of doctoral graduates' sector choices. These studies found that individual preferences, objective labour market conditions, subjective career prospects, and external encouragement are such determinants. However, these determinants have hardly been comprehensively explained theoretically. In addition, in Germany, where the number of awarded doctoral degrees is highest within the European Union and where no established academic tenure-track system exists, the determinants of doctoral graduates' sector choices remain largely unexplored. Therefore, this paper's purpose was to derive the determinants from theory and to expand international research on doctoral graduates' sector choices with insights for Germany.

We found that preferences as well as objective and subjective constraints are associated with doctoral graduates' employment sectors in one way or another and jointly influence their sector choices in Germany. The effects of the determinants investigated in our study largely corresponded to both previous research and our theoretical expectations. The wide version of RCT has proven to be helpful in integrating empirically known determinants into an overarching theoretical framework. Overall, our study provides important insights into postdoctoral career trajectories.

Appendix

Table 6.4: Imputation model

Variables		$\%_{missing}$	$N_{complete}$	$N_{imputed}$	Estimator
Dependent variable	Employment sector	14.94	1,959	344	Multinomial logit (augmented)
Life goals	Having a job that contributes to innovations	0.78	2,285	18	Ordered logit
	Developing new ideas	0.52	2,291	12	Ordered logit
	Working on difficult and challenging tasks	0.61	2,289	14	Ordered logit
	Making and designing things	0.65	2,288	15	Ordered logit
	Having a well-equipped workplace	0.61	2,289	14	Ordered logit
	Achieving a good match between job requirements and own skills	0.69	2,287	16	Ordered logit
	Having good opportunities for career advancement	0.56	2,290	13	Ordered logit
	Working in a managerial position	0.69	2,287	16	Ordered logit
	Independently organising my work	0.56	2,290	13	Ordered logit
	Having a position that gives me the authority to make my own decisions	0.61	2,289	14	Ordered logit
	Achieving above-average job performance	0.52	2,291	12	Ordered logit
	Fully exploiting my potential	0.74	2,286	17	Ordered logit
	Managing and leading other people	0.65	2,288	15	Ordered logit
	Enjoying trust among colleagues	0.65	2,288	15	Ordered logit
	Working in a well-respected profession	0.61	2,289	14	Ordered logit
	Having a secure job	0.61	2,289	14	Ordered logit
	Being sure of always having a job	0.65	2,288	15	Ordered logit
	Earning a lot of money	0.56	2,290	13	Ordered logit
	Earning so much that one can afford a great deal of things	0.83	2,284	19	Ordered logit
	Having a manager who treats me fairly	0.96	2,281	22	Ordered logit
	Standing up for others	0.74	2,286	17	Ordered logit
	Maintaining many social contacts	0.56	2,290	13	Ordered logit
	Expanding my mental horizon	0.61	2,289	14	Ordered logit
	Further developing my abilities	0.56	2,290	13	Ordered logit
	Developing my personality	0.74	2,286	17	Ordered logit
	Reconciling career and family	0.65	2,288	15	Ordered logit
	Having a lot of time for my partner	0.74	2,286	17	Ordered logit
	Having a lot of free time	0.65	2,288	15	Ordered logit
	Enjoying life to the fullest	0.74	2,286	17	Ordered logit
	Having a high social standing	0.78	2,285	18	Ordered logit
	Enjoying public recognition	0.61	2,289	14	Ordered logit
	Having children	0.65	2,288	15	Ordered logit
Objective labour market conditions	Subject group	0.09	2,301	2	Multinomial logit (augmented)
Subjective career prospects	Subjective employment prospects inside academia	5.21	2,183	120	Ordered logit
	Subjective employment prospects outside academia	5.30	2,181	122	Ordered logit
External encouragement	Encouraged to pursue a research career inside academia	1.30	2,273	30	Logit (augmented)
	Encouraged to pursue a research career outside academia	1.30	2,273	30	Logit (augmented)
	Encouraged to pursue a non-research career	1.30	2,273	30	Logit (augmented)
Individual career constraints	Final grade of doctorate	0.13	2,300	3	Logit (augmented)
	Age at graduation	0.22	2,298	5	Ordered logit
Controls	Gender	0.00	2,303	0	Logit (augmented)
	Parenthood	5.43	2,178	125	Logit (augmented)
	Main funding of the doctorate	1.22	2,275	28	Multinomial logit (augmented)

Data: DZHW PhD Panel 2014 (phd2014_p_o_4-0-0)

Table 6.5: Correlation matrix (*to be continued*)

	1a	1b	1c	1d	1e	2	3	4	5	6a	6b	6c	6d	6e	6f	6g
1a Empl. Sector: academic sector	1.00															
1b Empl. Sector: research in public sector		1.00														
1c Empl. Sector: research in private sector			1.00													
1d Empl. Sector: non-research in public sector				1.00												
1e Empl. Sector: non-research in private sector					1.00											
2 Preferences for career	-0.15		0.12		0.08	1.00										
3 Preferences for security				0.06		0.15	1.00									
4 Preferences for innovation	0.07		0.16	-0.09	-0.15	0.15	-0.08	1.00								
5 Preferences for autonomy						**0.39**		0.23	1.00							
6a Subject group: natural sciences, math.		-0.05	0.10	-0.12	0.06	-0.06	0.13		-0.17	1.00						
6b Subject group: engineering, computer sci.	-0.08	-0.08	0.25	-0.15		0.10	-0.05	0.16			1.00					
6c Subject group: social sciences	0.14	0.05	-0.13	0.08	-0.12	-0.06	-0.05		0.11			1.00				
6d Subject group: humanities, arts	0.11	0.10	-0.19	0.14	-0.11	-0.09	-0.07		0.05				1.00			
6e Subject group: economics					0.08	0.12	-0.07		0.09					1.00		
6f Subject group: law	-0.11		-0.08	0.19				-0.16							1.00	
6g Subject group: other			-0.05		0.10		0.07	-0.11								1.00
7 Subj. employment prospects in academia	**0.31**			-0.11	-0.20		-0.09	0.16	0.09		0.08				-0.05	
8 Subj. employment prospects outside acad.	**-0.34**		0.21		0.13	0.21			0.08	-0.07	0.17	-0.06	-0.15	0.09	0.09	
9 Encour. to pursue research career in acad.	0.29		-0.12	-0.08	-0.11	-0.07	-0.06	0.08	0.04		-0.08	0.08			-0.09	
10 Encour. to pursue res. career outside acad.			0.06	-0.07				0.12		0.09		-0.06	-0.05		-0.07	
11 Encour. to pursue non-research career	-0.08		0.04	0.06				-0.05								
12a Main funding: research assistant position	0.09	-0.05	0.09	-0.19		-0.05	0.08		-0.08	0.20	0.15	-0.09	-0.25		-0.13	
12b Main funding: scholarship	0.07		-0.06	0.06	-0.07						-0.10		0.13	-0.05		
12c Main funding: employment outside acad.	-0.16	0.05		0.14	0.06	0.09	-0.07		0.11	-0.19		0.06	0.07	0.06	0.15	
12d Main funding: other funding source	-0.06			0.08						-0.15	-0.10	0.05	0.19		0.05	0.06
13 Final grade of the doctorate	0.20	-0.05		-0.07	-0.10		-0.07	0.06		-0.07				0.11		-0.06
14a Age at graduation: < 30 years	-0.05	-0.05	0.06			0.06	0.10			0.16	-0.10	-0.08	-0.10	-0.05	0.05	0.07
14b Age at graduation: 30 to 34 years				-0.06						0.06	0.06	-0.05	-0.07			
14c Age at graduation: 35 to 39 years		0.07	-0.06			-0.06				-0.17		0.07	0.12	0.05		
14d Age at graduation: >=40 years		0.07	-0.06	0.09			-0.10	0.10	0.11	-0.15		0.12	0.14			
15 Gender		0.07	-0.19	0.10	0.06	-0.08	0.10	-0.19			-0.27	0.14	0.05	-0.08		0.15
16 Parenthood									0.06	-0.06	0.06			0.06		

Note: Significant Pearson correlations only (p≤.05), correlations greater than ±0.3 are marked in bold, correlations between categories of the same categorical variable are omitted; *data:* DZHW PhD Panel 2014 (phd2014_p_o_4–0–0); unweighted data; using first imputation

Table 6.5 *(continued)*

	7	8	9	10	11	12a	12b	12c	12d	13	14a	14b	14c	14d	15	16
1a Empl. Sector: academic sector																
1b Empl. Sector: research in public sector																
1c Empl. Sector: research in private sector																
1d Empl. Sector: non-research in public sector																
1e Empl. Sector: non-research in private sector																
2 Preferences for career																
3 Preferences for security																
4 Preferences for innovation																
5 Preferences for autonomy																
6a Subject group: natural sciences, math.																
6b Subject group: engineering, computer sci.																
6c Subject group: social sciences																
6d Subject group: humanities, arts																
6e Subject group: economics																
6f Subject group: law																
6g Subject group: other																
7 Subj. employment prospects in academia	1.00															
8 Subj. employment prospects outside acad.	-0.07	1.00														
9 Encour. to pursue research career in acad.	0.20	-0.13	1.00													
10 Encour. to pursue res. career outside acad.	0.10		0.09	1.00												
11 Encour. to pursue non-research career	-0.06	0.06		0.05	1.00											
12a Main funding: research assistant position	0.09		0.09			1.00										
12b Main funding: scholarship		-0.07	0.06	0.05			1.00									
12c Main funding: employment outside acad.	-0.07	0.15	-0.16	-0.08				1.00								
12d Main funding: other funding source	-0.05		-0.05	-0.05					1.00							
13 Final grade of the doctorate	0.17	-0.06	**0.33**		-0.07	0.10		-0.13	-0.06	1.00						
14a Age at graduation: < 30 years		0.05	0.07	0.09	0.07	0.05	0.05	-0.12			1.00					
14b Age at graduation: 30 to 34 years						0.14		-0.13	-0.13			1.00				
14c Age at graduation: 35 to 39 years			-0.06			-0.08		0.08	0.08				1.00			
14d Age at graduation: >=40 years			-0.10	-0.05		-0.24	-0.09	**0.31**	0.19	-0.11				1.00		
15 Gender	-0.07	-0.13		-0.07	-0.05	-0.05			0.08	-0.06	0.13	-0.06	-0.08		1.00	
16 Parenthood				-0.08				0.07			-0.11			0.08	-0.05	1.00

*Note: S*ignificant Pearson correlations only (p≤.05), correlations greater than ±0.3 are marked in bold, correlations between categories of the same categorical variable are omitted; *data:* DZHW PhD Panel 2014 (phd2014_p_o_4–0–0); unweighted data; using first imputation

Table 6.6: Significant coefficients and relative risk ratios for all pairs of outcomes (*to be continued*)

					b	z	P>|z|	rrr
Preferences	Career *(z-stand.)*	res. priv. sec.	vs.	acad. sec.	0.369	4.175	0.000	1.446
		res. priv. sec.	vs.	res. pub. sec.	0.228	1.984	0.047	1.256
		non-res. pub.	vs.	res. priv. sec.	–0.229	–2.020	0.043	0.795
		non-res. priv.	vs.	acad. sec.	0.412	4.438	0.000	1.510
		non-res. priv.	vs.	res. pub. sec.	0.272	2.349	0.019	1.313
		non-res. priv.	vs.	non-res. pub.	0.273	2.426	0.015	1.313
	Security *(z-stand.)*	non-res. pub.	vs.	res. priv. sec.	0.271	2.757	0.006	1.312
		non-res. priv.	vs.	acad. sec.	–0.222	–2.711	0.007	0.801
		non-res. priv.	vs.	res. pub. sec.	–0.231	–2.253	0.024	0.794
		non-res. priv.	vs.	non-res. pub.	–0.338	–3.506	0.000	0.713
	Innovation *(z-stand.)*	res. priv. sec.	vs.	acad. sec.	0.187	2.227	0.026	1.206
		res. priv. sec.	vs.	res. pub. sec.	0.241	2.217	0.027	1.273
		non-res. pub.	vs.	res. priv. sec.	–0.224	–2.239	0.025	0.799
		non-res. priv.	vs.	acad. sec.	–0.313	–3.617	0.000	0.731
		non-res.priv.	vs.	res. pub. sec.	–0.260	–2.399	0.016	0.771
		non-res. priv.	vs.	res. priv. sec.	–0.501	–6.076	0.000	0.606
		non-res. priv.	vs.	non-res. pub.	–0.277	–2.869	0.004	0.758
	Autonomy *(z-stand.)*	res. priv. sec.	vs.	acad. sec.	–0.228	–2.693	0.007	0.796
Objective labour market coditions	Engeneering, computer sciences	res. priv. sec.	vs.	acad. sec.	0.426	2.104	0.035	1.531
		res. priv. sec.	vs.	res. pub. sec.	0.836	2.476	0.013	2.306
		non-res. pub.	vs.	acad. sec.	–12.435	–2.157	0.031	0.288
		non-res. pub.	vs.	res. priv. sec.	–16.692	–2.963	0.003	0.188
		non-res. priv.	vs.	non-res. pub.	13.969	2.430	0.015	4.043
	Social sciences	res. priv. sec.	vs.	acad. sec.	–15.105	–5.519	0.000	0.221
		res. priv. sec.	vs.	res. pub. sec.	–12.331	–3.718	0.000	0.291
		non-res. pub.	vs.	res. priv. sec.	17.828	5.412	0.000	5.947
		non-res. priv.	vs.	acad. sec.	–17.960	–5.737	0.000	0.166
		non-res. priv.	vs.	res. pub. sec.	–15.186	–4.222	0.000	0.219
		non-res. priv.	vs.	non-res. pub.	–20.683	–5.839	0.000	0.126
	Humanities, arts	res. priv. sec.	vs.	acad. sec.	–20.942	–5.986	0.000	0.123
		res. priv. sec.	vs.	res.. pub. sec.	–20.901	–5.371	0.000	0.124
		non-res. pub.	vs.	res. priv. sec.	26.541	6.897	0.000	14.213
		non-res. priv.	vs.	acad. sec.	–14.930	–4.881	0.000	0.225
		non-res. priv.	vs.	res. pub. sec.	–14.889	–4.420	0.000	0.226
		non-res. priv.	vs.	non-res. pub.	–20.529	–6.197	0.000	0.128
	Economics	non-res. priv.	vs.	res. priv. sec.	0.631	2.209	0.027	1.880
	Law	res. pub. sec.	vs.	acad. sec.	10.084	2.273	0.023	2.741
		res. priv. sec.	vs.	res. pub. sec.	–18.005	–3.852	0.000	0.165
		non-res. pub.	vs.	acad. sec.	20.695	5.306	0.000	7.921
		non-res. pub.	vs.	res. pub. sec.	10.612	2.465	0.014	2.890
		non-res. pub.	vs.	res. priv. sec.	28.617	7.079	0.000	17.491
		non-res. priv.	vs.	res. pub. sec.	–0.916	–2.186	0.029	0.400
		non-res. priv.	vs.	res. priv. sec.	0.885	2.326	0.020	2.423
		non-res. priv.	vs.	non-res. pub.	–19.768	–5.809	0.000	0.139
	Other	non-res. pub.	vs.	res. priv. sec.	10.103	2.473	0.013	2.746
		non-res. priv.	vs.	res. priv. sec.	0.711	2.247	0.025	2.036
Subjective career prospects	Encouraged to pursue a research career in academia: yes *(ref: no)*	res. pub. sec.	vs.	acad. sec.	–0.477	–5.060	0.000	0.620
		res. priv. sec.	vs.	acad. sec.	–0.597	–7.070	0.000	0.551
		non-res. pub.	vs.	acad. sec.	–0.635	–6.376	0.000	0.530
		non-res. priv.	vs.	acad. sec.	–0.911	–10.206	0.000	0.402
		non-res. priv.	vs.	res. pub. sec.	–0.434	–4.337	0.000	0.648
		non-res. priv.	vs.	res. priv. sec.	–0.315	–3.851	0.000	0.730
		non-res. priv.	vs.	non-res. pub.	–0.276	–2.653	0.008	0.759
	Encouraged to pursue a research career outside academia: yes *(ref.: no)*	res. pub. sec.	vs.	acad. sec.	0.403	4.211	0.000	1.497
		res. priv. sec.	vs.	acad. sec.	0.685	7.659	0.000	1.983
		res. priv. sec.	vs.	res. pub. sec.	0.281	2.637	0.008	1.325
		non-res. pub.	vs.	acad. sec.	0.516	5.030	0.000	1.675
		non-res. priv.	vs.	acad. sec.	0.623	7.169	0.000	1.864
		non-res. priv.	vs.	res. pub. sec.	0.220	2.082	0.037	1.246
	Encouraged to pursue a non-research career: yes *(ref.: no)*	res. pub. sec.	vs.	acad. sec.	–0.544	–2.357	0.018	0.581
		res. priv. sec.	vs.	acad. sec.	–0.950	–5.268	0.000	0.387
		non-res. pub.	vs.	acad. sec.	–0.841	–3.660	0.000	0.431
		non-res. priv.	vs.	acad. sec.	–0.668	–3.562	0.000	0.513

Data: DZHW PhD Panel 2014 (phd2014_p_o_4–0–0); N=1,959; weighted data; using first imputation

Table 6.6 *(continued)*

					b	z	P>|z|	rrr
Individual career constraints	Scholarship	non-res. pub.	vs.	acad. sec	0.511	2.229	0.026	1.666
		non-res. pub.	vs.	res. pub. sec	0.622	2.250	0.024	1.863
		non-res. pub.	vs.	res. priv. sec	0.623	2.459	0.014	1.864
		non-res. priv.	vs.	non-res. pub.	–0.776	–3.035	0.002	0.460
	Employment outside academia	res. pub. sec	vs.	acad. sec	0.967	2.852	0.004	2.630
		res. priv. sec	vs.	acad. sec	12.138	4.012	0.000	3.366
		non-res. pub.	vs.	acad. sec	15.146	4.434	0.000	4.548
		non-res. priv.	vs.	acad. sec	13.178	4.350	0.000	3.735
	Other funding source	res. priv. sec	vs.	acad. sec	13.897	3.479	0.001	4.014
		res. priv. sec	vs.	res. pub. sec	10.923	2.285	0.022	2.981
		non-res. pub.	vs.	acad. sec	12.678	3.189	0.001	3.553
		non-res. pub.	vs.	res. pub. sec	0.970	2.151	0.031	2.639
		non-res. priv.	vs.	acad. sec	14.625	3.817	0.000	4.317
		non-res. priv.	vs.	res. pub. sec	11.650	2.538	0.011	3.206
	Final grad of doctorate: summa cum laude *(ref.: other)*	res. pub. sec	vs.	acad. sec	–0.632	–2.669	0.008	0.532
		res. priv. sec	vs.	acad. sec	–0.349	–1.970	0.049	0.706
		non-res. pub.	vs.	acad. sec	–0.583	–2.513	0.012	0.558
		non-res. priv.	vs.	acad. sec	–0.648	–3.351	0.001	0.523
	Age at graduation 30 to 34 years	res. priv. sec	vs.	acad. sec	–0.514	–2.751	0.006	0.598
	Age at graduation 35 to 39 years	res. priv. sec	vs.	acad. sec	–11.005	–3.851	0.000	0.333
		res. priv. sec	vs.	res. pub. sec	–12.681	–3.503	0.000	0.281
		non-res. pub.	vs.	acad. sec	–0.827	–2.283	0.022	0.437
		non-res. pub.	vs.	res. pub. sec	–0.994	–2.437	0.015	0.370
		non-res. priv.	vs.	acad. sec	–0.845	–2.816	0.005	0.429
		non-res. priv.	vs.	res. pub. sec	–10.129	–2.810	0.005	0.363
	Age at graduation ≥40 years	res. priv. sec	vs.	acad. sec	–11.625	–2.937	0.003	0.313
		res. priv. sec	vs.	res. pub. sec	–15.246	–3.374	0.001	0.218
		non-res. priv.	vs.	res. pub. sec	–11.228	–2.579	0.010	0.325
	Gender: female *(ref.: male)*	res. pub. sec	vs.	acad. sec	0.440	2.219	0.026	1.553
		res. priv. sec	vs.	acad. sec	–0.360	–2.119	0.034	0.698
		res. priv. sec	vs.	res. pub. sec	–0.800	–3.847	0.000	0.449
		non-res. pub.	vs.	acad. sec	0.447	2.228	0.026	1.564
		non-res. pub.	vs.	res. priv. sec	0.807	3.854	0.000	2.242
		non-res. priv.	vs.	res. priv. sec	0.663	4.089	0.000	1.940
	Parenthood: yes *(ref.: no)*	non-res. pub.	vs.	acad. sec	0.476	2.493	0.013	1.609
		non-res. pub.	vs.	res. priv. sec	0.446	2.260	0.024	1.562

Data: DZHW PhD Panel 2014 (phd2014_p_o_4–0–0); N=1,959; weighted data; using first imputation

7 Associations between doctoral graduates' academic career intentions, employment sectors, and professional success (*Paper 3*)

Goldan, L., Jaksztat, S., & Gross, C. (2022). Laufbahnintentionen, Tätigkeitsbereiche und Berufserfolg von Promovierten. *Beiträge zur Hochschulforschung, 44*(1), 30–51.[1, 2, 3]

Zusammenfassung: In diesem Beitrag wird mithilfe des DZHW-Promoviertenpanels 2014 untersucht, in welchen Bereichen Promovierte fünf Jahre nach ihrer Promotion tätig sind und inwiefern diese Tätigkeitsbereiche ihren ursprünglichen Laufbahnintentionen entsprechen. Zudem werden objektive und subjektive Indikatoren des Berufserfolgs differenziert nach Tätigkeitsbereich der Promovierten beschrieben. Die Analysen zeigen, dass für Promovierte einerseits Tätigkeiten außerhalb der Wissenschaft und andererseits forschungsbezogene Tätigkeiten von hoher Relevanz sind. Die Mehrzahl der Promovierten kann ihre ursprüngliche Laufbahnintention realisieren und ist gemessen an verschiedenen objektiven und subjektiven Indikatoren beruflich erfolgreich. Promovierte in der Privatwirtschaft mit und ohne Forschungsbezug haben zahlreiche Vorteile gegenüber Promovierten in anderen Tätigkeitsbereichen. Promovierte in der Wissenschaft haben zwar bei einigen objektiven Indikatoren das Nachsehen, sind dafür aber besonders häufig adäquat beschäftigt.

7.1 Einführung in die Thematik

Der Doktortitel erfüllt in Deutschland eine doppelte Qualifizierungsfunktion. Einerseits ist eine Promotion die zwingende Voraussetzung für eine akademische Laufbahn. Andererseits finden Promovierte auch auf dem nicht-akademischen Arbeitsmarkt gute Beschäftigungsbedingungen vor. Im nicht-akademischen öffentlichen und im privaten Sektor haben sie z. B. Vorteile beim Zugang zu Führungspositionen, insbesondere wenn es sich um forschungs- oder wissenschaftsnahe Stellen handelt (BuWiN, 2017, S. 226–227; Enders & Bornmann, 2001, S. 89–142). Promovierte leisten zudem inner- und außerhalb der Wissenschaft einen erheblichen Beitrag zur Wissensproduktion und gesellschaftlichen, wirtschaftlichen und technischen Innovationsfähigkeit (Bogle et al., 2010; Diamond et al., 2014).

Nach ihrem Promotionsabschluss müssen Promovierte in der Regel entscheiden, ob sie (vorerst) in der Wissenschaft bleiben möchten oder nicht. Obwohl Promovierte durchschnittlich ein hohes intrinsisches Interesse an wissenschaftlichen Tätigkeiten haben (Briedis et al., 2014), kann und möchte nur ein Teil der Promovierten langfristig in der Wissenschaft bleiben. Dafür gibt es mindestens drei Gründe: *Erstens* nehmen viele eine Promotion ausdrücklich mit dem Wunsch auf, ihre außerwissenschaftlichen

[1] Note that the paper has been published in German language and therefore is also included in German in this thesis. The English title would be *'Career intentions, employment sectors, and professional success of doctoral graduates'*.

[2] Anmerkung: Die Studie ist gefördert durch die Deutsche Forschungsgemeinschaft DFG (Projekt "Subjektiver und objektiver Berufserfolg von Promovierten in Deutschland" – 433155285) und ein Promotionsstipendium der Studienstiftung des deutschen Volkes. Die der Arbeit zugrundeliegenden Analyseskripte sind beim Forschungsdatenzentrum des DZHW archiviert (DOI: 10.21249/DZHW:goldan2022:1.0.0).

[3] Danksagung: Unser Dank gilt den anonymen Gutachtenden und den Herausgebenden für wertvolle Hinweise zum Manuskript, die wesentlich zu dessen Verbesserung beigetragen haben. Ebenso danken wir Micha Pastuschka für hilfreiche Hinweise zu einer früheren Version des Manuskripts.

Karriereaussichten zu verbessern (Briedis, 2007; Briedis et al., 2014; BuWiN, 2013, S. 290). *Zweitens* sinkt bei einem Teil der Promovierenden die akademische Laufbahnintention im Promotionsverlauf zugunsten außerwissenschaftlicher Tätigkeiten (Roach & Sauermann, 2017) – eventuell aufgrund der erhaltenen Einblicke in die unsicheren Beschäftigungs- und Aufstiegsaussichten innerhalb der Wissenschaft. *Drittens* sehen sich viele Promovierte schlichtweg aufgrund der geringen Anzahl unbefristeter Stellen gezwungen, die Wissenschaft zu verlassen (Borgwardt, 2010; BuWiN, 2017) – etwa nach Ablauf der vom Wissenschaftszeitvertragsgesetz vorgegebenen maximalen Befristungshöchstdauer.

In bisherigen Untersuchungen wurden häufig der Verbleib in der Wissenschaft und schließlich das Erreichen einer Professur fokussiert und als beruflicher Erfolg von Promovierten gewertet (z. B. Jaksztat et al., 2017; Jungbauer-Gans & Gross, 2013; Zimmer, 2018). Dies ist angemessen, wenn es um Promovierte geht, die sicher in der Wissenschaft bleiben wollen und entsprechend nach der Promotion weitere akademische Qualifizierungsmaßnahmen aufnehmen, z. B. eine Habilitation oder Juniorprofessur. Da Promovierte häufig außerwissenschaftliche Karrierewege anstreben und auch auf dem nicht-akademischen Arbeitsmarkt gute Karrierechancen vorfinden, stellt ein Austritt aus der Wissenschaft aber keinesfalls einen beruflichen Misserfolg dar, sondern kann einen ebenso erfolgreichen Karriereweg einleiten wie der idealtypische Verbleib in der Wissenschaft mit anschließender Berufung auf eine Professur.

Der Bundesbericht Wissenschaftlicher Nachwuchs (BuWiN) fordert daher, dass "*Analysen zu den Karrierewegen des wissenschaftlichen Nachwuchses nicht von einer Dichotomie von Erfolg durch Erreichen einer Professur und jedwedem anderen Misserfolg geprägt sind*" (BuWiN, 2013, S. 334–335) und dass Promovierte, die das Wissenschaftssystem verlassen, verstärkt in den Blick genommen werden (BuWiN, 2013, S. 346). Die vorliegende deskriptive Arbeit kommt diesen Forderungen nach, indem der berufliche Verbleib von Promovierten fünf Jahre nach Promotionsabschluss anhand differenzierter Tätigkeitsbereiche und verschiedener Erfolgsindikatoren betrachtet wird. Darüber hinaus wird dargestellt, inwiefern Promovierte mittelfristig ihre ursprüngliche Laufbahnintention realisieren können. Dabei liegt dieser Arbeit eine breite Erfolgsdefinition zugrunde, da Berufserfolg als mehrdimensionales Konstrukt anhand objektiver und subjektiver Indikatoren bestimmt wird. Objektive Erfolgsindikatoren sind z. B. die Lohnhöhe oder die erreichte Berufsposition, subjektive Indikatoren sind z. B. die subjektiv eingeschätzte Beschäftigungsadäquanz oder die Berufszufriedenheit.

Für die Analysen wird das Promoviertenpanel des Deutschen Zentrums für Hochschul- und Wissenschaftsforschung (DZHW) genutzt, welches Angaben zu den Karrierewegen der Promotionskohorte 2014 bis fünf Jahre nach Promotionsabschluss enthält. Die Daten umfassen Promovierte aller Fächergruppen und Promotionskontexte und ermöglichen es, den beruflichen Verbleib und Erfolg von Promovierten jenseits der Dichotomie von wissenschaftlicher und nicht-wissenschaftlicher Tätigkeit zu beschreiben. Um aktuelle Einblicke in die vielfältigen Karrierewege von Promovierten zu gewinnen, sollen die folgenden Fragen mittels deskriptiver Analysen beantwortet werden: *(a) In welchen Bereichen sind Promovierte fünf Jahre nach ihrer Promotion tätig? (b) Inwiefern entsprechen diese Tätigkeitsbereiche ihren ursprünglichen Laufbahnintentionen? (c) Wie erfolgreich sind Promovierte in Abhängigkeit ihres beruflichen Verbleibs?*

Der Beitrag betrachtet die berufliche Situation fünf Jahre nach Promotionsabschluss. Die ersten Jahre nach der Promotion sind entscheidend für den langfristigen beruflichen Verbleib (Béret, Giret & Recotillet, 2003; Enders & Bornmann, 2001; Flöther, 2017) und der Austritt aus der Wissenschaft erfolgt häufig zeitnah nach Erwerb des Doktortitels (BuWiN, 2013; BuWiN, 2021, S. 211–216; Lind, 2004). Zudem handelt es sich bei dem Übergang von der Promotion in weiterführende Beschäftigungen

nicht um ein punktuelles Ereignis, sondern um einen Prozess, welcher jedoch bis fünf Jahre nach der Promotion weitestgehend abgeschlossen sein sollte.

Die (internationale) empirische Forschung hat in jüngerer Zeit viele neue Erkenntnisse zu den *Mechanismen* und *Prozessen* generiert, die im Kontext der Karrieren von Promovierten wirksam werden, etwa zu individuellen beruflichen Entscheidungsprozessen nach der Promotion (Bloch, Graversen & Pedersen, 2015; Waaijer, 2017), zu typischen Berufsverläufen (Vinkenburg et al., 2020), zu heterogenen monetären Promotionserträgen (Goldan, 2021; Trennt & Euler, 2019) oder zum Beitrag von Promovierten zu wirtschaftlichen Innovationsprozessen (Heinisch & Buenstorf, 2018). Dieser Beitrag *beschreibt* den beruflichen Verbleib und Erfolg von Promovierten deutscher Hochschulen anhand aktueller Daten und kann somit eine Grundlage für weitere Forschung zu den Mechanismen und Prozessen ihrer Karrieren bieten. Weil das Ziel dieser Arbeit nicht die *Erklärung* von Karriereverläufen oder -entscheidungen ist, wird auf die theoriebasierte Ableitung von Hypothesen bewusst verzichtet. Zunächst wird der aktuelle Forschungsstand zum beruflichen Verbleib und Erfolg von Promovierten beschrieben (Abschnitt 2). Im Anschluss daran werden die verwendeten Daten vorgestellt (Abschnitt 3) und die Ergebnisse präsentiert (Abschnitt 4). Der letzte Abschnitt (5) fasst die Ergebnisse zusammen und verweist auf weitere Forschungslücken.

7.2 Forschungsstand zum beruflichen Verbleib und Erfolg von Promovierten

Der berufliche Verbleib von Promovierten wurde erstmals systematisch im Rahmen der Kasseler Promoviertenstudie untersucht (Enders, 2002; Enders & Bornmann, 2001). Neuere Studien zu den Laufbahnintentionen und den Tätigkeitsbereichen von Promovierten in Deutschland basieren auf Befragungsdaten des DZHW-Promoviertenpanels 2014, Daten aus Absolventenstudien oder auf Daten zu den Erwerbsbiographien von Promovierten des Instituts für Arbeitsmarkt- und Berufsforschung und des International Centre for Higher Education Research Kassel.

Etwa ein Jahr nach Promotionsabschluss hat insgesamt etwa ein Viertel aller Promovierten eine akademische Laufbahnintention (BuWiN, 2013, S. 290; Jaksztat et al., 2017). Bezüglich der Laufbahnintention bestehen jedoch erhebliche Fächerunterschiede. Promovierte aus den Rechts- und Ingenieurwissenschaften sowie der Chemie streben mehrheitlich Tätigkeiten außerhalb der Wissenschaft an, während Promovierte der Biologie und vor allem der Geisteswissenschaften häufig Tätigkeiten in der Wissenschaft anstreben (BuWiN, 2013, S. 290–292).

Vor bzw. kurz nach dem Promotionsabschluss ist der Großteil der Promovierten in der Wissenschaft tätig (BuWiN, 2021, S. 212–215; Flöther, 2015). Etwa ein Jahr nach der Promotion trifft dies über alle Fächergruppen hinweg noch auf ca. 27 bis 34 Prozent der Promovierten zu (BuWiN, 2013, S. 274–275; BuWiN, 2021, S. 213; Flöther, 2015; Jaksztat et al., 2017, S. 324). Im weiteren Verlauf wechseln Promovierte häufig von der Wissenschaft in außerwissenschaftliche Beschäftigungen, aber nur vergleichsweise selten vom privaten oder öffentlichen Sektor in andere Beschäftigungssektoren (Enders & Bornmann, 2001, S. 115; König et al., 2019). Zehn Jahre nach Promotionsabschluss ist nur noch etwa ein Fünftel der Promovierten in der Wissenschaft tätig (BuWiN, 2021, S. 213–215). Wenngleich viele Promovierte im weiteren Berufsverlauf nicht (mehr) in der Wissenschaft beschäftigt sind, haben ihre Tätigkeiten trotzdem häufig einen Forschungsbezug (Briedis et al., 2014; BuWiN, 2013, S. 287–290; Enders & Kottmann, 2009, S. 98; Flöther, 2015).

Verschiedene Studien verweisen auf Fächerunterschiede in den Tätigkeitsbereichen von Promovierten (Briedis et al., 2014; BuWiN, 2021, S. 214–215; Enders & Bornmann, 2001; Flöther, 2015, 2017; König

et al., 2019). Laut Flöther (2017) sind Promovierte der Ingenieurwissenschaften ein Jahr nach der Promotion am häufigsten im privaten Sektor tätig (79 %) und nur vergleichsweise selten an Hochschulen oder außeruniversitären Forschungseinrichtungen (14 %). Im Fächergruppenvergleich sind Promovierte der Geisteswissenschaften zu diesem Zeitpunkt am häufigsten an Hochschulen beschäftigt (39 %). Promovierte Medizinerinnen und Mediziner sind hingegen am seltensten an Hochschulen beschäftigt (2 %) und gehen dafür besonders häufig forschungsfremden Tätigkeiten im öffentlichen Sektor nach (68 %). In den Rechtswissenschaften sind ebenfalls nur wenige Promovierte an Hochschulen beschäftigt (5 %), während forschungsfremde Tätigkeiten im öffentlichen Sektor (35 %) und vor allem im privaten Sektor (59 %) hier die Regel sind. Promovierte Physikerinnen und Physiker sind von allen Promovierten am häufigsten in außeruniversitären Forschungseinrichtungen beschäftigt (10 %), sind insgesamt aber vor allem im privaten Sektor tätig (59 %).

Die erste Forschungsfrage, die dieser Arbeit zugrunde liegt, zielt auf die Beschreibung der Tätigkeitsbereiche von Promovierten ab. Die genannten Studien haben hierzu wichtige Befunde geliefert, allerdings beziehen sich diese teilweise auf ältere Promotionskohorten oder auf frühere Karrierezeitpunkte. In unserem Beitrag werden mit fünf Jahren nach der Promotion die mittelfristigen Tätigkeitsbereiche einer aktuellen und deutschlandweit repräsentativen Promotionskohorte beschrieben. Zudem werden die Tätigkeitsbereiche hinsichtlich ihres Forschungsbezugs weiter differenziert und vor dem Hintergrund der zweiten Forschungsfrage den ursprünglichen Laufbahnintentionen der Promovierten gegenübergestellt. Auf diese Weise kann gezeigt werden, inwiefern sich der intendierte und der realisierte berufliche Verbleib entsprechen. Bisherige Studien beschreiben Laufbahnintentionen von Promovierten oder ihren beruflichen Verbleib; setzen diese beiden Dimensionen – mit Ausnahme des BuWiN (2013, S. 293) – jedoch nicht in Beziehung zueinander.

Die dritte Forschungsfrage fokussiert den Berufserfolg von Promovierten in Abhängigkeit ihres beruflichen Verbleibs. Vorhandene Studien zum Berufserfolg Promovierter deuten darauf hin, dass sich dieser zwischen den verschiedenen Beschäftigungssektoren unterscheidet. So ist das Durchschnittseinkommen von Promovierten in der Privatwirtschaft höher als im öffentlichen Sektor und in der Wissenschaft (BuWiN, 2013, S. 293; Falk & Küpper, 2013; Flöther, 2015; König et al., 2019; M. Schwabe, 2011). Tendenziell scheint der Anteil von Promovierten in Führungspositionen in außerwissenschaftlichen Sektoren höher zu sein als in der Wissenschaft (BuWiN, 2013, S. 293; Enders & Bornmann, 2001, S. 119; de Vogel, 2020, S. 283). Zudem ist der Anteil unbefristeter Beschäftigungen in der Privatwirtschaft deutlich höher als im öffentlichen Sektor und in der Wissenschaft (BuWiN, 2013, S. 293). Mehrere Studien zeigen, dass Promovierte in der Wissenschaft bzw. im öffentlichen Sektor (subjektiv) häufiger adäquat beschäftigt sind als in anderen Tätigkeitsbereichen (BuWiN, 2013, S. 293; Enders, 2002; Engelage & Schubert, 2009; König et al., 2019). Hinsichtlich der Berufszufriedenheit sind die empirischen Befunde nicht einheitlich. M. Schwabe (2011) findet keine Unterschiede in der Berufszufriedenheit zwischen Promovierten in den verschiedenen Sektoren, Enders und Bornmann (2001, S. 229) zufolge ist die Berufszufriedenheit hingegen an Hochschulen höher als im öffentlichen Sektor und in der Privatwirtschaft. Die vorliegende Arbeit knüpft anhand aktueller Daten an diesen Forschungsstand an, indem zum einen zwischen forschungsbezogenen und nicht forschungsbezogenen Tätigkeiten in der Privatwirtschaft und im öffentlichen Sektor differenziert wird und zum anderen innerhalb dieser differenzierteren Tätigkeitsbereiche verschiedene objektive und subjektive Erfolgsindikatoren ausgewiesen werden.

7.3 Daten, Variablen und Methoden

Die Analysen basieren auf dem DZHW-Promoviertenpanel 2014 (Brandt, Briedis et al., 2020b; Brandt, de Vogel, Jaksztat et al., 2020) – einer jährlichen, deutschlandweit repräsentativen Längsschnittbefragung von Personen, die im Wintersemester 2013/14 oder Sommersemester 2014 an einer deutschen Hochschule ihre Promotion abgeschlossen haben. Die Daten erlauben, Berufs- und Lebensverläufe von Promovierten aller Fachrichtungen und Promotionskontexte für einen Zeitraum von rund fünf Jahren nachzuverfolgen und dabei sowohl Promovierte, die in der Wissenschaft verblieben als auch solche, die nach ihrer Promotion aus dem Wissenschaftssystem ausgeschieden sind, zu berücksichtigen.

Die erste Befragungswelle (fortan: W1) wurde postalisch etwa ein halbes bis anderthalb Jahre nach Promotionsabschluss mit 5408 Promovierten realisiert. Diese Promovierten wurden anhand jährlicher Folgebefragungen bis fünf Jahre nach Promotionsabschluss online befragt (fortan: W5). Die Daten bilden die Grundgesamtheit gut ab, vor allem wenn sie anhand der vom DZHW bereitgestellten kalibrierten Ausfallgewichte für Querschnittsanalysen gewichtet werden (Vietgen, de Vogel & Brandt, 2020); diese gewichten die Stichprobe in den einzelnen Wellen mittels bekannter Parameter der Grundgesamtheit und geschätzter Ausfallwahrscheinlichkeiten (Brandt, de Vogel, Jaksztat et al., 2020, S. 42–45). Um Abweichungen zwischen der Stichprobe und der Grundgesamtheit auszugleichen sowie Ausfallprozesse zwischen den Wellen zu berücksichtigen, werden die Analysen daher gewichtet.

In die vorliegenden Analysen fließen die Fälle mit ein, die an W1 und W5 teilgenommen haben (3037 Fälle). Aufgrund der Sonderstellung des Doktortitels in der Medizin (Berning & Falk, 2006, S. 123–140; Epstein, 2016, S. 39–44) werden die Analysen ohne Angehörige der Fächergruppe Humanmedizin und Gesundheitswissenschaften durchgeführt (–694 Fälle). Ebenfalls ausgeschlossen werden Promovierte, die seit Abschluss der Promotion nicht erwerbstätig waren (–11 Fälle) und solche, die in W5 keine gültige Gewichtungsvariable aufweisen (–29 Fälle). Für den Umgang mit fehlenden Werten wird die Methode der "*multiple imputation by chained equations*" (MICE) genutzt mit 20 Imputationen und 70 Iterationen (s. Tabelle 2 in Abschnitt 7.6 für weitere Informationen zur Imputation). Zudem wurde von Hippels (2007) Empfehlung "*multiple imputation, then deletion*" (MID) umgesetzt und entsprechend die abhängige Variable (Tätigkeitsbereich in W5) im Imputationsmodell berücksichtigt, anschließend aber die Fälle mit ursprünglich fehlendem Wert bei dieser aus den Analysen ausgeschlossen (–344 Fälle).[4] Damit liegt die Größe des finalen Analysesamples bei 1959 Fällen.

Der intendierte berufliche Verbleib wird anhand einer Frage zur akademischen Laufbahnintention in W1 bestimmt (Fragentext: "*Beabsichtigen Sie, dauerhaft in der Wissenschaft tätig zu sein?*"; Antwortskala von 1 = "*nein, auf keinen Fall*" bis 5 = "*ja, auf jeden Fall*"). Es werden Promovierte mit akademischer Laufbahnintention (Kategorien 4 + 5), ohne eindeutige Laufbahnintention (Kategorie 3) und Promovierte ohne akademische Laufbahnintention (Kategorien 1 + 2) unterschieden.

Der realisierte berufliche Verbleib wird über den *Tätigkeitsbereich* in W1 und W5 operationalisiert. Es werden insgesamt fünf verschiedene Tätigkeiten unterschieden: (1) Tätigkeiten in der Wissenschaft[5], (2) forschungs- und (3) nicht-forschungsbezogene Tätigkeiten im öffentlichen bzw. nicht-gewinnorientierten Sektor[6] sowie (4) forschungs- und (5) nicht-forschungsbezogene Tätigkeiten in der Privatwirtschaft. Ein Forschungsbezug wird dann angenommen, wenn die Befragten angegeben haben, dass sie (sehr) intensiv in die Konzeption oder Koordination von Forschungs- oder Entwicklungs-

[4] Wenngleich es in dieser Arbeit keine eindeutige abhängige Variable gibt, so stellen die Tätigkeitsbereiche in W5 die zentrale Variable dar, sodass der MID-Ansatz stattdessen auf diese Variable angewendet wird.
[5] D. h. an Hochschulen oder außeruniversitären Forschungseinrichtungen.
[6] Ohne Hochschulen und außeruniversitäre Forschungseinrichtungen; inkl. Verbänden, Parteien, Kirchen, Kunst und Kultur.

projekten oder in die Anwendung wissenschaftlicher Methoden, Verfahren oder Techniken involviert sind.[7]

Um ein möglichst umfassendes und mehrdimensionales Bild des Berufserfolgs zu erhalten, wird dieser anhand verschiedener objektiver und subjektiver Indikatoren bestimmt. Zu den objektiven Indikatoren zählen das *Bruttomonatseinkommen* in Euro inklusive des monatlichen Anteils jährlicher Gehaltszulagen, der *Bruttostundenlohn* in Euro und das Innehaben einer *Führungsposition*, einer *unbefristeten Beschäftigung* oder einer *Vollzeitbeschäftigung*. Als subjektiver Indikator wird zum einen die Berufszufriedenheit herangezogen (Fragentext: "*Wie zufrieden sind Sie alles in allem mit Ihrer beruflichen Situation?*"; Antwortskala von 1 = "*gar nicht*" bis 5 = "*in hohem Maße*"). Zum anderen werden die subjektiv eingeschätzte Positions-, Niveau- und Fachadäquanz betrachtet (Fragentext: "*Würden Sie sagen, dass Sie entsprechend Ihrer Qualifikation (der abgeschlossenen Promotion) beschäftigt sind? 1. Hinsichtlich der beruflichen Position, 2. hinsichtlich des Niveaus der Arbeitsaufgaben, 3. hinsichtlich der fachlichen Qualifikation (Promotionsfach)*"; Antwortskala: 1 = "*trifft überhaupt nicht zu*" bis 5 = "*trifft voll und ganz zu*").

Aufgrund der empirisch nachgewiesenen Fächerunterschiede beim beruflichen Verbleib von Promovierten (s. Forschungsstand), werden die Laufbahnintention und der Tätigkeitsbereich getrennt nach *Fächergruppen* ausgewiesen. Dabei werden fünf Fächergruppen unterschieden: (1) Geisteswissenschaften (inkl. Kunst), (2) Rechts-, Wirtschafts- und Sozialwissenschaften, (3) Mathematik und Naturwissenschaften, (4) Agrar-, Forst-, Ernährungswissenschaften und Veterinärmedizin, (5) Ingenieurwissenschaften.

7.4 Ergebnisse zum beruflichen Verbleib und Erfolg von Promovierten

Zunächst wird anhand der akademischen Laufbahnintention und des Tätigkeitsbereichs der berufliche Verbleib der Promovierten beschrieben. Anschließend wird anhand verschiedener Indikatoren der Berufserfolg in Abhängigkeit des Tätigkeitsbereichs untersucht.

7.4.1 Akademische Laufbahnintention

Abbildung 7.1 gibt einen Überblick über die Verteilung der akademischen Laufbahnintention in W1. Etwa ein Jahr nach der Promotion hat gut ein Viertel der Promovierten eine akademische Laufbahnintention (27 %), knapp die Hälfte keine akademische Laufbahnintention (48 %) und das letzte Viertel ist diesbezüglich noch unentschlossen (25 %). Zwischen der Laufbahnintention und der Fächergruppe der Promotion besteht ein signifikanter Zusammenhang (Cramers V: 0,12; χ^2: 58,81; p: 0,00). Die meisten Promovierten mit akademischer Laufbahnintention finden sich in den Geisteswissenschaften (46 %), die wenigsten in den Agrar-, Forst- und Ernährungswissenschaften sowie Veterinärmedizin (18 %) bzw. in den Ingenieurwissenschaften (21 %).

[7] Mit den vorhandenen Daten kann innerhalb der Wissenschaft nicht eindeutig zwischen forschungs- und nicht-forschungsbezogenen Tätigkeiten unterschieden werden.

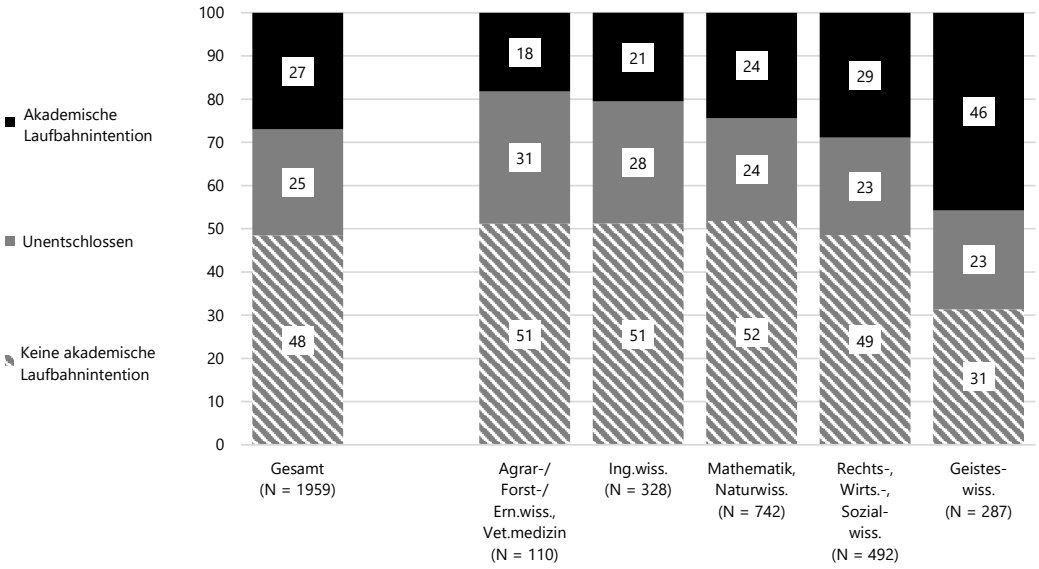

Abbildung 7.1: **Akademische Laufbahnintention (W1) nach Fächergruppe der Promotion in Prozent.**
Anmerkung: Multipel imputierte und gewichtete Daten, Ergebnisse werden für die erste Imputation dargestellt; DZHW-Promoviertenpanel 2014 (SUF: 4.0.0), ohne Medizin.

7.4.2 Tätigkeitsbereiche

Abbildung 7.2 veranschaulicht die Tätigkeitsbereiche in W1 und W5 sowie die Wechsel zwischen beiden Messzeitpunkten. Sowohl in W1 als auch in W5 geht der Großteil der Promovierten wissenschaftlichen oder forschungsbezogenen Tätigkeiten nach (W1: 70 %; W5: 67 %), allerdings ist die Zusammensetzung nach Beschäftigungssektoren zu den beiden Zeitpunkten anders. In W1 stellt die Wissenschaft den wichtigsten Tätigkeitsbereich dar (41 %), bis W5 verliert diese aber als einziger Bereich an Bedeutung (–12 Prozentpunkte). Forschungsbezogene Tätigkeiten im öffentlichen bzw. nicht-gewinnorientierten Sektor (+3 Prozentpunkte) und in der Privatwirtschaft (+6 Prozentpunkte) gewinnen hingegen an Bedeutung. In W5 sind genauso viele Promovierte forschungsbezogen in der Privatwirtschaft tätig wie in der Wissenschaft (jeweils 29 %). Im öffentlichen bzw. nicht-gewinnorientierten Sektor sind sowohl in W1 als auch in W5 nur vergleichsweise wenige Promovierte tätig (16 % bzw. 20 %), wobei forschungsbezogene Tätigkeiten im öffentlichen bzw. nicht-gewinnorientierten Sektor zu beiden Zeitpunkten am seltensten sind (6 % bzw. 9 %). Über die Hälfte der Promovierten ist in W1 und W5 jeweils im selben Tätigkeitsbereich (59 %; nicht dargestellt). Zwischen dem Tätigkeitsbereich in W1 und W5 besteht ein signifikanter Zusammenhang (V: 0,46; χ^2: 1700,00; p: 0,00). Zwischen W1 und W5 finden nur wenige Wechsel von der Privatwirtschaft in die anderen Beschäftigungssektoren statt. Die meisten Wechsel des Beschäftigungssektors sind von der Wissenschaft in die Privatwirtschaft oder in den öffentlichen bzw. nicht-gewinnorientierten Sektor zu beobachten.

In Abbildung 7.3 sind die Tätigkeitsbereiche in W5 differenziert nach Fächergruppen dargestellt; zwischen beiden besteht ein signifikanter Zusammenhang (Cramers V: 0,21; χ^2: 355,85; p: 0,00). Im Fächergruppenvergleich sind in den Geisteswissenschaften die meisten Promovierten im öffentlichen bzw. nicht-gewinnorientierten Sektor (37 %) bzw. in der Wissenschaft (45 %) tätig. Damit sind Promovierte der Geisteswissenschaften häufiger als Promovierte anderer Fächergruppen den oftmals unsicheren Beschäftigungsbedingungen in der Wissenschaft ausgesetzt. Promovierte der Ingenieurwissenschaften sind mehrheitlich in der Privatwirtschaft tätig (72 %) und hier häufig mit Forschungsbezug (52 %). Promovierte der Ingenieurwissenschaften können ihre Forschungsqualifikation der Promoti-

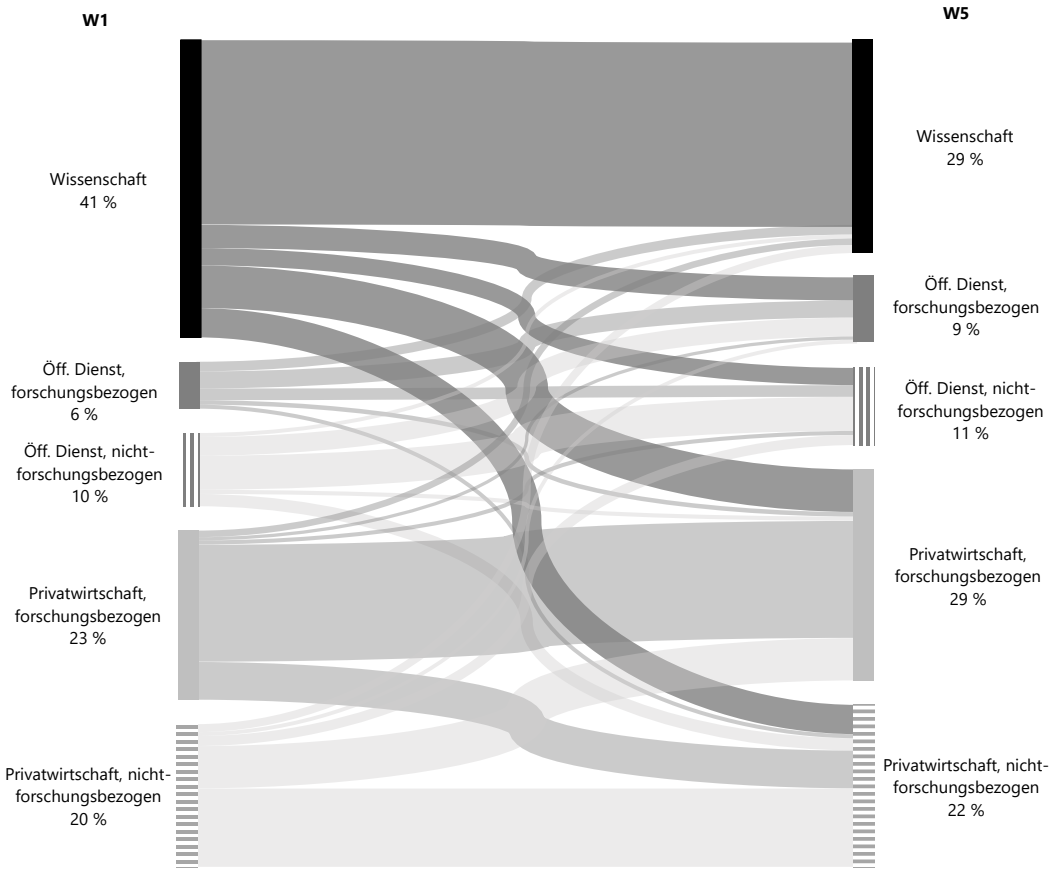

Abbildung 7.2: **Übergang des Tätigkeitsbereichs von W1 zu W5.**
Anmerkung: Multipel imputierte und gewichtete Daten, Ergebnisse werden für die erste Imputation dargestellt; DZHW-Promoviertenpanel 2014 (SUF: 4.0.0), ohne Medizin; N: 1959.

on also anscheinend gut in der Privatwirtschaft verwerten. Dasselbe scheint in geringerem Umfang auch auf Promovierte der Mathematik und Naturwissenschaften zuzutreffen, da immerhin ein Drittel forschungsbezogen in der Privatwirtschaft tätig ist (33 %). In den Agrar-, Forst- und Ernährungswissenschaften sowie der Veterinärmedizin ist der Anteil von Promovierten mit forschungsbezogenen oder wissenschaftlichen Tätigkeiten insgesamt am geringsten (51 %).

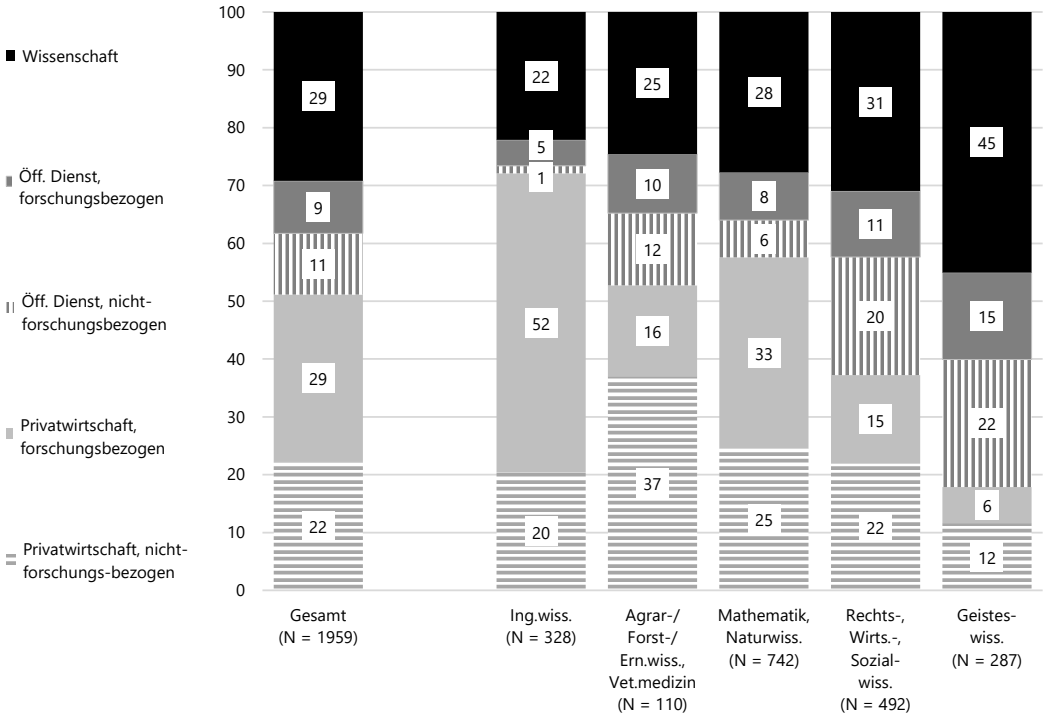

Abbildung 7.3: **Tätigkeitsbereich (W5) nach Fächergruppe der Promotion in Prozent.**
Anmerkung: Multipel imputierte und gewichtete Daten, Ergebnisse werden für die erste Imputation dargestellt; DZHW-Promoviertenpanel 2014 (SUF: 4.0.0), ohne Medizin.

7.4.3 Akademische Laufbahnintention und Tätigkeitsbereiche

Abbildung 7.4 stellt die akademische Laufbahnintention in W1 dem Tätigkeitsbereich in W5 gegenüber; zwischen beiden besteht ein signifikanter Zusammenhang (Cramers V: 0,37; χ^2: 550.65; p: 0,00). In der Gruppe der Promovierten ohne akademische Laufbahnintention sind in W5 die meisten in der Privatwirtschaft tätig, 38 Prozent mit und 32 Prozent ohne Forschungsbezug. 20 Prozent sind im öffentlichen bzw. nicht-gewinnorientierten Sektor tätig und 9 Prozent in der Wissenschaft. In der Gruppe der Promovierten mit akademischer Laufbahnintention sind in W5 zwar die meisten in der Wissenschaft tätig (65 %), gleichzeitig geht aber etwa ein Drittel Beschäftigungen außerhalb der Wissenschaft nach (35 %). Hierbei handelt es sich jedoch mehrheitlich um forschungsbezogene Tätigkeiten.

An dieser Stelle sei darauf hingewiesen, dass es auf beruflichen Misserfolg hindeuten kann (aber nicht muss), wenn Promovierte ihre ursprüngliche Laufbahnintention nicht realisieren können. Von der ursprünglichen Intention abweichende Tätigkeitsbereiche können entweder aus einer bewussten Entscheidung für einen anderen Karriereweg oder aus einer vergeblichen Stellensuche im eigentlich gewünschten Tätigkeitsbereich resultieren. Nur der zweite Fall würde auf beruflichen Misserfolg hindeuten.

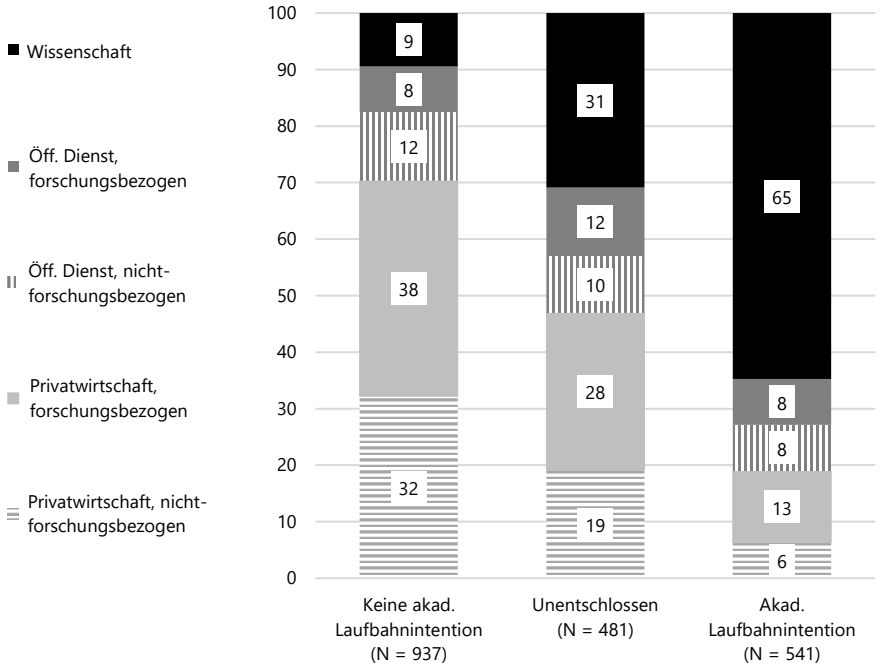

Abbildung 7.4: **Tätigkeitsbereich (W5) nach akademischer Laufbahnintention (W1) in Prozent.**
Anmerkung: Multipel imputierte und gewichtete Daten, Ergebnisse werden für die erste Imputation dargestellt; DZHW-Promoviertenpanel 2014 (SUF: 4.0.0), ohne Medizin; N: 1959.

7.4.4 Beruflicher Erfolg nach Tätigkeitsbereich

Im Folgenden werden die objektiven und subjektiven Berufserfolgsindikatoren nach Tätigkeitsbereich in W5 dargestellt (Tabelle 7.1). Mit Blick auf die objektiven Berufserfolgsindikatoren sind im Vergleich zu allen anderen Tätigkeitsbereichen forschungsbezogene und nicht-forschungsbezogene Tätigkeiten in der Privatwirtschaft besonders vorteilhaft. Hier sind das mittlere Bruttomonatseinkommen (6851 € bzw. 5917 €), der mittlere Bruttostundenlohn (42 € bzw. 37 €), der Anteil von unbefristeten Arbeitsverträgen (95 % bzw. 93 %) und der Anteil von Vollzeitbeschäftigungen (89 % bzw. 79 %) am höchsten. Promovierte in forschungs- und nicht-forschungsbezogenen Tätigkeiten im öffentlichen bzw. nicht-gewinnorientierten Sektor sind hingegen vergleichsweise häufig in Führungspositionen (48 % bzw. 52 %). Tätigkeiten in der Wissenschaft liegen beim Bruttomonatseinkommen und -Stundenlohn ungefähr auf dem Niveau des öffentlichen bzw. nicht-gewinnorientierten Sektors, Vollzeitbeschäftigungen sind mit 77 Prozent ähnlich verbreitet wie in forschungsbezogenen Tätigkeiten im öffentlichen bzw. nicht-gewinnorientierten Sektor (75 %) oder in nicht-forschungsbezogenen Tätigkeiten in der Privatwirtschaft (79 %). Hingegen sind Führungspositionen in der Wissenschaft seltener (32 %) und der Anteil unbefristeter Beschäftigungen ist mit 34 Prozent deutlich niedriger als in allen anderen Tätigkeitsbereichen.[8]

Auch bei den subjektiven Indikatoren sind Unterschiede zwischen den Tätigkeitsbereichen erkennbar. Promovierte in forschungsbezogenen Tätigkeiten in der Privatwirtschaft sind besonders häufig

[8] Es ist denkbar, dass die Unterschiede in den Erfolgsindikatoren zwischen den Tätigkeitsbereichen eigentlich auf Fächerunterschiede zurückzuführen sind, da Promovierte bestimmter Fächergruppen typischerweise auch eher in bestimmte Tätigkeitsbereiche übergehen (s. Abbildung 7.3). Um dies zu kontrollieren, wurden zusätzlich mithilfe von Regressionsanalysen alle Erfolgsindikatoren unter Kontrolle der Tätigkeitsbereiche und Fächergruppen untersucht, wobei die Mittelwerte der Erfolgsindikatoren nach Tätigkeitsbereich jeweils anhand der durchschnittlichen Fächergruppe geschätzt wurden ("*adjusted prediction at the means*"). Dabei hat sich gezeigt, dass die dargestellten Ergebnisse robust sind und sich unter Berücksichtigung der Fächergruppen kaum verändern. Die Ergebnisse dieser zusätzlichen Analysen können auf Anfrage gerne zur Verfügung gestellt werden bzw. sind mittels der bereitgestellten Analyseskripte replizierbar.

Tabelle 7.1: Indikatoren des Berufserfolgs (W5) nach Tätigkeitsbereich (W5)

	Wissenschaft	Öffentlicher Dienst		Privatwirtschaft		Gesamt
		forsch.-bezogen	nicht-forsch.-bezogen	forsch.-bezogen	nicht-forsch.-bezogen	
	(N = 614)	(N = 194)	(N = 231)	(N = 506)	(N = 414)	(N = 1959)
Objektive Indikatoren						
Bruttomonatseinkommen (in €; Median)	4700	4805	4496	6851	5917	5200
Bruttostundenlohn (in €; Median)	29	29	28	42	37	32
Führungsposition (%)	32	48	52	42	32	39
Unbefristete Beschäftigung (%)	34	70	79	95	93	73
Vollzeitbeschäftigung (%)	77	75	68	89	79	80
Subjektive Indikatoren						
Berufszufriedenheit (Kategorien 4+5, %)	61	68	69	76	58	66
Positionsadäquanz (Kategorien 4+5, %)	86	65	50	75	54	70
Niveauadäquanz (Kategorien 4+5, %)	82	65	43	75	52	68
Fachadäquanz (Kategorien 4+5, %)	73	59	33	56	29	53

Anmerkung: Multipel imputierte und gewichtete Daten, Ergebnisse werden für die erste Imputation dargestellt; DZHW-Promoviertenpanel 2014 (SUF: 4.0.0), ohne Medizin.

beruflich (sehr) zufrieden (76 %). Bei Promovierten in nicht-forschungsbezogenen Tätigkeiten in der Privatwirtschaft (58 %) und in der Wissenschaft (61 %) ist der Anteil am geringsten. Promovierte mit wissenschaftlichen bzw. forschungsbezogenen Tätigkeiten betrachten ihre Beschäftigung hinsichtlich der beruflichen Position, des Niveaus der Arbeitsaufgaben und der fachlichen Qualifikation häufiger als adäquat als Promovierte in nicht-forschungsbezogenen Tätigkeiten. Promovierte in der Wissenschaft geben am häufigsten an, (sehr) positions- (86 %), niveau- (82 %) und fachadäquat (73 %) beschäftigt zu sein.

7.5 Fazit

Die vorliegende Arbeit hatte zum Ziel, den beruflichen Verbleib von Promovierten zu untersuchen und in Beziehung zu ihrem Berufserfolg zu setzen. Der Arbeit lagen dabei drei Forschungsfragen zugrunde.

Die *erste* Frage hat auf die Tätigkeitsbereiche der Promovierten abgezielt. Die Analysen haben gezeigt, dass Tätigkeiten außerhalb der Wissenschaft für Promovierte von hoher Relevanz sind. Fünf Jahre nach der Promotion sind sieben von zehn Promovierten im öffentlichen bzw. nicht-gewinnorientierten Sektor oder in der Privatwirtschaft tätig und nur drei von zehn in der Wissenschaft und damit möglicherweise im Begriff, eine akademische Laufbahn zu realisieren. Ungeachtet des Beschäftigungssektors gehen jedoch etwa zwei Drittel der Promovierten wissenschaftlichen oder forschungsbezogenen Tätigkeiten nach, was bisherigen Erkenntnissen entspricht (vgl. Briedis et al., 2014; BuWiN, 2013; Flöther, 2015). Die Mehrheit der Promovierten nutzt also ihre Forschungsqualifikation, wenn auch häufig außerhalb der Wissenschaft. Somit wird der Doktortitel anscheinend nicht (nur) als Statussymbol bzw. Signal genutzt, sondern dient einer spezifischen Forschungsqualifikation, die auch über die Wissenschaft hinaus relevant ist. Gleichzeitig bezeichnet jedoch nur rund ein Drittel der Promovierten, die nicht-forschungsbezogen tätig sind, die eigene Beschäftigung hinsichtlich der mitgebrachten fachlichen Qualifikation als adäquat.

Die Gegenüberstellung der Tätigkeitsbereiche in W1 und W5 hat zudem gezeigt, dass ein Teil der Promovierten bis W5 den Tätigkeitsbereich wechselt, wobei nur wenig Wechsel von der Privatwirtschaft in andere Tätigkeitsbereiche erfolgen, jedoch umso mehr aus der Wissenschaft heraus. Dieser Befund deckt sich mit den Ergebnissen von Enders und Bornmann (2001) sowie einer neueren Studie von König et al. (2019). Grundsätzlich sind die Karrierewege aber vielfältig und es finden Wechsel in alle Richtungen statt.

Die *zweite* Frage zielte darauf ab, inwiefern sich der intendierte und realisierte berufliche Verbleib von Promovierten entsprechen. Tendenziell gibt es eine hohe Übereinstimmung zwischen der Laufbahnintention in W1 und dem Tätigkeitsbereich in W5, da nur wenige Promovierte in W5 entgegen ihrer Laufbahnintention aus W1 tätig sind. Jedoch umfassen die vorliegenden Analysen nur die ersten fünf Jahre nach der Promotion und es ist möglich, dass einige Promovierte in der Wissenschaft im weiteren Karriereverlauf an der Berufung auf eine Professur scheitern.

Die *dritte* Forschungsfrage hat den beruflichen Erfolg der Promovierten in Abhängigkeit des beruflichen Verbleibs in den Blick genommen. Objektive und subjektive Erfolgsindikatoren unterscheiden sich teils stark zwischen den Tätigkeitsbereichen. Dieser Befund liegt im Einklang zu bisheriger Forschung (BuWiN, 2013; Enders, 2002; Enders & Bornmann, 2001; Engelage & Schubert, 2009; Falk & Küpper, 2013; Flöther, 2015; M. Schwabe, 2011) und kann diese mittels stärkerer Differenzierung der Tätigkeitsbereiche sinnvoll erweitern. Je nach Sektor und Forschungsbezug der Tätigkeit sind Promovierte mit unterschiedlichen beruflichen Vor- und Nachteilen konfrontiert. Zwar gibt es nicht den einen Tätigkeitsbereich, in dem Promovierte rundum beruflich erfolgreich oder erfolglos sind, jedoch haben Promovierte in der Privatwirtschaft zahlreiche Vorteile gegenüber Promovierten in anderen Tätigkeitsbereichen. Insbesondere die hohen Löhne und der hohe Anteil unbefristeter Beschäftigungen stechen hier hervor. Promovierte in der Wissenschaft haben zwar hinsichtlich einiger objektiver Erfolgsindikatoren das Nachsehen, nehmen ihre Beschäftigung aber besonders häufig als adäquat wahr. Tätigkeiten im öffentlichen bzw. nicht-gewinnorientierten Sektor nehmen gewissermaßen eine Zwischenposition ein, denn während die Löhne in etwa denen in der Wissenschaft entsprechen, so ist hier doch die Mehrzahl der Promovierten unbefristet beschäftigt.

Wie steht es nun insgesamt um den Zusammenhang zwischen dem beruflichen Verbleib und Erfolg bei Promovierten? Die Mehrzahl der Promovierten kann ihre ursprüngliche Laufbahnintention realisieren und ist gemessen an verschiedenen Indikatoren beruflich erfolgreich. Alle Tätigkeitsbereiche gehen mit spezifischen Vor- und Nachteilen hinsichtlich des Berufserfolgs einher. Die Analysen bestätigen, dass der berufliche Verbleib und Erfolg nicht dichotom beurteilt werden können, sondern mehrdimensional betrachtet werden müssen. Beruflicher Erfolg und Misserfolg hängen letztendlich davon ab, welche Bedeutung die Promovierten den einzelnen Erfolgsindikatoren selber beimessen.

Da sich gezeigt hat, dass viele Promovierte früher oder später aus der Wissenschaft ausscheiden, könnten Angebote zur Karriereberatung und Weiterbildung Promovierender an Hochschulen entsprechend weiter ausgebaut werden. Die Angebotsstrukturen an Hochschulen könnten stärker anerkennen, dass Promovierte häufiger andere als akademische Laufbahnen einschlagen. Promovierende könnten daher bereits während ihrer Promotion explizit auch auf außerwissenschaftliche Tätigkeiten vorbereitet, über ihre vielfältigen Karriereoptionen aufgeklärt und dadurch in ihrer individuellen Karriereplanung unterstützt werden. Angesichts steigender Promotionszahlen und hoher Austrittszahlen aus der Wissenschaft stellt sich aber auch ganz grundsätzlich die Frage nach dem Zweck der Promotion in der heutigen Zeit und nach adäquaten Qualifizierungsbedingungen für Promovierende.

Dass fünf Jahre nach Abschluss nur etwa zwei Drittel der Promovierten mit akademischer Laufbahnintention in der Wissenschaft tätig sind, wirft zudem die Fragen auf, wie viele von ihnen auch langfristig in der Wissenschaft bleiben können und ob das andere Drittel die Wissenschaft aufgrund attraktiver Karriereoptionen außerhalb der Wissenschaft verlassen hat oder z. B. aufgrund mangelnder Stellenangebote und Beschäftigungsperspektiven "gegangen wurde". Letzteres ist vor dem Hintergrund der andauernden Debatten zu prekären Beschäftigungsbedingungen in der Wissenschaft, die z. B. auch durch unseren Befund des besonders niedrigen Anteils von unbefristeten Beschäftigungen bei Promovierten in der Wissenschaft gestützt wird, durchaus wahrscheinlich. Damit diejenigen, die in der Wissenschaft bleiben möchten, dies auch entlang planbarer Karrierewege tun können und ihr Forschungspotenzial voll ausgeschöpft werden kann, könnten z. B. verlässliche Beschäftigungsmöglichkeiten für forschungsstarke Promovierte jenseits der Professur geschaffen werden.

Die in diesem Beitrag präsentierten Analysen sind mit einigen Limitationen verbunden, die gleichzeitig auch Anknüpfungspunkte für zukünftige Forschung bieten. *Erstens* wurde die Laufbahnintention in W1 betrachtet, d. h. etwa ein Jahr nach der Promotion. Diese Laufbahnintention ist aber bereits das Resultat der Erfahrungen während und nach der Promotion. Zukünftige Forschung könnte die Laufbahnintention während der Promotion berücksichtigen (z. B. auf Basis der NACAPS-Daten des DZHW). *Zweitens* konnte mit den vorhandenen Daten nur die akademische Laufbahnintention berücksichtigt werden. Hinter einer nicht-akademischen Laufbahnintention können sich aber sehr heterogene Intentionen verbergen, die mit den vorhandenen Daten nicht offengelegt werden konnten. *Drittens* konnten mit den vorhandenen Daten Tätigkeiten innerhalb der Wissenschaft nicht weiter ausdifferenziert werden und damit der Diversifizierung der Tätigkeiten im Bereich Wissenschaftsmanagement, d. h. "*an der Schnittstelle zwischen Wissenschaft und Verwaltung respektive Wissenschaft und Management*" (BuWiN, 2017, S. 196; s. auch Schneijderberg et al., 2013) nicht Rechnung getragen werden. Es ist zu vermuten, dass Promovierte jüngerer Abschlusskohorten zunehmend häufiger im Wissenschaftsmanagement tätig werden, daher sollte dieser spezielle Tätigkeitsbereich auch gesondert untersucht werden. *Viertens* wurde mit fünf Jahren nach Promotionsabschluss nur der mittelfristige berufliche Verbleib und Erfolg von Promovierten berücksichtigt. Wie eingangs erwähnt, ist diese Einschränkung inhaltlich angemessen. Allerdings kann mit diesem Beobachtungszeitraum der langfristige Berufserfolg nicht untersucht werden. So bleibt z. B. unklar, wie viele Promovierte, die in W5 in der Wissenschaft tätig sind, schlussendlich auch eine Professur oder andere dauerhafte Beschäftigung in der Wissenschaft erreichen. Mit der Veröffentlichung weiterer Befragungswellen des DZHW-Promoviertenpanels wird es zukünftig möglich sein, die Tätigkeitsbereiche auch zu einem späteren Karrierezeitpunkt zu untersuchen. *Fünftens* waren die Analysen rein deskriptiv. Die theoriegeleitete Erklärung der Karrierewege von Promovierten in die einzelnen Tätigkeitsbereiche und des Zusammenhangs zwischen dem beruflichen Verbleib und Erfolg von Promovierten sollte daher Gegenstand zukünftiger Forschung sein. Hierbei könnten auch soziale Ungleichheiten in den Karrierewegen und Promotionserträgen in den Blick genommen werden.

Trotz der beschriebenen Einschränkungen und daraus abgeleiteten Forschungsdesiderate liefert die vorliegende Arbeit neue Einblicke in die vielfältigen Karrierewege von Promovierten innerhalb und außerhalb der Wissenschaft, indem ihre Tätigkeitsbereiche differenziert betrachtet sowie objektive und subjektive Erfolgskriterien berücksichtigt wurden.

Anhang

Tabelle 7.2: Imputationsmodell, Schätzverfahren, Anzahl der imputierten Werte

Variablen	Welle	$N_{gültig}$	$\%_{fehlend}$	$N_{imputiert}$	Schätzverfahren
Akademische Laufbahnintention	W1	2238	0,03	65	Ordered Logit
Promotionsfach	W1	2281	0,01	22	Multinomial Logit (augmented)
Tätigkeitsbereich	W1	2083	0,10	220	Multinomial Logit (augmented)
Tätigkeitsbereich	W5	1959	0,15	344	Multinomial Logit (augmented)
Wochenarbeitszeit	W5	1858	0,19	445	Propensity Mean Matching mit 5 nächsten Nachbarn
Bruttomonatseinkommen	W5	2092	0,09	211	Propensity Mean Matching mit 5 nächsten Nachbarn
Führungsposition	W5	2156	0,06	147	Logit (augmented)
Unbefristete Beschäftigung	W5	2108	0,08	195	Logit (augmented)
Berufszufriedenheit	W5	2184	0,05	119	Logit (augmented)
Positionsadäquanz	W5	2156	0,06	147	Logit (augmented)
Niveauadäquanz	W5	2150	0,07	153	Logit (augmented)
Fachadäquanz	W5	2148	0,07	155	Logit (augmented)

DZHW-Promoviertenpanel 2014 (SUF: 4.0.0), ohne Medizin.

8 Association between doctoral graduates' contract type and job satisfaction (*Paper 4*)

Goldan, L., Jaksztat, S., & Gross, C. (2023b). How does obtaining a permanent employment contract affect the job satisfaction of doctoral graduates inside and outside academia? ***Higher Education, 86*****(1), 185–208.**[1, 2, 3, 4, 5, 6, 7]

Abstract: Previous research has shown that temporary employment is negatively associated with many psychological and job-related outcomes, such as well-being, health, wages, organisational commitment, and job satisfaction. Among recent doctoral graduates, the proportion of temporary contracts is particularly high. However, research on the association between contract type and job satisfaction specifically among recent doctoral graduates is scarce. Therefore, whether and how obtaining permanent employment affects doctoral graduates' job satisfaction remains a notable research gap that we intend to narrow by using panel data from a recent doctoral graduation cohort and by adopting a panel research design. We examine what effect obtaining permanent employment has on doctoral graduates' job satisfaction and whether this effect differs by labour market sector. 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. We apply fixed-effects regression to approximate the within-effect of obtaining a permanent employment contract on job satisfaction. The analyses indicate that obtaining permanent employment increases doctoral graduates' job satisfaction and that this increase is not driven by time-varying confounders. We also find that doctoral graduates' labour market sector moderates the effect: the increase in job satisfaction is highest in the academic sector and statistically significantly different from that in the private sector. Overall, this paper offers new insights into the effect of obtaining a permanent contract on the job satisfaction of recent doctoral graduates throughout their first years after graduation, when they are often employed on temporary contracts.

8.1 Introduction

In recent decades, temporary employment has increased worldwide (OECD, 2021b). Temporary employment is defined as a paid job with a fixed determination date. Types of temporary arrangement vary widely (e.g., seasonal workers, on-call workers, temporary agency workers), and the specific statutory provisions of temporary employees depend on national legislation; e.g., in Europe, these provisions are more protective than in Australia, Canada, or the US (de Cuyper et al., 2008, p. 27; Wilkin, 2013).

[1]This is a pre-copyedited, author-produced version of an article published by Springer Nature in Higher Education in 2022 following peer review. The version of record is available online at: https://doi.org/10.1007/s10734-022-00908-7.
[2]Funding: This work was supported by the German Research Foundation (DFG, Deutsche Forschungsgemeinschaft) under grant 433155285 and a doctoral scholarship by the German Academic Scholarship Foundation (Studienstiftung des deutschen Volkes). Proofreading was subsidised by the Faculty of Human Sciences at the University of Würzburg under grant 10 2020/3.25.
[3]Conflicts of interest/Competing interests: The authors declare that they have no conflicts of interest or competing interests.
[4]Availability of data: The dataset analysed in the current study is available at the Research Data Centre for Higher Education Research and Science Studies (FDZ-DZHW) as scientific use file (DOI: 10.21249/DZHW:phd2014:4.0.0).
[5]Code availability: We used Stata/SE 16.1 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: https://doi.org/10.21249/DZHW:goldan2022c:1.0.0.
[6]Author's contributions: All authors contributed to the study conception and design. Data analysis was performed by Lea Goldan. The first draft of the manuscript was written by Lea Goldan, except for the discussions and conclusions, of which the first draft was written by Steffen Jaksztat. All authors revised previous versions of the manuscript and approved the final manuscript.
[7]Acknowledgements: We thank Micha Pastuschka for literature review.

For employers, temporary contracts offer several advantages over permanent contracts. First, temporary employees may be particularly productive to increase their chances of obtaining a permanent employment contract. Second, employers can screen new employees before granting them a permanent contract. Finally, they enable employers to minimise adjustment costs in their workforce because they can flexibly react to changing labour market conditions and to increasing or decreasing demands for their products or services.

For employees, temporary employment often leads to job insecurity, which is negatively associated with many psychological and job-related outcomes, such as well-being, health, wages, organisational commitment, and job satisfaction (e.g., Dawson, Veliziotis, & Hopkins, 2017; de Witte & Näswall, 2003; Hünefeld, Gerstenberg, & Hüffmeier, 2019; Macmillan & Shanahan, 2021; Virtanen, Janlert, & Hammarström, 2011). Temporary contracts usually only have advantages for employees when the alternative is unemployment. In such cases, temporary employment may be an attractive possibility to gain professional experience and give employees the opportunity to demonstrate their productivity and commitment.

In many countries, temporary employment is increasingly common among doctoral graduates (Auriol, 2010; Auriol, Misu, & Freeman, 2013; BuWiN, 2013, p. 259; Mertens & Röbken, 2013; Passaretta, Trivellato, & Triventi, 2019), especially in the first years after graduation (Auriol, 2010; Auriol, Misu, & Freeman, 2013; M. Schwabe, 2011, p. 155). In Germany, temporary employment and insecure employment prospects are especially widespread in the academic sector. However, research on the impact of temporary employment on doctoral graduates' outcomes is scarce. One of the few studies is by Waaijer et al. (2017), who examined the association between doctoral graduates' contract type and job satisfaction. They found that temporary employment is negatively associated with graduates' job satisfaction and private lives, and that doctoral graduates inside academia are less satisfied with their terms of employment than those outside academia. Their study provided initial insights into this association, but it was only cross-sectional and therefore simply allowed for descriptive interpretations.

However, whether and how obtaining permanent employment affects doctoral graduates' job satisfaction remains a notable research gap that we intend to narrow in this paper: *what effect does obtaining a permanent employment contract have on recent doctoral graduates' job satisfaction?* In addition, we intend to provide insights into whether the effect differs by labour market sector by addressing the following question: *is the effect different for doctoral graduates inside and outside academia?* To answer these research questions, we connect two different lines of research, namely, research on the association between contract type and job satisfaction and research on doctoral graduates' job satisfaction.

In addition to the research gap, there are further reasons for our research interest. First, job satisfaction is related to behavioural, emotional, and health outcomes; specifically, people who are satisfied with their job show higher job performance, less absenteeism, less intention to quit, less work-related stress, a lower risk of burnout, better mental health, and higher general life satisfaction (Fritzsche & Parrish, 2005; Ringelhan et al., 2013). Thus, working conditions that ensure high job satisfaction are in the interests of employees, employers, and the economy, especially among doctoral graduates because they contribute substantially to economic growth, social innovation, and technological progress (Bogle et al., 2010; Diamond et al., 2014). The higher their job satisfaction is, the higher their motivation and work performance. Therefore, knowledge about the determinants of doctoral graduates' job satisfaction and conducive measures is necessary.

Second, the importance of temporary employment among doctoral graduates is unclear. On the one hand, doctoral graduates may be particularly affected by sustained temporary employment after graduation because they have already been concerned with temporary contracts for a long time during their doctoral training and they are comparatively old when entering the labour market after graduation. If they cannot transition to permanent employment after graduation, job insecurity may affect their further career development and private lives (Waaijer et al., 2017). This holds especially for doctoral graduates in Europe who remain in academia after graduation because temporary employment is inherent in the European academic system (Herschberg, Benschop, & van den Brink, 2018; Waaijer, 2015; Waaijer et al., 2017). On the other hand, recent doctoral graduates may be less constrained by temporary employment than other educational groups if they consider temporary employment a necessary part of their early-career development that offers the opportunity to gain pertinent professional experience and to flexibly develop their careers, both of which improve their future job prospects (Auriol, Misu, & Freeman, 2013, p. 16; M. Schwabe, 2011, p. 155; Waaijer et al., 2017). Due to their high educational attainment, doctoral graduates may have particular confidence in their future career prospects. Against this background, we need to better understand the importance of temporary employment for postdoctoral careers and how permanent contracts affect job satisfaction both inside and outside academia.

Finally, the focus on a single, homogeneous, and highly educated group offers methodological advantages. Doctoral graduates seldom experience the most precarious types of temporary employment (e.g., on-call work, seasonal jobs). Therefore, by choosing this homogeneous group, we eliminate differences in types of temporary employment.

Building on Waaijer et al. (2017), this paper examines the effect of obtaining a permanent employment contract on job satisfaction among doctoral graduates throughout their first years after graduation. We use the PhD Panel 2014 (waves 1–5) of the German Centre for Higher Education Research and Science Studies (DZHW), which are unique panel data on the careers of a recent doctoral graduation cohort from Germany over five years following their graduation. These data include doctoral graduates from all subject groups, from all formal types of doctoral training, and with postdoctoral employment inside or outside academia. These data enable us to estimate the effect of permanent contracts on doctoral graduates' job satisfaction by labour market sector net of time-constant unobserved heterogeneity and time-varying confounders.

8.2 Temporary employment and career structures in German academia

In Germany, temporary employment in the general working population has increased, especially from the 1980s to 2010 (OECD, 2021b). In 2019, twelve percent of the German employees had a temporary employment contract, which is below the average for the EU-27 countries, but slightly above the OECD average.

It is regulated by law that employers are generally not allowed to employ their employees on a temporary basis for longer than two years (*'Teilzeit- und Befristungsgesetz'*). However, a special legal regulation was created for the academic sector to enable continuing scientific qualification of early career researchers (*'Wissenschaftszeitvertragsgesetz'*). It generally allows temporary employment for six years prior to doctoral graduation and another six years after the doctorate. This twelve-year period can be extended for parents by two years for each child born within this period. In the case of third-party funding, the duration of temporary employment is unlimited.

For researchers inside academia, permanent employment typically presupposes the appointment to a regular professorship. According to official statistics (Federal Statistical Office, 2021a), approximately 48,500 researchers held a professorship at a university in 2019, 87 % of whom were permanently employed. In the same year, more than 212,000 researchers were employed below the professorship level. In this group, in contrast, only approximately 20 % were employed on permanent contracts. Given that the average age of appointment to a professorship is 40 years (Federal Statistical Office, 2021a), doctoral graduates striving for an academic career typically have to cope with long periods of career insecurity and with the risk of unintended dropout at a high age with very specific (i.e., academic) skills. Only recently have attempts been made to improve this situation by establishing tenure track systems.

The relatively low proportion of permanent positions inside academia and the high number of doctoral graduates lead to a fierce competition for tenured positions. As the number of doctorates awarded per year and, thus, the number of potential candidates for postdoc positions have increased in recent decades (1999: 24,545; 2019: 28,690; Federal Statistical Office 2021b), the rigor of performance evaluation has also increased.

Against this background, most doctoral graduates in Germany leave academia for jobs in other sectors. Five years after graduation, only 29 % of them are employed in the academic sector, while 51 % and 20 % work in the private and non-academic public sector, respectively, with 70 % to 95 % being permanently employed (Goldan, Jaksztat, & Gross, 2022). Because permanent employment is the rule outside academia and the exception rather than the rule inside academia, it appears likely that the effect of obtaining permanent employment on individual job satisfaction is sector-specific.

8.3 Literature review

8.3.1 Contract types and job satisfaction

There is a large body of research on individual, psychological, and job-related outcomes of temporary employment or of subjective job insecurity among countries' general working populations (e.g., de Witte & Näswall, 2003; Hünefeld, Gerstenberg, & Hüffmeier, 2019; Macmillan & Shanahan, 2021; Virtanen, Janlert, & Hammarström, 2011; Wilkin, 2013). This research shows that temporary employees report lower well-being, have lower wages, achieve worse job matches, and participate less in training than permanent employees (e.g., Bertrand-Cloodt et al., 2012; Dawson, Veliziotis, & Hopkins, 2017). However, findings are largely inconclusive regarding job satisfaction (de Cuyper et al., 2008). Some studies find that overall job satisfaction is lower among temporary employees than among permanent employees (e.g., Aleksynska, 2018; Forde & Slater, 2006), while other studies find the opposite pattern (e.g., McDonald & Makin, 2000; Wooden & Warren, 2004) or differences by contract type only for some facets of satisfaction (Booth, Francesconi, & Frank, 2002; Dawson, Veliziotis, & Hopkins, 2017), and still others find no or only small differences in job satisfaction by contract type (e.g., Chadi & Hetschko, 2016; de Witte & Näswall, 2003; Wilkin, 2013). According to Chadi and Hetschko (2016), there is a honeymoon effect of starting a new job, which results in a short-term increase in job satisfaction. However, most studies examine the association between temporary employment and job satisfaction based on cross-sectional data.

8.3.2 Doctoral graduates' contract types

Temporary employment is increasingly common among doctoral graduates in many countries (Auriol, 2010; Auriol, Misu, & Freeman, 2013; BuWiN, 2013; Mertens & Röbken, 2013; Passaretta, Trivellato, & Triventi, 2019) and more frequent than among other higher education graduates and employees (BuWiN, 2013, pp. 258–259; Mertens & Röbken, 2013). According to the German National Report on Junior Scholars (BuWiN, 2013), one in five employed doctoral graduates between the ages of 35 and 45 has a temporary contract, while among higher education graduates of the same age, it is less than one in ten and only one in twenty among all employees in that age group. Studies have shown that while doctoral graduates frequently experience temporary employment during the first years after graduation, this is much less the case in later career stages (Auriol, 2010; Auriol, Misu, & Freeman, 2013; M. Schwabe, 2011, p. 155).

Inside academia, the proportion of doctoral graduates with temporary employment is particularly high because postdoctoral positions at universities or research institutions below professorship are usually temporary positions (Auriol, Misu, & Freeman, 2013), especially in Germany (BuWiN, 2013; Kreckel, 2016; Waaijer, 2015). These positions are considered a "qualification phase"; therefore, temporary contracts seem legitimate, and temporary contracts induce competitive pressure, which is supposed to motivate early-career researchers to be particularly productive. In addition, there are relatively few professorial positions (BuWiN, 2013, 2021, pp. 147–150; Kreckel, 2016). Thus, doctoral graduates seeking an academic career are particularly constrained by temporary employment and are likely to stagger from one temporary contract to the next. Therefore, there is an ongoing discussion about precarious working conditions inside academia and their side effects (e.g., Borgwardt, 2010; BuWiN, 2021; Herschberg, Benschop, & van den Brink, 2018; Loher et al., 2019).

8.3.3 Doctoral graduates' job satisfaction

Previous research found that doctoral graduates' job satisfaction is moderate to high (BuWiN, 2013, pp. 279–281; BuWiN, 2021, pp. 231–232; Enders, 2002; Enders & Bornmann, 2001, pp. 160–170; M. Schwabe, 2011) and associated with personal, doctoral, and job characteristics (Bender & Heywood, 2006; Canal Domínguez, 2013; Di Paolo, 2016; Enders & Bornmann, 2001, pp. 193–196; Escardíbul & Afcha, 2017; Moguérou, 2002; Parenti, Pinto, & Sarno, 2022; Waaijer et al., 2017). The latter studies largely agree that earnings, relative pay, management positions, company size, and job adequacy are positively associated with doctoral graduates' job satisfaction and that partnerships have no effect. The studies disagree on whether parenthood, age, marriage, working hours, and labour market sector are associated with job satisfaction and, if so, in which direction. For example, Bender and Heywood (2006) and Escardíbul and Afcha (2017) find that labour market sector and job satisfaction are not associated when controlling for contract type and many other covariates. In contrast, Waaijer et al. (2017) find an association only with satisfaction with terms of employment, and other studies with similar model specifications find associations, albeit not uniform ones (Canal Domínguez, 2013; Di Paolo, 2016; Moguérou, 2002; Parenti, Pinto, & Sarno, 2022). However, the studies employed cross-sectional research designs, which simply permitted the identification of empirical associations between the determinants investigated and job satisfaction.

8.3.4 Doctoral graduates' contract types and job satisfaction

To the best of our knowledge, there is little and only cross-sectional research on contract types and doctoral graduates' job satisfaction. Some of the studies on the determinants of doctoral graduates' job satisfaction have accounted for contract type as one such determinant. Although referring to the same countries, namely, Spain and the US, these studies provide mixed evidence: according to Canal Domínguez (2013), Escardíbul and Afcha (2017), and Moguérou (2002), doctoral graduates with permanent employment have, on average, higher job satisfaction than those with temporary employment. In contrast, Di Paolo's (2016) regression analyses indicate that contract type and job satisfaction are not associated when controlling for various other predictors. According to Bender and Heywood (2006), temporary jobs are positively associated with job satisfaction; however, this finding is likely to be biased by overcontrol bias, inter alia, because they included not only temporary employment in their regression analyses but also a measure for tenure, and these variables should be highly correlated with each other.

The most comprehensive study is by Waaijer et al. (2017), who examined the association between contract type and job satisfaction using cross-sectional survey data on recent doctoral graduates from five Dutch universities. They find that doctoral graduates on temporary contracts are less satisfied with several job aspects, especially job security, than those on permanent contracts, while they are more satisfied with the intellectual challenge of their jobs. In regression analyses, they find that doctoral graduates on temporary contracts tend to be less satisfied with job content and terms of employment while controlling for personal, doctoral, and job characteristics. They also find that temporary contracts negatively influence the ability to obtain a mortgage, the stability of family life, and the possibility to start a family. Because doctoral graduates inside academia more often experience temporary employment, the negative effects of temporary employment on personal lives are larger in this group. Overall, Waaijer et al. show that temporary employment not only lowers doctoral graduates' job satisfaction but also restrains their personal lives. Taken together, panel studies of the effect of doctoral graduates obtaining a permanent contract on their job satisfaction are a gap in research, especially in combination with sector-specific analyses.

8.4 Theoretical approach

To investigate the effect of obtaining a permanent employment contract on job satisfaction, we address our research interest through the lens of different theoretical perspectives: the sociological effort-reward imbalance model and the economic rational choice theory. We will see that regardless of which approach we adopt, or which social mechanism is postulated, we obtain the same intuitive conclusion: permanent contracts increase doctoral graduates' job satisfaction.

First, the *effort-reward imbalance model* (Siegrist, 1996, 2017) concerns social reciprocity in costly transactions, such as employment contracts. Following the principle of social reciprocity, employment contracts define what "efforts are expected to be delivered by employees in exchange for rewards provided by the employer" (Siegrist, 2017, p. 25). Typically, such rewards in the workplace are financial (salary, wages), status-related (promotion, job security), and socio-emotional (esteem, recognition). Note that employment contracts do not specify efforts and rewards in detail but provide a flexible framework for their exchange. If employees perceive their efforts and rewards as balanced, their job motivation is high, which should also apply to their job satisfaction. However, if employees perceive that their employer violates the principle of reciprocity and their efforts disproportionately exceed

their rewards, this effort-reward imbalance induces negative emotions such as anger, frustration, and stress in the short term and decreases health and well-being in the long term. As a result, employees' job satisfaction is also likely to decrease. Applying the effort-reward imbalance model to doctoral graduates, we suggest that obtaining a permanent employment contract, ceteris paribus, increases their rewards in terms of job security. Therefore, any previously existing effort-reward imbalance should be redressed to some degree, and their job satisfaction should increase.

Second, we approach the effect of obtaining a permanent contract from a *rational choice perspective* with bounded rationality (e.g., Lindenberg, 1985; Opp, 1999; Simon, 1955). From this perspective, individuals are utility-maximisers, i.e., rational, as they attempt to realise their preferences in decision-making situations under constraints. If individuals must decide between different alternative actions, they choose the alternative that promises the greatest utility. However, individuals are often not fully informed about all aspects that are important for that decision; therefore, decisions are typically made under a certain degree of uncertainty. The more information is available in the decision-making situation, the more accurate and reliable the decision, and the higher the satisfaction. Such rational decisions also occur in career and life planning. Individuals take rational decisions about their jobs and private lives against the background of their given working and living conditions – for example, in career advancement and household decisions such as the choice of residence and starting a family. However, temporary employees take such decisions under greater uncertainty than permanent employees. We assume that obtaining a permanent employment contract reduces that uncertainty because it increases the predictability of career trajectories and private lives. Employees can make decisions with more certainty, and thus, their job satisfaction should increase. This effect should be even more pronounced among doctoral graduates, because they have already been concerned with temporary contracts for a long time during doctoral training and are comparatively old when entering the labour market after graduation. Therefore, they are in a phase of life where decisions under certainty are particularly essential.

Although they stem from different disciplines, both theoretical perspectives suggest that obtaining a permanent employment contract increases doctoral graduates' job satisfaction. Accordingly, our main assumption is that *a change in contract type from temporary to permanent employment increases doctoral graduates' job satisfaction*. Furthermore, in accordance with previous research on doctoral graduates' job satisfaction, we assume that there may be confounders, i.e., variables that may affect both self-selection into permanent employment and job satisfaction. These confounders need to be considered to prevent omitted variable bias. While sociodemographic, personal, and doctoral characteristics may be time-constant confounders (e.g., gender, personality, final grade, or doctoral subject), there may also be time-varying confounders, namely, sociodemographic (e.g., household characteristics, age) and job characteristics. Empirical evidence suggests that job characteristics may be particularly important for job satisfaction. However, job characteristics may change along with permanent contracts; therefore, we need to account for the possibility of changing job characteristics. If we do not condition on job characteristics, we risk overestimating the permanent employment effect. We, therefore, condition on both time-constant and time-varying confounders to estimate the effect of permanent contracts on doctoral graduates' job satisfaction.

Since the employment situation inside and outside academia differs greatly, we assume that the labour market sector moderates the effect of permanent employment on job satisfaction. After graduation, doctoral graduates can either continue their academic qualification and attempt to obtain one of the few permanent academic positions, or they can search for jobs in the private or non-academic public sector. Inside academia, temporary employment is very common, especially in the first years

after doctoral graduation; in the private and public sectors, it is far less common. Especially inside academia, obtaining a permanent contract should be perceived as a reward for individual performance and as a sign of professional success. Following *social comparison theory* (Festinger, 1954), doctoral graduates inside academia who are permanently employed may appreciate this privilege and be particularly satisfied with their job, because they compare themselves with other doctoral graduates inside academia who are temporarily employed. In contrast, because permanent employment is more common in the private and non-academic public sectors, it may increase job satisfaction to a smaller extent. Therefore, we assume that *obtaining a permanent employment contract particularly increases the job satisfaction of doctoral graduates inside academia*.

8.5 Data and methods

8.5.1 Data and sample

We use the DZHW PhD Panel 2014 (waves 1–5) (Brandt, Briedis, et al., 2020b; Brandt, de Vogel, Jaksztat, et al., 2020). These data are representative of the 2014 doctoral graduation cohort in Germany, i.e., persons who earned a doctorate at a German university in the winter semester 2013/14 or summer semester 2014. These graduates' employment and life courses were observed repeatedly over up to five panel waves. The first wave was realised as a standardised postal survey approximately one year after graduation. The subsequent waves were realised as annual standardised online surveys. Note that, in principle, the data allow for both gaps in the data and panel attrition.

The original dataset includes 5,408 doctoral graduates providing 17,533 person-years; however, for the purpose of our panel analyses, we confine the analysis to graduates who participated in at least two survey waves (–1,337 persons) and, consistent with previous research (de Cuyper et al., 2008, p. 27), were never self-employed (–327 persons), leaving 3,744 persons providing 14,835 person-years in the analysis. Little's (1988) MCAR-test indicates that missing values were not missing completely at random in each wave (p: 0.00). Therefore, we multiply impute missing values in the full baseline sample, which only requires missing values to be missing at random, compensates for item nonresponse, and is recommended for panel data (D. Y. Lee, Harring, & Stapleton, 2019; Romaniuk, Patton, & Carlin, 2014; Westermeier & Grabka, 2016; Young & Johnson, 2015). We apply multiple imputation by chained equations with $m = 25$ imputations and 70 iterations to replace the missing values in all relevant variables in wide format (see Table 8.4 in the appendix for details on imputation).

After imputation, we exclude imputed person-years in the contract type variable (–2,133 person-years, –97 persons), which is necessary to exclude graduates who were already permanently employed afterwards when first observed (–5,289 person-years, –1,542 persons). Thus, the final estimation sample consists of 2,105 persons providing 7,413 person-years. Of the 2,105 persons 812 (38.6 %) changed to a permanent position. Note that persons who never obtained a permanent position have no within-variation and, therefore, do not contribute to estimating the effect of obtaining a permanent contract; however, they do contribute to estimating the time-varying controls. On average, the respondents participated in 3.5 waves.

8.5.2 Variables and controls

Our outcome variable is overall *job satisfaction*, which in previous research has been measured either by a single item or by a scale of facet satisfactions. In the literature, there are arguments for and against

both types of measurement (Judge et al., 2001, pp. 32–33; Nagy, 2002; Scarpello & Campbell, 1983; Wanous, Reichers, & Hudy, 1997). In our data, there was no single-item measure of job satisfaction available across waves, and therefore, we had to use an additive scale of facets of job satisfaction. The scale consists of 13 facet satisfactions with various job aspects that were measured on a 5-point scale from 1 'not at all' to 5 'to a high extent' in each wave.[8] We checked all scales for their reliability and found them to be internally consistent in each wave (Cronbach's alpha: 0.84–0.86). The additive scale was min-max normalized between 0 and 1. *Contract type* is the treatment variable and is coded 1 for permanent contracts and 0 for temporary contracts.

Because obtaining a permanent employment contract is likely to be accompanied by changes in other job- and person-related characteristics, we control for potential time-varying confounders measured in each wave: *gross monthly earnings* in 1,000 €, *working time arrangement* (full-time, part-time/not fixed), *company size* (large, small/medium), *management position* (yes, no), *labour market sector* (academic, non-academic public, private), *vertical* and *horizontal job adequacy* (1 low–5 high)[9], *parenthood* (yes, no), *partnership* (yes, no), and *age* in years. Previous research has either shown that these variables are associated with doctoral graduates' job satisfaction or provided mixed evidence for their association with job satisfaction. These variables are also in line with de Cuyper et al.'s (2008, p. 40) recommendations on the selection of control variables when studying temporary and permanent employment.

8.5.3 Methods

To estimate the effect of obtaining a permanent contract on doctoral graduates' job satisfaction, we adopt a panel research design based on within-estimation (Allison, 2009; Brüderl & Ludwig, 2015). Panel research designs identify the effect of a treatment by investigating how the outcome changes if the same persons change from the control to the treatment condition over time (within-estimation), i.e., they implement a before and after comparison. Within-estimation provides an average treatment effect on the treated that can be generalised to those who are potentially able to experience the treatment. It requires temporal homogeneity and is unaffected by time-constant unobserved heterogeneity. Within-estimation builds on the error components model:

$$y_{it} = x_{it}\beta + \alpha_i + \epsilon_{it} \tag{8.1}$$

where y_{it} denotes the observed outcome of person *i* at time *t*, x_{it} is a vector of covariates of this person measured at the same time, and β is the corresponding vector of parameters to be estimated. The error term consists of two components: the person-specific, time-constant error term α_i, which captures time-constant individual heterogeneity, and the time-varying error term ϵ_{it} (idiosyncratic error). The intercept is collinear with the person-specific error α_i and therefore dropped.

[8] Job content, position, salary, working conditions, career opportunities, opportunities for further training, room for private life, job security, appropriateness of qualifications, equipment, opportunities to contribute own ideas, working atmosphere, and family-friendliness.

[9] *Vertical* adequacy describes whether the formal qualification level matches the job requirement level, while *horizontal* adequacy describes whether the specific content of the qualification is used in the job (Engelage & Schubert, 2009). To assess the degree of subjective job adequacy, respondents were asked in each wave to rate on a 5-point scale (from 1 'does not apply at all' to 5 'applies completely') whether they are employed according to their qualification (i.e., the doctoral degree). Vertical adequacy refers to 1) the professional position and 2) the level of work tasks. Horizontal adequacy refers to 1) the doctoral subject and 2) the dissertation topic. For both dimensions of job adequacy, we have added the single-item values and divided the sum by two (Cronbach's alpha for vertical adequacy: 0.85—0.87; Cronbach's alpha for horizontal adequacy: 0.83—0.85).

In our analysis, we use fixed-effects regression, which is a specific type of within-estimation that applies pooled OLS regression to data that are transformed by demeaning prior to estimation. Demeaning means subtracting the person-specific mean values for each parameter from the equation above (within-transformation), which yields:

$$y_{it} - \overline{y}_i = (x_{it} - \overline{x}_i)\beta + \epsilon_{it} - \overline{\epsilon}_i \tag{8.2}$$

This transformation removes all between-variation, i.e., person-specific, time-constant parameters. Consequently, the time-constant error-term α_i is dropped from the equation, and fixed-effects estimation uses within-variation only. Fixed-effects estimation is consistent if the covariates are uncorrelated with the idiosyncratic error term at any time (strict exogeneity assumption). Further assumptions of fixed-effects estimation are that the idiosyncratic errors have constant variance across time (homoskedasticity) and are serially uncorrelated (no autocorrelation). To correct for heteroskedasticity and arbitrary serial correlation, we calculate panel-robust standard errors.

Our treatment is obtaining a permanent contract, and our outcome variable is job satisfaction. To disentangle the effect of obtaining a permanent contract on job satisfaction net of potential confounders, we condition on time-constant and time-varying confounders in two different ways. Because of within-estimation, we eliminate all time-constant unobserved heterogeneity by default. By controlling for potential time-varying confounders, we account for time-varying observed heterogeneity to a certain degree, which is a potential source of endogeneity and omitted variable bias. Note that a general limitation of fixed-effects estimation is that it does not allow to identify causal effects but only correlative effects. Thus, we cannot rule out the possibility of reverse or more complex causal relationships between out treatment and outcome (what is explained in detail under the term 'causal dynamics' in Imai & Kim 2019), such as higher job satisfaction increasing the chance of obtaining a permanent employment or of persons anticipating the attainment of a permanent employment and therefore being already more satisfied. However, based on our theoretical arguments, presented in section 4, we assume that the main direction of the effect is from obtaining a permanent contract on job satisfaction. Another potential source of bias is measurement error. In general, we cannot fully exclude measurement error and argue that reduced bias due to time-constant unobserved heterogeneity in fixed-effects regression outweighs the possible bias due to measurement error. Another potential source of bias is endogenous selection bias if both the treatment and the outcome affect the response rate in the survey and cause panel attrition. To control for such bias, we repeated our analyses only with graduates who were observed in all five waves. The results were robust and therefore unlikely to be biased by panel attrition.

The analyses are conducted in four steps. First, we describe the variables with a special focus on the treatment and the outcome (Table 8.1, Table 8.2, Figure 8.1). Second, we run fixed-effects regression on job satisfaction using contract type and the above-mentioned time-varying controls (M2 in Table 8.2). Third, to gain further insights and to test our assumption regarding the moderating effect, we add an interaction term to M2 to account for the interaction of contract type with the labour market sector (M3 in Table 8.2; Figure 8.2). Finally, for a more complete overview, we include a conditional effect plot that shows the change in job satisfaction by waves since obtaining a permanent employment contract to investigate whether there is a honeymoon effect (Figure 8.3).

8.6 Results

8.6.1 Descriptive results

Table 8.1 presents all variables, their distributions, and their between- and within-variation. We find that both the treatment and the outcome vary over time (within-variation). Over all person-years, the global mean of job satisfaction is 0.65. Between respondents, job satisfaction varies with a standard deviation of 0.13. Within respondents, job satisfaction varies with a standard deviation of 0.10, which is each respondent's average deviation from their mean over time. The global mean of the contract variable is 0.23, which indicates that 23 % of all person-years' contracts are permanent and 77 % are temporary. The variation in contract type between respondents (SD: 0.29) is nearly equal to the variation observed within respondents over time (SD: 0.30).

Table 8.1: Description of variables

	Variable		Mean	SD	Min	Max
Outcome	Job satisfaction	overall	0.65	0.16	0.00	1.00
		between		0.13		
		within		0.10		
Treatment	Permanent contract (ref. temporary)	overall	0.23	0.42	0.00	1.00
		between		0.29		
		within		0.30		
Controls	Gross monthly earnings (in 1,000 €)	overall	5.19	8.66	0.01	470.22
		between		4.64		
		within		7.23		
	Working-time arrangement: full-time (ref. part-time/not fixed)	overall	0.75	0.43	0.00	1.00
		between		0.35		
		within		0.27		
	Company size: large (ref. small/medium)	overall	0.71	0.45	0.00	1.00
		between		0.38		
		within		0.25		
	Management position: yes (ref. no)	overall	0.20	0.40	0.00	1.00
		between		0.31		
		within		0.26		
	Labour market sector: academic	overall	0.46	0.50	0.00	1.00
		between		0.45		
		within		0.22		
	Labour market sector: public	overall	0.32	0.47	0.00	1.00
		between		0.42		
		within		0.21		
	Labour market sector: private	overall	0.22	0.42	0.00	1.00
		between		0.36		
		within		0.21		
	Vertical job adequacy (1 low–5 high)	overall	3.95	1.08	1.00	5.00
		between		0.88		
		within		0.68		
	Horizontal job adequacy (1 low–5 high)	overall	3.28	1.34	1.00	5.00
		between		1.15		
		within		0.75		
	Parenthood: yes (ref. no)	overall	0.37	0.48	0.00	1.00
		between		0.44		
		within		0.22		
	Partnership: yes (ref. no)	overall	0.83	0.37	0.00	1.00
		between		0.34		
		within		0.18		
	Age (in years)	overall	34.56	4.09	26.00	63.40
		between		3.93		
		within		1.36		

Data: DZHW PhD Panel 2014 (waves 1–5); multiply imputed data, results reported for m = 1; 7,413 person-years clustered in 2,105 persons

Figure 8.1 indicates the distribution of permanent contracts across waves, both overall and by labour market sector. In each wave, we find that the highest proportion of graduates with permanent contracts is in the private sector, followed by the public and academic sectors. Five years after graduation, the proportion of graduates with permanent contracts is 67 % in the private sector, 46 % in the public sector, and only 24 % in the academic sector.

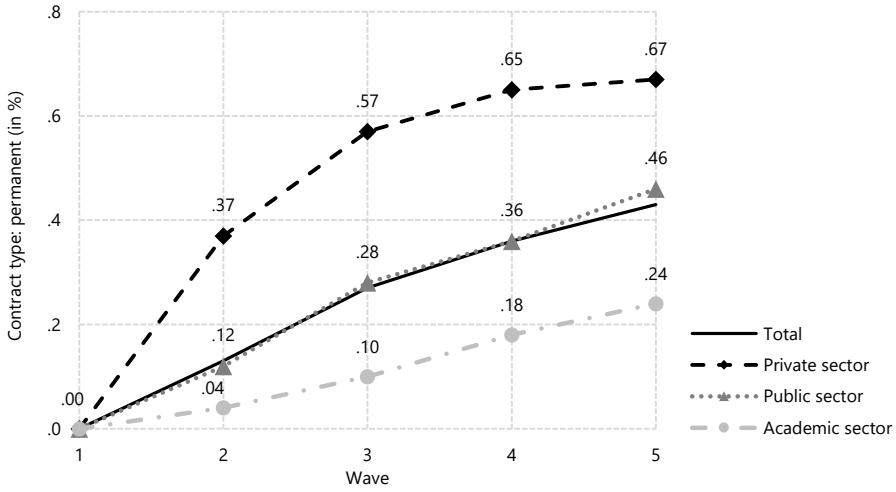

Figure 8.1: **Proportion of permanent contracts by wave and labour market sector.**

Table 8.2 presents the average job satisfaction in each sector for those in temporary and permanent employment as well as the mean difference within sectors and overall difference, without any controls. We find that average job satisfaction in each sector is lower in temporary employment than in permanent employment. The mean difference in job satisfaction between temporarily and permanently employed graduates is 10 percentage points in the academic and public sectors and 6 percentage points in the private sector. However, these are only gross differences that do not account for confounders, within-variation, and time trends. Therefore, the following fixed-effects regressions will provide a better understanding of the associations between contract type, labour market sector, and job satisfaction.

Table 8.2: Description of job satisfaction by labour market sector and contract type

Labour market sector	Contract type	Person-years	Mean	SD	Δ_{mean}
Academic	Temporary	3,048	0.65	0.16	+0.10
	Permanent	345	0.75	0.15	
Public	Temporary	1,806	0.60	0.15	+0.10
	Permanent	573	0.70	0.14	
Private	Temporary	820	0.63	0.16	+0.06
	Permanent	821	0.69	0.15	
Overall	Temporary	5,674	0.63	0.16	+0.07
	Permanent	1,739	0.70	0.15	

Data: DZHW PhD Panel 2014 (waves 1–5); multiply imputed data, results reported for m = 1;
7,413 person-years clustered in 2,105 persons

8.6.2 Within-effect of obtaining permanent employment on job satisfaction

Table 8.3 displays the results of the fixed-effects regression. M1 includes only the contract type variable. As expected, we find that obtaining a permanent employment contract statistically significantly increases doctoral graduates' job satisfaction. If doctoral graduates change from temporary to

permanent employment, their job satisfaction increases on average by 7.6 percentage points. The within-R^2 indicates that changes in contract type explain 5.8 % of the within-variation in job satisfaction.

Table 8.3: Fixed-effects regressions on job satisfaction

	M1	M2	M3
Treatment			
Permanent contract *(ref. temporary)*	0.076***	0.071***	0.087***
	(0.006)	(0.006)	(0.011)
Controls			
Gross monthly earnings *(in 1,000 €)*		0.000	0.000
		(0.000)	(0.000)
Working-time arrangement: full-time *(ref. part-time)*		0.007	0.007
		(0.006)	(0.006)
Company size: large *(ref. small/medium)*		0.005	0.005
		(0.007)	(0.007)
Management position: yes *(ref. no)*		0.009	0.008
		(0.005)	(0.005)
Labour market sector *(ref. academic)*			
• Non-academic public		0.014	0.015
		(0.009)	(0.009)
• Private		0.040***	0.054***
		(0.010)	(0.011)
Vertical job adequacy *(1 low–5 high)*		0.047***	0.047***
		(0.003)	(0.003)
Horizontal job adequacy *(1 low–5 high)*		0.007**	0.007**
		(0.002)	(0.002)
Parenthood: yes *(ref. no)*		–0.003	–0.003
		(0.006)	(0.006)
Partnership: yes *(ref. no)*		–0.004	–0.004
		(0.007)	(0.007)
Age *(in years)*		–0.001	–0.001
		(0.001)	(0.001)
Interaction			
Permanent contract # labour market sector (ref. academic)			
• Non-academic public			–0.006
			(0.014)
• Private			–0.037**
			(0.014)
Constant	0.629***	0.417***	0.420***
	(0.001)	(0.046)	(0.046)
R^2 within	0.058	0.188	0.191
Person-years	7,413	7,413	7,413
Persons	2,105	2,105	2,105

Significance: * p < .05, ** p < .01, *** p < .001; panel-robust standard errors in parentheses; data: DZHW PhD Panel 2014 (waves 1–5), multiply imputed data

Note that the within-effect of obtaining a permanent employment contract would be overestimated if other variables changed along with the contract type and affected job satisfaction. Therefore, we take potential time-varying confounders into account in M2: job characteristics, household characteristics, and age. When controlling for these variables in M2, the contract type effect on job satisfaction is robust, as it barely changes (β: 0.071). This implies that obtaining a permanent employment contract increases job satisfaction and that the effect is not driven by the time-varying confounders taken into account.

Nevertheless, some of the covariates in M2 are also statistically significantly associated with doctoral graduates' job satisfaction. If doctoral graduates change from the academic to the private sector, their job satisfaction increases by 4 percentage points, ceteris paribus. If their vertical and horizontal job adequacy increase by one unit, their job satisfaction increases by 4.7 and 0.7 percentage points, respectively. None of the other covariates have a statistically significant effect on doctoral graduates' job satisfaction. The within-R^2 indicates that the model fit has substantially improved because changes in the covariates explain 18.8 % of the within-variation in job satisfaction.

In M3, we add the interaction term that associates contract type with labour market sector. We find no interaction effect in the academic vs. public sector, i.e., obtaining a permanent employment contract has a similar effect in both sectors. However, in the academic vs. private sector, we do find a statistically significant interaction effect that indicates that the increase in job satisfaction due to permanent employment is statistically significantly higher in the academic sector than in the private sector.

Figure 8.2 plots the interaction between contract type and labour market sector based on M3. Starting-level job satisfaction in temporary employment differs across the three sectors, with satisfaction being lowest in the academic sector. Permanent employment increases job satisfaction in all three sectors and is eventually similar across sectors for permanent employment. As noted previously, permanent contracts similarly increase job satisfaction in the academic and public sectors. However, we find statistically significant interaction effects in the private sector and both the academic and public sectors. As expected, the increase in job satisfaction is highest in the academic sector.

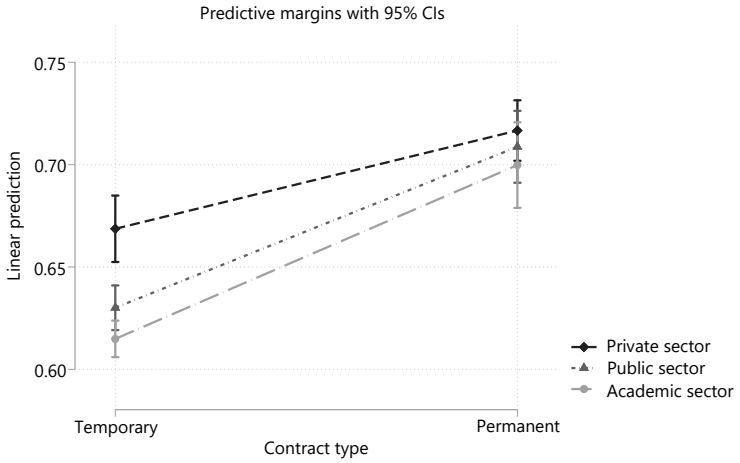

Figure 8.2: **Conditional effect plot (predictive margins) of the interaction effect of contract type and labour market sector based on M3.**

Figure 8.3 shows how doctoral graduates' job satisfaction increases over time after obtaining a permanent employment contract. The largest increase is directly after the change in contract type. In the first wave after obtaining a permanent employment contract, i.e., approximately one year later, their job satisfaction increased by approximately 7 percentage points on average. Interestingly, doctoral graduates' job satisfaction does not decrease thereafter but rather tends to increase slightly further over time – at least in the short period of five years after graduation that is considered here. Thus, their increase in job satisfaction does not seem to be the result of a honeymoon effect, which would be the case if their job satisfaction after the change in contract type were initially high but rapidly decreased later.

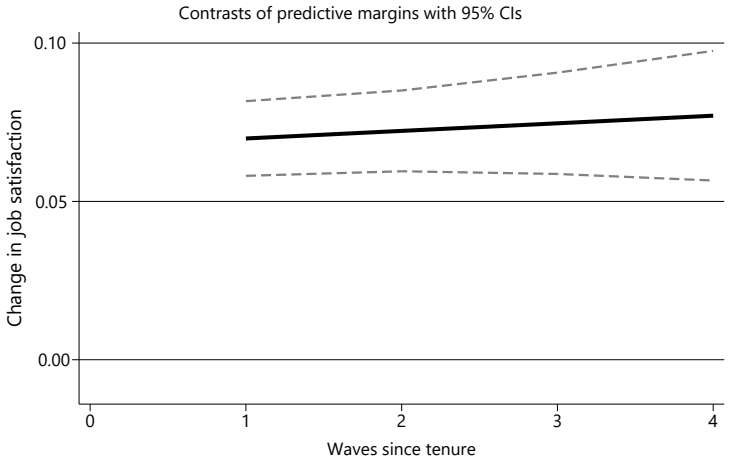

Figure 8.3: **Conditional effect plot (contrasts of predictive margins) based on M2 with additional control for waves since obtaining permanent employment.**

8.7 Discussion and conclusions

This paper sought to answer the following questions: what effect does obtaining a permanent employment contract have on recent doctoral graduates' job satisfaction? Is the effect different for doctoral graduates inside and outside academia? Based on panel survey data with German doctoral graduates, we estimated the within-effect of contract type changes using fixed-effects regressions. The results show that obtaining permanent employment increases doctoral graduates' job satisfaction. Controlling for potential time-varying confounders confirmed the robustness of this finding. Moderator analyses revealed that the effect of permanent contracts is especially large in the academic sector.

We identified different theoretical mechanisms explaining why obtaining a permanent employment contract increases job satisfaction and why this effect is sector-specific. From the perspective of the effort-reward imbalance model, a permanent employment contract can be viewed as a form of reward provided by the employer. Thus, a permanent contract positively influences the ratio of job-related efforts and rewards and, consequently, leads to higher job satisfaction. From a rational choice perspective, doctoral graduates on permanent contracts can make decisions about their jobs and private lives (e.g., family formation or choice of residence) with more certainty, which increases job satisfaction. According to social comparison theory, doctoral graduates are likely to compare their achievements with other doctoral graduates in the same employment sector. As a result, a permanent position inside academia, where temporary contracts are the rule, is perceived more as a reward for individual performance and as a sign of professional success compared with its perception in other sectors and, thus, particularly increases job satisfaction.

Our main results relate to previous cross-sectional studies among doctoral graduates in Spain (Canal Domínguez, 2013; Escardíbul & Afcha, 2017), the US (Moguérou, 2002), and the Netherlands (Waaijer et al., 2017). In contrast to these studies, we were able to apply panel analyses and to estimate the within-effect of changes in contract type. In addition, our study expands the state of research by focusing on doctoral graduates in Germany and by performing sector-specific analyses.

Nevertheless, our paper has some limitations. First, within-estimation demonstrates an average treatment effect on the treated that can only be generalised to those who are potentially able to experience the treatment, such as doctoral graduates who were temporarily employed when first observed in our case. Second, with a maximum of five waves, our panel is short; therefore, our

analyses indicate short-term effects on job satisfaction rather than medium- or long-term effects. Repeating our analyses with first-differences regression supports this assumption because it indicates the immediate effect of a treatment on the outcome; here, the size and direction of the regression coefficients were similar to those of fixed-effects regression. Third, we cannot differentiate between different types of temporary employment. However, doctoral graduates seldom experience the most precarious types of temporary employment. We compared the between-variance of job characteristics of doctoral graduates with temporary and permanent contracts and found that between-variance is similar in both groups or partly even higher between doctoral graduates with permanent contracts than between doctoral graduates with temporary contracts. Fourth, our panel data are unbalanced. If both the treatment and the outcome affected the response rate in the survey and caused panel attrition, our analyses would be biased. However, the results were robust when we repeated our analyses with a subsample of graduates who participated in all waves. Finally, because our results are based on survey data and not experimental data, causal interpretations should still be made with caution. Although we were able to control for many potential job- and person-related time-varying confounders, we cannot rule out the possibility that our results are biased due to time-varying unobserved heterogeneity (e.g., health status, geographic mobility, household characteristics such as the partner's income), or reversed or more complex patterns of causality (Imai & Kim, 2019). Despite these limitations, our study provides evidence that obtaining a permanent employment contract increases job satisfaction. This suggests that it may also yield a wide range of other positive behavioural, emotional, and health outcomes because people who are satisfied with their job show higher job performance, less absenteeism, less intention to quit, less work-related stress, a lower risk of burnout, better mental health, and higher general life satisfaction (Fritzsche & Parrish, 2005; Ringelhan et al., 2013).

Inside academia, temporary employment is particularly common, and our analyses demonstrate that the satisfaction-increasing effect of permanent contracts is particularly high. In Germany, the proportion of faculty with temporary contracts has increased in recent years. Possibly, this development has also resulted in less satisfying (and less healthy) working environments, especially among early-career researchers striving for an academic career. According to Reevy and Deason (2014), faculty in temporary positions perceive the precariousness of their positions as the most important work-related stressor. Studies have also reported a high prevalence of mental health problems among early-career researchers (Levecque et al., 2017). Against this background, increasing the proportion of tenured positions inside academia could be a means of increasing the attractiveness of academic careers. However, the academic system uses competition for permanent positions to enhance academic productivity. Moreover, universities have to ensure the scientific qualification of future graduates, which requires constant change of staff. However, these principles do not release policy-makers and employers from their obligation to strive for health-promoting working conditions inside academia. Since permanent positions are rare in academia, the recruitment procedures should be as transparent and fair as possible. Increasing the number of tenure-track professorships with clearly formulated requirements and structured procedures can increase the predictability of future career trajectories. Furthermore, universities may also optimise measures to prepare early-career researchers for careers outside academia, for example by expanding doctoral training to include skills that are needed in non-academic sectors (Waaijer et al., 2017) or by expanding their career guidance offers.

Future research must evaluate which measures or organisational reforms are appropriate to improve the situation of postdocs inside academia. Empirical studies could also contribute to the state of research by examining the effects of obtaining permanent employment on other outcomes, such as health, or by identifying specific vulnerable groups.

Appendix

Table 8.4: Imputation model

Variable	Wave	$\%_{missing}$	$N_{complete}$	$N_{imputed}$	Estimator
Job satisfaction	1	7.75	3,454	290	Propensity mean matching[a]
	2	11.05	2,584	321	
	3	8.02	2,466	215	
	4	7.50	2,528	205	
	5	7.36	2,568	204	
Contract type	1	24.01	2,845	899	Logit[b]
	2	20.86	2,299	606	
	3	8.09	2,464	217	
	4	7.68	2,523	210	
	5	7.25	2,571	201	
Gross monthly earnings	1	11.94	3,297	447	Propensity mean matching[a]
	2	15.01	2,469	436	
	3	10.26	2,406	275	
	4	9.37	2,477	256	
	5	9.34	2,513	259	
Working-time arrangement	1	23.96	2,847	897	Logit[b]
	2	20.90	2,298	607	
	3	8.54	2,452	229	
	4	7.79	2,520	213	
	5	7.32	2,569	203	
Company size	1	8.57	3,423	321	Logit[b]
	2	11.67	2,566	339	
	3	11.67	2,368	313	
	4	15.66	2,305	428	
	5	14.61	2,367	405	
Management position	1	24.73	2,818	926	Logit[b]
	2	21.31	2,286	619	
	3	8.62	2,450	231	
	4	8.12	2,511	222	
	5	7.32	2,569	203	
Labour market sector	1	9.05	3,405	339	Multinomial logit[b]
	2	11.57	2,569	336	
	3	11.19	2,381	300	
	4	15.29	2,315	418	
	5	14.25	2,377	395	
Vertical job adequacy	1	8.71	3,418	326	Propensity mean matching[a]
	2	11.02	2,585	320	
	3	7.83	2,471	210	
	4	7.21	2,536	197	
	5	6.78	2,584	188	
Horizontal job adequacy	1	8.95	3,409	335	Propensity mean matching[a]
	2	11.05	2,584	321	
	3	7.94	2,468	213	
	4	7.28	2,534	199	
	5	6.82	2,583	189	
Parenthood	1	9.27	3,397	347	Logit[b]
Partnership	1	0.27	3,734	10	Logit[b]
	2	6.16	2,726	179	
	3	5.71	2,528	153	
	4	5.93	2,571	162	
	5	5.66	2,615	157	
Year of birth	1	0.16	3,738	6	Propensity mean matching[a]

[a] propensity mean matching with five nearest neighbours, [b] augmented; data: DZHW PhD Panel 2014 (waves 1–5)

9 Determinants of the gender pay gap among doctoral graduates (*Paper 5*)

Disclaimer: *The paper was originally published with errors because of a mistake in the scientific use file used for analyses. These errors have been corrected in the text of the paper and are described in detail in the following correction note. Note that, in contrast to the online versions of the paper and the correction note, I have moved the corrected tables and figures from the correction note to the paper to improve readability and have marked them accordingly.*

**(2021). Correction. *European Journal of Higher Education, 11*(2), iii–vii.
https://doi.org/10.1080/21568235.2020.1866232**

Correction

When conducting the analyses, the author had used the most recent scientific use file (version 3.0.0) available at that time. However, after the online publication of the article, the author was informed by the Research Data Centre of the DZHW that there had been an error in a variable in version 3.0.0. The error concerned the variable that was supposed to clearly identify the respondents of the survey: the person identification variable. The error occurred only when combining the two separate data sets that make up the data: a spell data set with calendar information about different types of activities and an individual data set with all other variables. Variables from one data set can be merged with the other data set using the person identification variable. However, due to the error in the person identification variable, this merging did not work correctly in version 3.0.0 of the scientific use file. To correct this error, the Research Data Centre has published a corrected scientific use file (version 4.0.0).

Unfortunately, this error also affected the analyses in the above-mentioned article. The author had generated a variable, namely professional experience after graduation, via the calendar information in the spell data set and had merged it with the individual data set using the person identification variable. Due to the error in the person identification variable, the merging was incorrect. As a result, the variable had too many missing values and its distribution was biased. Therefore, the author erroneously did neither find gender differences in professional experience after graduation nor professional experience contributing to the explanation of the gender pay gap. After repeating the multiple imputation procedure and all analyses using version 4.0.0 of the scientific use file, the author found that the overall results and interpretations were unchanged. However, the specific figures reported in the tables and text throughout the results chapter were slightly changed (Table 9.2, Table 9.3, Figure 9.3). In addition, the results regarding the variable in question had changed largely. Unlike before, there were now statistically significantly gender differences in professional experience after graduation that contributed to explaining the gender pay gap among doctoral graduates.

Goldan, L. (2021). Explaining the gender pay gap among doctoral graduates: analyses of the German labour market. *European Journal of Higher Education, 11*(2), 137–159.[1, 2, 3, 4, 5]

Abstract: Previous research has shown that female doctoral graduates earn less than male doctoral graduates; however, there has been little research on the determinants of this gender pay gap. This paper investigates the determinants of the gender pay gap among doctoral graduates in Germany. By relying on human capital theory, traditional gender roles and beliefs, and previous empirical findings, I examine gender differences in doctoral and occupational characteristics as potential determinants of the gender pay gap. I use data from a representative German panel study of the 2014 doctoral graduation cohort. Regression analyses on the logarithmic gross monthly earnings reveal that female graduates earn 30.4 % less than male graduates five years after graduation. This gender pay gap is driven by a substantive wage premium for male doctoral graduates outside academia. Important determinants of the overall gender pay gap are doctoral subjects, professional experience after graduation, industries, management positions, and, above all, working hours. However, the considered determinants only partially explain the gender pay gap, as it remains substantial and statistically significant. The paper enhances the research on gender inequalities in post-doctoral careers and offers new insights into the determinants of the gender pay gap among doctoral graduates.

9.1 Introduction

Higher education research has shown that returns on doctoral education are generally high compared to other levels of education. Doctoral graduates fare better in terms of earnings, job satisfaction, management positions, and risk of unemployment (e.g., Enders, 2002; Engelage & Hadjar, 2008; Falk & Küpper, 2013; Pedersen, 2016; Waite, 2017). Since the 1990s, the total number of students who have earned a doctorate has increased worldwide. Currently, Germany is one of the countries with the highest doctoral graduation rate (Auriol, Misu, & Freeman, 2013) and the highest number of earned doctorates in Europe (Eurostat, 2020), specifically, approximately 28,000 each year. See Figure 9.1 for the increase in the number of earned doctorates in Germany since 1995. Although the number of female doctoral graduates has increased substantially, men continue to outnumber women at the doctorate level.

Despite their high educational attainment, female doctoral graduates earn less than male doctoral graduates (e.g., Amilon & Persson, 2013; Bornmann & Enders, 2004; Goldan, 2019; U. Schulze, 2015). However, there has been little research on the determinants of the gender pay gap among doctoral graduates. Therefore, this paper's research question is: *what are the determinants of the gender pay gap among doctoral graduates?* By using data from a representative German panel study of the 2014 doctoral graduation cohort, this paper examines the determinants of the gender pay gap five years after graduation in Germany.

In general, gender pay gaps are an important issue from meritocratic, individual, and economic perspectives — especially among doctoral graduates. First, equal pay for women and men is legally

[1] This is an Accepted Manuscript of an article published online by Taylor & Francis in the European Journal of Higher Education on 22 October 2020, available at: http://www.tandfonline.com/10.1080/21568235.2020.1835516.

[2] Acknowledgement: I thank the editors and anonymous reviewers of this journal, Christiane Gross, and Fine Cordua for helpful suggestions for improving the manuscript. I am grateful to the participants of the following conferences for their comments on earlier versions of the paper: 14th Conference of the Society for Higher Education Research (GfHf) in Magdeburg (DE) 2019, 7th Conference of the Society for Empirical Educational Research (GEBF) in Cologne (DE) 2019, and 2nd Forum on Higher Education and the Labour Market (HELM) in Hanover (DE) 2019. Further thanks go to the German Centre for Higher Education Research and Science Studies (DZHW) for both collecting and providing the data and to the Faculty of Human Sciences at the University of Würzburg for funding the editing of the manuscript.

[3] Disclosure statement: No potential conflict of interest was reported by the author.

[4] Funding: This work was supported by the German Research Foundation (DFG, Deutsche Forschungsgemeinschaft) under grant 433155285; Faculty of Human Sciences at the University of Würzburg under grant OH 10/2019/III.18.

[5] The Stata code used for analyses is available upon request at the Research Data Centre for Higher Education Research and Science Studies (FDZ-DZHW) under DOI: 10.21249/DZHW:goldan2021:1.0.0.

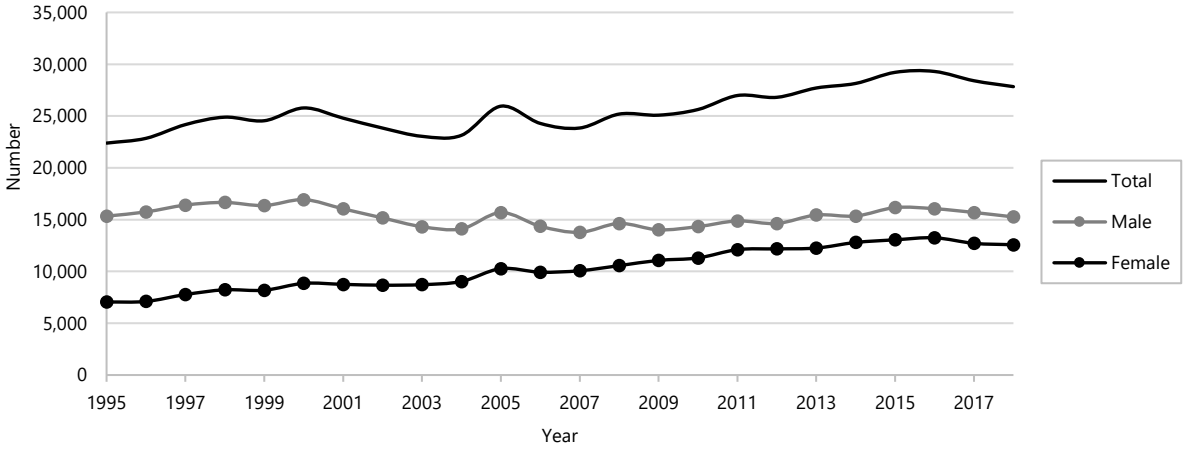

Figure 9.1: **Number of earned doctorates per year by gender in Germany between 1995 and 2018.**
Source: Federal Statistical Office 2019, author's elaboration.

required in Germany. If two groups' remunerations differ despite equal performance and work activity, this difference reflects unacceptable and non-meritocratic social inequality. Second, earnings are very high among doctoral graduates; thus, pay disadvantages among female graduates add up to a particularly large sum throughout their employment trajectories and considerably reduce their later retirement pensions. Third, knowledge-based societies depend on making efficient use of human resources to promote economic growth and innovations (Bogle et al., 2010; Diamond et al., 2014). To attract the best graduates for pursuing a doctoral degree, societies need to provide good post-doctoral career prospects that acknowledge individual attainment and performance regardless of gender. In addition, doctoral graduates are likely to be future leaders and decision makers who hold the most prestigious, influential, and remunerative jobs inside and outside academia. However, if female graduates earn less than male graduates, their human resources and productivity are used inefficiently and the potential for economic development and innovation is inhibited.

9.2 Doctoral training in Germany

In Germany, there are only research doctorates and no professional doctorates as in the US or the UK (Kehm, Freeman, & Locke, 2018; Schneijderberg & Teichler, 2018). Professional doctorates are programmes of advanced studies that provide research skills, which are required in non-academic professional contexts. Professional doctorates exist in subjects with relatively clear professional fields, e.g. business administration, medicine, or engineering; and they prepare candidates for a non-academic career in these professional fields.

By contrast, research doctorates are strongly embedded into academic work and in-depth research, the doctoral thesis is expected to be an original contribution to the research in one's discipline, and doctoral training primarily prepares candidates for an academic career. Because of the research doctorate's prevalence in Germany, doctoral candidates are referred to as early career researchers and not as doctoral students. A previous university degree — usually a master's degree or state examination — is a prerequisite for admission to doctoral training except for medicine, where the doctorate is earned alongside undergraduate studies.

Table 9.1 shows the doctoral rate by subject. Across all subjects, the doctoral rate is 21.4 %. In medicine, the doctorate is the most common degree, with a doctoral rate of 55.5 %. Table 9.1 also

indicates that with 45.314 (32.1 %), most doctorates are earned in mathematics and the natural sciences. The least doctorates are earned in sports (0.5 %) and in art (1.1 %).

Table 9.1: Doctoral rate by subject in Germany for a period of five years

	University degrees[a] (2010–2014)	Doctorates (2014–2018)	Doctoral rate[b]
Humanities	108,214	12,246	11.3
Sports	7,733	690	8.9
Legal, economic, social sciences	210,333	20,786	9.9
Mathematics, natural sciences	120,505	45,314	37.6
Medicine	65,779	36,488	55.5
Agriculture, forestry, nutrition sciences, veterinary medicine	19,952	5,039	25.3
Engineering	126,571	20,811	16.4
Art	35,015	1,504	4.3
Total	**659,087**	**141,374**	**21.4**

[a] All university degrees qualifying for doctoral training (master's degree, state examination, traditional degrees prior to Bologna)

[b] Number of earned doctorates 2014–2018 divided by the number of earned university degrees 2010–2014

Source: Federal Statistical Office, 2019; author's calculations

There are different formal types and funding channels of doctoral training. The most common formal type is employment at a university. Other formal types are non-university employment, doctoral grants, structured doctoral programmes, or private means. Structured doctoral programmes include compulsory lectures and classes on research-related topics and scientific methods. Doctoral training is completed by submitting a written doctoral thesis and passing an oral examination.

Despite doctoral training primarily preparing candidates for an academic career, doctoral graduates encounter good career prospects both inside and outside academia in Germany. Therefore, in contrast to other countries (Auriol, Misu, & Freeman, 2013), most doctoral graduates leave academia after graduation. Approximately two years after graduation, only one-third of doctoral graduates work inside academia (Flöther, 2015, p. 122; Jaksztat et al., 2017, p. 324).

9.3 Literature review

Previous research indicates a gender pay gap among doctoral graduates in Canada, Germany, Italy, Sweden, and the UK (Amilon & Persson, 2013; Ballarino & Colombo, 2010; Bornmann & Enders, 2004; Christie & Shannon, 2001; Desjardins & King, 2011; Enders & Bornmann, 2001; Engelage & Hadjar, 2008; Goldan, 2019; U. Schulze, 2015; Waite, 2017). In Germany, Bornmann and Enders (2004) show across several doctoral graduation cohorts that, in terms of median hourly earnings, female graduates earn between 20 % and 46 % less than male graduates ten to twenty years after graduation. However, earnings differ more within than between genders. Goldan (2019) finds that female graduates earn 16 % less per hour than male graduates in Germany approximately six years after graduation. In Austria, female graduates' annual earnings were 24 % lower than the annual earnings of male graduates across several doctoral graduation cohorts in 2006 (M. Schwabe, 2011). U. Schulze (2015) examines one doctoral graduation cohort in the UK 3.5 years after graduation and finds that female graduates' annual earnings are 11 % lower than male graduates' earnings. Amilon and Persson (2013) study all doctoral graduates in Sweden in 2004 and find that female graduates earned 16 % less than male graduates per year.

Thus, there is empirical evidence of a gender pay gap among doctoral graduates; however, there is little research on its determinants. To examine the determinants of the gender pay gap, I combine human capital theory with traditional gender roles and beliefs.

9.3.1 Human capital theory

Human capital theory (G. S. Becker, 1964; Mincer, 1958, 1962) assumes that educational investments and on-the-job training increase an individual's human capital, which is the individual's personal stock of marketable skills and knowledge. Immediate investments in human capital increase future productivity and earnings in the labour market. According to the theory, the investment in a doctorate considerably increases doctoral graduates' human capital stock and, thus, their future productivity and remuneration.

There are two types of human capital: general and (firm-)specific human capital. General human capital consists of broad skills, which are flexibly applicable in many professions and companies. General human capital is not subject to rapid technological change and thus depreciates slowly, for example, due to work interruptions or changes of employer. By contrast, specific human capital is more specialised, less flexible in application, and only valid in select professions and companies. Therefore, specific human capital enhances productivity and earnings more strongly but depreciates faster than general human capital (Polachek, 1981). In the case of doctoral training, different subjects provide different types of human capital, which affects the returns on the doctorate.

9.3.2 Traditional gender roles and beliefs

According to several theoretical approaches to *gender roles and beliefs* (Acker, 1990; Correll & Ridgeway, 2003; Eagly, 1987; Ridgeway, 2011), labour markets are structured by gender, with resources, opportunities, and rewards being unequally distributed between women and men (Waite, 2017, p. 114). Gender beliefs are widely shared cultural beliefs that assess one gender as more status-worthy and competent than another. In general, men are believed to be higher in status and more competent, for example, as experts in mechanical tasks, whereas women are believed to be experts in domestic and nurturing tasks (Ridgeway, 2011). Accordingly, men's traditional gender role is the family breadwinner, whereas domestic responsibility and active parenthood are traditionally attributed to women (Crompton & Harris, 2003; Eagly, 1987).

Gender roles and beliefs have become institutionalised and lead to gender differences in educational choices and career paths that systematically bias women's opportunities in the labour market. For example, women and men tend to choose different subjects and jobs, women have to perform better than men to be perceived as equally competent, and from an employer's perspective, the ideal worker is neither emotional nor sexual and does not procreate, which favours men and excludes women (Acker, 1990).

9.3.3 Determinants

Human capital theory explains the gender pay gap only in combination with traditional gender roles and beliefs. The gender division of labour in the household places a disproportionate burden of childcare and other domestic responsibilities on women (Blau & Winkler, 2018). Therefore, women may anticipate shorter and less continuous work lives and may invest in general rather than in specific human capital. If women experience unemployment or work interruptions more often, they gain less on-the-job training, their previously acquired human capital depreciates, and their productivity and earnings growths stagnate. By contrast, as men fulfil their traditional gender role by taking up gainful employment, their incentive to invest in specific human capital should be high, they should gain more on-the-job training, and their productivity and earnings should grow stronger.

It may be assumed that female doctoral graduates are particularly career-oriented and therefore less affected by traditional gender roles, but among academics and doctoral graduates, gender roles also become more traditional in the case of parenthood (Brandt, 2018; Flöther & Oberkrome, 2017).

By relying on human capital theory, traditional gender roles and beliefs, and empirical findings from previous research on doctoral graduates, I hypothesise determinants of the gender pay gap.

9.3.3.1 *Horizontal segregation of doctoral subjects*

Depending on their doctoral subject, doctoral graduates acquire different types of human capital, which affects their future productivity and likelihood of employment in differently paid occupations. According to human capital theory, subjects that provide general training, such as arts or humanities, should increase productivity and thus earnings less than subjects that provide more specific training. By contrast, subjects that provide specific types of training, such as engineering or mathematics, should considerably increase productivity and earnings.

Against the background of traditional gender roles and beliefs, I expect women and men to differ in doctoral subjects with women more often studying subjects that impart general human capital and men more often studying subjects that impart specific human capital. These gender differences in subjects can be explained by both gender-typical preferences for or interests in certain subjects and by the anticipation of gender-specific labour market participation prior to university. For example, if women anticipate less continuous work lives, they may tend to earn doctorates in subjects that impart general human capital, which depreciates less and facilitates their re-entry into the labour market after work interruptions. Either way, the gender-typical choice of subjects leads to differences in the acquired types of human capital, which, in turn, lead to gender differences in productivity and earnings. Official statistics confirm gender differences in doctoral subjects. The average proportion of doctorates earned by women between 2014 and 2018 was 66.5 % in art and 65.4 % in agriculture, forestry, nutrition sciences, and veterinary medicine (Federal Statistical Office, 2019a; author’s calculations). By contrast, women earned doctorates less frequently in mathematics and natural sciences (40.9 %) and engineering (18.7 %).

Previous research has shown that the gender pay gap among doctoral graduates is associated with doctoral subjects (Ballarino & Colombo, 2010; Bornmann & Enders, 2004; Desjardins & King, 2011; Goldan, 2019; U. Schulze, 2015). Accordingly, I expect gender differences in doctoral subjects to explain why female graduates earn less than male graduates.

H1a: Because of gender differences in doctoral subjects, female doctoral graduates earn less than male doctoral graduates.

In Germany, the educational system and the labour market are strongly interwoven. Depending on their doctoral subject, doctoral graduates should therefore be more likely to find jobs in some industries than in others. Subjects that provide general training may increase the likelihood of employment in industries that require less specific human capital and that entail smaller losses of pay for periods spent out of the labour market and lower earnings (e.g. social and cultural services). By contrast, subjects that provide specific types of training may lead to employment in industries that require more specific human capital and are higher paid (e.g. manufacturing). There is no previous research on either the industries of doctoral graduates or related gender differences, but previous research indicates earning differences by industry among doctoral graduates with the highest wage level in manufacturing (Trennt & Euler, 2019). In terms of path dependency, I expect gender differences in doctoral subjects to lead to gender differences in industries that mediate the gender pay gap among doctoral graduates.

H1b: Because of gender differences in industries, female doctoral graduates earn less than male doctoral graduates.

9.3.3.2 *Doctoral performance*

While pursuing a doctoral degree, doctoral candidates acquire human capital through a variety of activities, e.g. publications, talks, teaching, and international experiences. These activities can be important competences in the labour markets inside and outside academia after graduation. High doctoral performance signals high productivity to potential employers when applying for jobs after graduation (Arrow, 1973; Spence, 1973). Therefore, high doctoral performance should positively affect post-doctoral job opportunities and remuneration. Indeed, previous research has shown that several indicators of doctoral performance affect doctoral graduates' probability of holding management positions both inside and outside academia (de Vogel, 2020, pp. 269–321).

However, it has also been shown that female doctoral graduates tend to have fewer publications (Jaksztat, 2017; Long, 1990) and lower grades than male doctoral graduates (BuWiN, 2013, p. 218). According to traditional gender roles, such performance differences may result from women being more engaged in domestic and family tasks. Another explanation may be that because of different skills and interests, women invest more working time in teaching and supervising students than in advancing their own research and doctoral theses (Wild & Frey, 1996). Taken together, I expect female graduates to earn less because of lower doctoral performance compared to male graduates.

H2: Because female doctoral graduates' performance is lower during doctoral training, they earn less than male doctoral graduates.

9.3.3.3 *Labour market participation*

According to human capital theory, an individual's human capital stock, productivity, and earnings increase by completing on-the-job training. Depending on the formal type and funding channel of doctoral training, doctoral candidates gain varying quantities of professional experience alongside their doctoral training. For example, compared to doctoral candidates with funding through doctoral grants or private means, doctoral candidates with gainful employment gain more professional experience,

are thus more productive, and should earn more after graduation. Accordingly, Ballarino and Colombo (2010) find that doctoral grants negatively affect earnings after graduation.

Statistical data indicate gender differences in the formal types of doctoral training. Women are less likely to be employed during their doctoral training and they are less likely to be employed at a university in particular (Federal Statistical Office, 2016; de Vogel, 2020, p. 191). Therefore, I expect female graduates to gain less professional experience alongside their doctoral training and to earn less after graduation.

> *H3a: Because of gender differences in the formal types of doctoral training, female doctoral graduates earn less than male doctoral graduates.*

In line with human capital theory and traditional gender roles, the post-doctoral employment trajectories of women may be less continuous and they may work fewer hours compared to men. If this holds true, female graduates complete less on-the-job training after graduation, their human capital depreciates, and their productivity growth stagnates, which leaves them with lower earnings.

Previous research indicates that gender differences in professional experience after graduation explain the gender pay gap among doctoral graduates. Female doctoral graduates are more likely to be unemployed or employed part-time (Auriol, Misu, & Freeman, 2013; Enders, 2002; Flöther & Oberkrome, 2017; M. Schwabe, 2011), they interrupt their careers more often (Enders, 2002; Enders & Bornmann, 2001; U. Schulze, 2015), and they gain generally less professional experience (Goldan, 2019). Therefore, I expect female graduates to both gain less professional experience and work fewer hours, which negatively affects their earnings.

> *H3b: Because female doctoral graduates gain less professional experience after graduation, they earn less than male doctoral graduates.*

> *H3c: Because female doctoral graduates work fewer hours, they earn less than male doctoral graduates.*

According to human capital theory and in terms of path dependency, labour market participation may affect the likelihood of holding a management position. Employees with the highest stock of human capital, i.e. the highest productivity, should be most likely to be promoted and to receive an associated pay raise. If female graduates have less continuous employment trajectories and work fewer hours than male graduates, they should be less likely to hold a management position. In addition, because of traditional gender roles and beliefs, women are also less likely to be acknowledged as legitimate managers, and because of anticipated discrimination (Fisk & Overton, 2019) and working conditions that are often difficult to reconcile with family (e.g. business travel, overtime), they may also be less inclined to aspire to management positions.

Empirically, doctoral graduates are more likely to hold management positions than other educational groups (BuWiN, 2013; Enders, 2002), and doctoral graduates with management positions earn more than doctoral graduates with lower job positions (Enders, 2002; Enders & Bornmann, 2001, p. 133). However, female graduates are demonstrably less likely to hold management positions than male graduates (Bornmann & Enders, 2004; Enders & Bornmann, 2001, p. 126; de Vogel, 2020, p. 300), and the gender pay gap among doctoral graduates is associated with management positions (Goldan, 2019). Accordingly, I expect that female graduates' lower labour market participation reduces their likelihood of holding a management position and thereby their earnings.

H3d: Because female doctoral graduates hold management positions less often, they earn less than male doctoral graduates.

9.3.3.4 *Moderation by academic employment*

Previous research on the gender pay gap among doctoral graduates has shown that the overall gender pay gap results from male graduates earning a large premium outside academia and a small premium inside academia (Amilon & Persson, 2013; U. Schulze, 2015). It is likely that the same holds for Germany. First, most academic jobs are in the public sector, where earnings are lower but more gender-equitable due to collective agreements than in the private sector. Thus, Enders and Bornmann (2001, pp. 130–132, 188–189) find that the gender pay gap among doctoral graduates is larger in the private sector than in the public sector in Germany. Second, according to Goldan (2019), the employment sector (private vs. public) does not mediate the gender pay gap. Instead, I expect academic employment to moderate the gender pay gap among doctoral graduates with a small gender pay gap inside academia and a large gender pay gap outside academia.

H4: The gender pay gap among doctoral graduates is small inside academia and large outside academia.

Figure 9.2 illustrates the theoretical model. Except for academic employment, which is expected to moderate the gender pay gap, all other determinants reflect mediating effects. The expected path dependencies between doctoral subjects and industries and between labour market participation and management positions are also included in the figure.

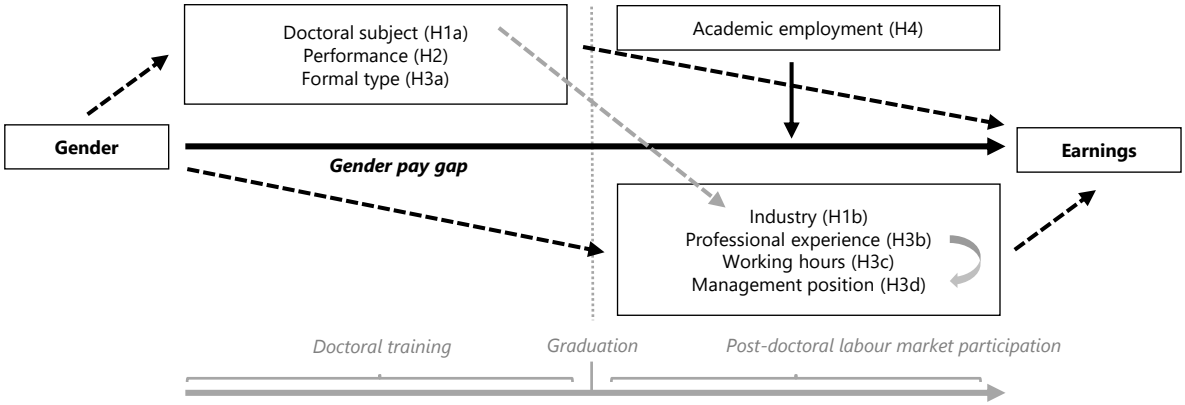

Figure 9.2: **Theoretical model, author's elaboration.**

9.3.4 Purpose of the study

This paper advances the research on gender inequalities in post-doctoral careers by examining the determinants of the gender pay gap among doctoral graduates and by using a unique data set as it reflects the employment situation of a recent doctoral graduation cohort five years after graduation in Germany. Previous research indicates a gender pay gap among doctoral graduates in several countries. However, most studies that reveal a gender pay gap among doctoral graduates are descriptive and mention it only briefly. Few studies explicitly investigate the gender pay gap and its determinants

(Amilon & Persson, 2013; Bornmann & Enders, 2004; Goldan, 2019; U. Schulze, 2015). In addition, there is disagreement about whether doctoral and occupational characteristics contribute to explaining the gender pay gap (Ballarino & Colombo, 2010; Goldan, 2019; U. Schulze, 2015). By relying on theoretical approaches and previous empirical findings, I examine gender differences in doctoral and occupational characteristics as potential determinants of the gender pay gap.

From a methodological perspective, the focus on doctoral graduates is a particular strength of this paper because gender differences in education-related human capital investments usually account for a large part of gender pay gaps. However, doctoral graduates are a homogeneous educational group, which allows for studying the determinants of the gender pay gap beyond differences in educational attainment.

By using data from one doctoral graduation cohort at the same career stage and at the national level, I prevent cohort and time effects and focus on a single labour market. In addition to reasons of data availability, Germany is an interesting case study because of its high numbers of doctorates and female doctoral graduates and because of the good career prospects for doctoral graduates both inside and outside academia.

9.4 Data, variables, and methods

9.4.1 Data and analysis sample

I use data from the first and fifth survey waves of the PhD Panel 2014 (Brandt, Briedis, et al., 2020a; Brandt et al., 2018), which were collected by the German Centre for Higher Education Research and Science Studies (DZHW). These data are representative of the 2014 doctoral graduation cohort in Germany, i.e. persons who earned a doctorate at a German university in the winter semester of 2013/14 or summer semester of 2014. The first wave was realised as a standardised postal survey one year after graduation and provides information on the graduates' gender, year of birth, and doctoral characteristics. The fifth wave was realised as a standardised online survey five years after graduation and provides information on the graduates' current family background and occupational characteristics. The full sample consists of 2,371 graduates who participated in both waves. To achieve a sample with uniform labour market structures, sample restrictions were necessary. Because of different pathways to and after the doctorate, I excluded graduates who earned a medical doctorate (694). Because of different working conditions, I also excluded graduates who were currently self-employed (93). To focus solely on the German labour market, I excluded graduates who were currently working abroad (202).[6]

Little's (1988) test indicated that missing values were not missing completely at random.[7] Therefore, a complete case analysis was not appropriate, and I multiply imputed missing values instead, which only requires the missingness mechanism of missing at random. I applied multiple imputation by chained equations with 20 imputations and 70 iterations to replace the missing values in all relevant variables (see Table 9.4 in the appendix for details on the imputation). According to von Hippel (2007), I excluded cases with a missing value in the dependent variable after imputation (201).[8] Thus, the final analysis sample consisted of 1,768 cases.

[6] For practical reasons, the exclusion of three additional subgroups was necessary: graduates whose formal type of doctoral training (45) or final grade (10) were unclear and graduates from two industries with particularly low case numbers (food and hospitality services: 6; other economic occupations: 18).

[7] The test indicated a χ^2 distance of 2935.49 with 1,732 degrees of freedom and a p-value of .000.

[8] I checked the distributions of the observed and imputed data and found that they are similarly distributed, which indicates a good fit of the imputation model to the observed data. In addition, the results are robust compared to complete case analyses.

9.4.2 Dependent variable

Table 9.2 gives an overview of all the variables and their distributions. The dependent variable is *gross monthly earnings* in € five years after graduation, which includes the monthly share of annual bonuses. The resulting earnings were right-skewed; therefore, I use the natural logarithm in the regression analyses.

9.4.3 Independent and control variables

Gender is the main independent variable and is coded 1 for females and 0 for males.

I consider several doctoral characteristics. *Doctoral subjects* fall into five subject groups according to the German Federal Statistical Office (2019a), with one exception. Because of low case numbers, I added art (29) and sports (13) to humanities. The *formal type of doctoral training* refers to the main source of funding and distinguishes between three types of employment (university, non-university research institution, outside academia), doctoral grants, and private funding. In line with de Vogel (2020, pp. 269–321), the following indicators show doctoral performance: the *number of publications* and given *talks*, which are both standardised by subject group; *teaching experience*; *international experience* in the form of a research stay abroad; the *final grade* of the doctorate; and the *duration* of doctoral training, which is also standardised by subject group.

The first occupational characteristic is *professional experience* gained after graduation, which is shown through the cumulative length of employment in months since graduation. Further occupational characteristics are five *industries* according to the 2010 German classification of occupations (Federal Employment Agency, 2011), *management position*, *working hours* per week, and *academic employment*.

The controls are *age*, *parenthood*, *marriage*, *company size* ('big' $\geq$ 250 employees vs. 'small/medium-sized' $<$ 250 employees), and the *region of employment* (West vs. East Germany).

9.4.4 Analytical strategy

To answer the research question, I examine the hypothesised determinants of the gender pay gap in three steps. First, I analyse the determinants separately by gender to reveal their explanatory potential (see Table 9.2).

Second, I test whether the determinants of H1a–3d mediate the gender pay gap by estimating stepwise log-linear regression models on the logarithmic gross monthly earnings (see Table 9.3). As the gender coefficient successively decreases, the added variables contribute to explaining the gender pay gap. Because the data were multiply imputed, I calculate the adjusted R^2 by using the method of Harel (2009). Model 1 (M1) is the baseline model that shows the size of the unadjusted gender pay gap. In M2 through M9, I add the controls and determinants stepwise. Due to the log transformation of the dependent variable, the regression coefficients need to be adjusted with the formula $\exp(\beta\Delta x) - 1$ to give the exact proportionate change in earnings for a one-unit change for each independent variable (Thornton & Innes, 1989; Wooldridge, 2013, pp. 191–194).

Third, I examine the expected moderating effect of academic employment on the gender pay gap (H4) both in an additional regression model in Table 9.3 (M10) and graphically (see Figure 9.3). In M10, I add a product term that includes gender and academic employment, which is coded 1 for women who are

employed inside academia and 0 for anyone else. Because of the product term, the gender coefficient in M10 is no longer comparable to the main effect of gender in the previous models; instead, it is now a simple effect and reflects the gender pay gap outside academia. The significance of the product term indicates whether there is a bilinear interaction.

9.5 Results

9.5.1 Bivariate analyses by gender

Table 9.2 displays the variables' distributions by gender and thus allows examining the gender differences in doctoral and occupational characteristics, which I hypothesised as determinants of the gender pay gap. Above all, the table indicates a substantial and statistically significant gender pay gap among doctoral graduates. On average, male graduates earn 7505.16 €/month, whereas female graduates earn 5211.16 €/month, i.e. approximately 30 % less.

We now examine the determinants. For the doctoral characteristics, I find statistically significant gender differences in doctoral subjects and some of the performance indicators. As expected, female graduates earned their doctorates less often in engineering, published less and gave fewer talks during their doctoral training, and earned their doctorates less often with summa cum laude; however, surprisingly, they more often earned their doctorates in mathematics and natural sciences, and gained less frequent teaching experience than male graduates. I do not find the expected gender differences in formal types of doctoral training.

Regarding the occupational characteristics, there are large differences in working hours with female graduates working approximately 4.5 h per week less than male graduates. I also find statistically significant gender differences in all other occupational characteristics: professional experience after graduation, industries, management positions, and academic employment.

Table 9.2: Description of variables *(corrected)*

		Proportional and mean values (standard deviations)			
		Total	*Female*	*Male*	*Significance*
Independent variable	**Gender: female** (ref. male)	.46			
Dependent variable	**Gross monthly earnings** (in €)	6442.58	5211.16	7505.31	***
		(8630.93)	(7258.00)	(9536.97)	
	Gross monthly earnings (log.)	8.54	8.34	8.71	***
		(.59)	(0.57)	(0.55)	
Mediators	**Doctoral subject**				
	- Humanities, art, sports	.14	.15	.13	n.s.
	- Legal, economic, social sciences	.25	.27	.23	*
	- Mathematics, natural sciences	.38	.41	.35	*
	- Agriculture, forestry, nutrition sciences, veterinary medicine	.06	.10	.03	***
	- Engineering	.17	.07	.26	***
	Formal type of doctoral training				
	- Employment at a university	.56	.54	.58	n.s.
	- Employment at a non-university research institution	.10	.10	.10	n.s.
	- Employment outside academia	.12	.12	.13	n.s.
	- Doctoral grant	.18	.20	.16	n.s.
	- Private financing	.04	.05	.03	*
	Number of publications (stand.)	.03	–.07	.12	***
		(1.08)	(.92)	(1.19)	
	Number of talks (stand.)	.00	–.07	.07	**
		(1.07)	(.96)	(1.16)	
	Teaching experience: yes (ref. no)	.62	.58	.65	**
	International experience: yes (ref. no)	.18	.17	.19	n.s.
	Final grade of doctorate				
	- Summa cum laude	.25	.22	.27	*
	- Magna cum laude	.61	.64	.58	**
	- Cum laude or less	.14	.14	.15	n.s.
	Duration of doctoral training (in years, z-stand.)	.03	.07	.00	n.s.
		(1.06)	(1.05)	(1.07)	
	Professional experience after graduation (in months)	55.43	53.58	57.03	***
		(9.62)	(10.31)	(8.67)	
	Industry				
	- Manufacturing	.14	.08	.20	***
	- Health	.12	.19	.05	***
	- Social, cultural services	.26	.29	.24	*
	- Commercial, business-related services	.30	.29	.31	n.s.
	- IT, natural scientific services	.18	.15	.21	**
	Management position: yes (ref. no)	.40	.34	.45	***
	Working hours (per week)	36.40	34.02	38.45	***
		(7.12)	(8.78)	(4.35)	
Moderator	**Academic employment: yes** (ref. no)	.37	.40	.35	*
Controls	**Age** (in years)	37.71	37.36	38.01	**
		(4.68)	(4.67)	(4.66)	
	Parenthood: yes (ref. no)	.57	.54	.60	*
	Marriage: yes (ref. no)	.61	.54	.67	**
	Company size: big (ref. small/medium)	.65	.61	.68	**
	Region of employment: West Germany (ref. East)	.83	.81	.84	n.s.

Significance: * p < .05, ** p < .01, *** p < .001; data source: DZHW PhD Panel 2014, 1st and 5th waves, multiply imputed data, the results reported for m = 1, N = 1,768, author's calculations

9.5.2 Multivariate analyses

Table 9.3 provides the regression results on the gender pay gap, which allows me to test the hypothesised determinants. M1 demonstrates that female doctoral graduates earn 30.4 % (β = –.363) less than male doctoral graduates five years after graduation. This gender pay gap is statistically highly significant (p = .000). When introducing the controls in M2, the gender pay gap decreases slightly to 29.9 % (β = –.355).

Table 9.3: OLS regression on the logarithmic gross monthly earnings *(corrected)*

	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10
Gender: female (ref. male)	–.363***	–.355***	–.311***	–.308***	–.302***	–.273***	–.246***	–.230***	–.112***	–.171***
	(.027)	(.026)	(.027)	(.027)	(.027)	(.027)	(.027)	(.026)	(.026)	(.032)
Doctoral subject (ref. humanities, art, sports)										
Legal, economic, social sciences			.293***	.281***	.293***	.266***	.214***	.199***	.147***	.144***
			(.043)	(.043)	(.044)	(.043)	(.044)	(.043)	(.041)	(.041)
Mathematics, natural sciences			.263***	.263***	.285***	.271***	.207***	.210***	.161***	.161***
			(.041)	(.042)	(.043)	(.043)	(.047)	(.046)	(.043)	(.043)
Agriculture, forestry, nutrition sciences, veterinary medicine			.112	.097	.116	.078	.058	.060	.023	.026
			(.063)	(.063)	(.064)	(.063)	(.069)	(.068)	(.064)	(.064)
Engineering			.418***	.413***	.436***	.389***	.289***	.275***	.216***	.204***
			(.047)	(.049)	(.049)	(.049)	(.053)	(.052)	(.049)	(.049)
Formal type of doct. training (ref. employment at a university)										
Employment at a non-univ. research institution				–.025	–.011	–.018	–.023	–.023	–.017	–.007
				(.043)	(.045)	(.045)	(.044)	(.043)	(.040)	(.040)
Employment outside academia				.100*	.148**	.119*	.101*	.072	.109*	.092*
				(.044)	(.048)	(.047)	(.047)	(.046)	(.043)	(.043)
Doctoral grant				–.034	–.028	–.021	–.020	–.024	–.013	–.009
				(.035)	(.036)	(.035)	(.035)	(.034)	(.032)	(.032)
Private financing				–.044	–.005	–.011	.004	–.014	.017	–.001
				(.069)	(.071)	(.070)	(.069)	(.068)	(.063)	(.063)
Number of publications (stand.)					.016	.014	.013	.006	.005	.008
					(.014)	(.014)	(.014)	(.014)	(.013)	(.013)
Number of talks (stand.)					.002	–.004	.003	.006	–.001	.002
					(.015)	(.015)	(.014)	(.014)	(.013)	(.013)
Teaching experience: yes (ref. no)					.048	.033	.035	.029	.054*	.052*
					(.030)	(.029)	(.029)	(.028)	(.027)	(.026)
International experience: yes (ref. no)					.059	.068*	.070*	.068*	.030	.031
					(.035)	(.034)	(.034)	(.033)	(.031)	(.031)
Final grade of doctorate (ref. summa cum laude)										
Magna cum laude					–.000	.003	–.015	–.010	–.002	–.012
					(.032)	(.031)	(.031)	(.030)	(.028)	(.028)
Cum laude or less					–.022	–.010	–.035	–.032	–.015	–.030
					(.046)	(.045)	(.044)	(.044)	(.041)	(.041)
Duration of doctoral training (in years, stand.)					–.002	.001	.001	.001	.002	–.001
					(.013)	(.012)	(.012)	(.012)	(.011)	(.011)
Professional experience after graduation (in months)						.011***	.010***	.010***	.007***	.008***
						(.001)	(.001)	(.001)	(.001)	(.001)
Industry (ref. social, cultural services)										
Manufacturing							.252***	.267***	.250***	.203***
							(.048)	(.048)	(.044)	(.047)
Health							.035	.051	.082	.056
							(.052)	(.051)	(.049)	(.050)
Commercial, business-related services							.245***	.234***	.205***	.156***
							(.036)	(.035)	(.033)	(.037)
IT, natural scientific services							.130**	.143**	.138***	.106*
							(.045)	(.045)	(.042)	(.042)
Management position: yes (ref. no)								.174***	.105***	.103***
								(.026)	(.024)	(.024)
Working hours									.031***	.031***
									(.002)	(.002)
Academic employment: yes (ref. no)										–.164***
										(.037)
Female*academic employment										.155**
										(.048)
Age (in years)		–.005	–.002	–.004	–.004	–.006	–.003	–.003	–.001	–.001
		(.003)	(.003)	(.003)	(.003)	(.003)	(.003)	(.003)	(.003)	(.003)
Parenthood: yes (ref. no)		–.128***	–.137***	–.137***	–.137***	–.119***	–.118***	–.125***	–.019	–.018
		(.031)	(.030)	(.030)	(.030)	(.030)	(.029)	(.029)	(.027)	(.027)
Marriage: yes (ref. no)		.024	.020	.019	.015	.017	.012	.014	.020	.015
		(.031)	(.031)	(.031)	(.031)	(.030)	(.030)	(.029)	(.027)	(.027)
Company size: big (ref. small/medium)		.198***	.170***	.176***	.171***	.162***	.159***	.169***	.139***	.142***
		(.028)	(.028)	(.028)	(.028)	(.028)	(.027)	(.027)	(.025)	(.025)
Region of employment: West Germany (ref. East)		.115**	.105**	.098**	.099**	.088*	.083*	.077*	.094**	.083**
		(.037)	(.036)	(.036)	(.036)	(.035)	(.035)	(.034)	(.031)	(.031)
Constant	8.707***	8.708***	8.366***	8.471***	8.407***	7.880***	7.731***	7.678***	6.559***	6.642***
	(.018)	(.116)	(.127)	(.133)	(.141)	(.153)	(.153)	(.151)	(.160)	(.160)
Adjusted R^2	.095	.139	.178	.181	.182	.210	.237	.257	.377	.380
N	1,768	1,768	1,768	1,768	1,768	1,768	1,768	1,768	1,768	1,768

Significance: * p < .05, ** p < .01, *** p < .001; standard errors in parentheses; data source: DZHW PhD Panel 2014, 1st and 5th waves, multiply imputed data, author's calculations

From M3 through M9, adding the mediators continuously reduces the gender pay gap. In M3, I add doctoral subjects to test H1a. As expected, I find that gender differences in doctoral subjects explain a considerable part of the gender pay gap because it narrows to 26.7 % (β = –.311) once the subjects are taken into account. The positive subject coefficients indicate that graduates in all subject groups earn more than graduates in humanities, art, and sports.

I expected that women and men would complete their doctoral training in different formal types and therefore earn differently after graduation (H3a). However, the gender pay gap changes only slightly from M3 to M4 (β = –.308); therefore, the formal types of doctoral training do not contribute to explaining the gender pay gap. This is not surprising because we have already seen in the bivariate analyses that the formal types do not differ by gender. Compared to graduates who completed their doctoral training with employment at a university, only the earnings of graduates who have been employed outside academia differ statistically significantly (β = .100; p = .024).

In M5, the gender pay gap decreases only slightly again (β = –.302). Thus, H2 cannot be confirmed – gender differences in doctoral performance do not contribute to explaining the gender pay gap. None of the performance indicators is statistically significantly associated with earnings.

By adding professional experience after graduation in M6, the gender pay gap narrows to 23.9 % (β = –.273). This indicates that female graduates gain less professional experience after graduation than male graduates and therefore earn less, which confirms H3b.

In M7, I take industries into account, which allows me to test H1b, and it indeed decreases the gender pay gap to 21.8 % (β = –.246). The coefficient of each industry is positive; therefore, earnings are higher in each industry than in social and cultural services.

I expected the gender pay gap to result from female graduates holding management positions less frequently (H3d). When introducing management positions in M8, I find that the gender pay gap decreases further to 20.5 % (β = –.230). Managers earn statistically significantly more than graduates in other job positions (β = .174; p = .000), and the fact that female graduates hold management positions less often than male graduates slightly contributes to explaining the gender pay gap.

In M9, I take working hours into account; therefore, the gender pay gap decreases strongly to 10.6 % (β = –.112) but remains statistically significant (p = .000). As we have already seen that female graduates work fewer hours than male graduates, working hours largely explain the gender pay gap, which confirms H3c.

As expected, I find in M10 that academic employment moderates the gender pay gap (H4). The coefficient of the product term is statistically significantly different from zero (β = –.155; p = .001); therefore, the size of the gender pay gap differs inside and outside academia. The gender coefficient in M10 indicates that female graduates earn 15.7 % (β = –.171) less than male graduates outside academia (ceteris paribus).

Figure 9.3 provides further insight into the moderating effect of academic employment. It shows the predicted values of the logarithmic gross monthly earnings by gender and academic employment derived from M10. The figure graphically reveals that female and male graduates' earnings do not statistically significantly differ inside academia, whereas male graduates earn statistically significantly more outside academia.

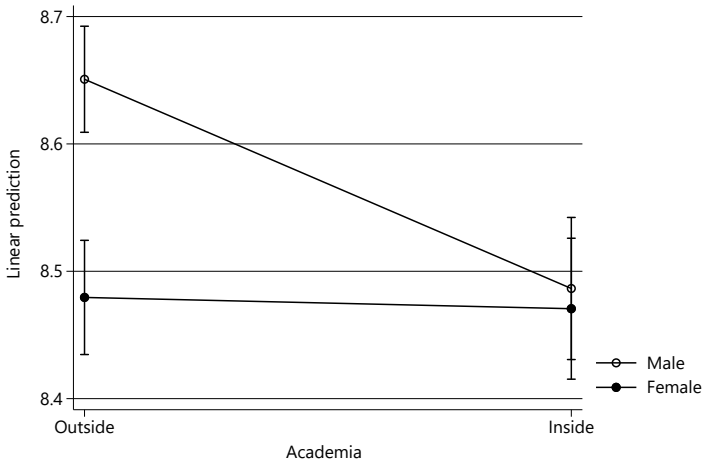

Figure 9.3: **Interaction effect of gender and academic employment on the logarithmic gross monthly earnings in M10 (predicted values and 95 % confidence interval)** *(corrected)*
Data source: DZHW PhD Panel 2014, 5th wave, multiply imputed data; author's calculations.

9.6 Discussion

The analyses revealed that female doctoral graduates earn 30.4 % less than male doctoral graduates in Germany five years after graduation. This unadjusted gender pay gap is substantive and likely to reduce the lifetime earnings of female graduates. The size of the gender pay gap is consistent with those found in studies with data on other countries and career stages (Amilon & Persson, 2013; Bornmann & Enders, 2004; Goldan, 2019; U. Schulze, 2015). Notably, the gender pay gap found here is higher than in some of these studies; however, this probably results from some studies measuring the gender pay gap in terms of hourly wages, which are already adjusted for working hours.

The findings support some of the hypothesised determinants and reject others. As expected and confirming some of the determinants found in previous research, female graduates earn less because of gender differences in doctoral subjects (H1a) and industries (H1b), because they gain less professional experience after graduation (H3b), because they are less likely to hold management positions (H3d), and in particular because they work fewer hours than male graduates (H3c). Against expectations, I found no mediating 'effect' of gender differences in doctoral performance (H2) and the formal types of doctoral training (H3a).

Overall, the considered doctoral and occupational characteristics only partially explained the gender pay gap. Throughout the model steps, the gender pay gap decreased from 30.4 % (M1) to 10.6 % (M9) but remained substantial and statistically significant. When controlling for doctoral and occupational characteristics, female graduates still earn less than male graduates.

Conforming with Amilon and Persson (2013) and U. Schulze (2015), one key finding is that academic employment moderates the gender pay gap in Germany (H4). Although there is no gender pay gap inside academia, female graduates earn 15.7 % less than male graduates outside academia (ceteris paribus). In the German case, this finding can be presumably traced to the public sector setting of academic jobs, where earnings are more gender-equitable due to collective agreements. However, the finding that there is no gender pay gap inside academia five years after graduation does not prove that women and men will also have similar earnings later in their careers. Differences may arise, for example, if men are appointed more often to chairs than women.

9.7 Conclusions

Previous research has shown a gender pay gap among doctoral graduates; however, there has been little research on its determinants. Therefore, this paper's purpose was to identify the determinants of the gender pay gap among doctoral graduates five years after graduation in Germany. The focus on doctoral graduates allowed for studying the determinants beyond gender differences in educational attainment. Germany was an interesting case study because of its high doctoral rate and good career prospects for doctoral graduates both inside and outside academia. I proposed several doctoral and occupational characteristics as human capital-related determinants and tested these by using a unique data set on the 2014 doctoral graduation cohort in Germany.

I found that doctoral subjects, professional experience after graduation, industries, management positions, and working hours mediate the gender pay gap among doctoral graduates. The analyses also confirmed that the gender pay gap varies considerably inside and outside academia with male graduates earning a large premium outside academia. Consistent with the general knowledge about different labour market conditions and structures inside and outside academia, this finding emphasises the importance of distinguishing between academic and non-academic employment when studying post-doctoral careers.

The present study has some limitations that need to be mentioned. First, the analytical strategy was cross-sectional and non-experimental and therefore did not allow a causal interpretation of the results. However, the covariates were clearly exogenous and carefully derived from theoretical approaches.

Second, for reasons of data availability, the analyses were restricted to one graduation cohort in Germany. Therefore, the results are only valid for Germany. However, this restriction is also a particular strength of this paper because it prevented cohort and time effects and biases due to national differences in post-doctoral labour markets. Nevertheless, the ongoing German National Academics Panel Study (Wegner & Briedis, 2020) will provide extensive panel data on further cohorts of doctoral candidates and graduates and will thus allow analyses of the educational outcomes and professional careers of several graduation cohorts.

Third, the considered determinants only partially explained the overall gender pay gap, as it remained substantial and statistically significant. This unexplained part of the gender pay gap may be due to discrimination against women both during doctoral training and after graduation or to determinants other than those considered here. These could be gender differences in preferences for risk taking and competition or in negotiation behaviours. Therefore, future research may explore these and other possible mechanisms of the gender pay gap among doctoral graduates.

This paper enhances the research on gender inequalities in post-doctoral careers and contributes to the larger gender pay gap literature by investigating the determinants of the gender pay gap in one doctoral graduation cohort in Germany.

Appendix

Table 9.4: Overview of the imputation model *(corrected)*

Variables	$N_{complete}$	$\%_{missing}$	$N_{imputed}$	Estimator
Gross monthly earnings (log.)	1,768	10.21	201	Propensity mean matching[a]
Gender	1,963	.30	6	Logit (augmented)
Doctoral subject	1,957	.61	12	Multinomial logit (augmented)
Formal type of doctoral training	1,945	1.22	24	Multinomial logit (augmented)
Number of publications	1,945	1.22	24	Propensity mean matching[a]
Number of talks	1,806	8.28	163	Propensity mean matching[a]
Teaching experience	1,949	1.02	20	Logit (augmented)
International experience	1,934	1.78	35	Logit (augmented)
Final grade of doctorate	1,968	0.05	1	Multinomial logit (augmented)
Duration of doctoral training	1,946	1.17	23	Propensity mean matching[a]
Professional experience	1,941	1.44	28	Propensity mean matching[a]
Industry	1,691	14.12	278	Multinomial logit (augmented)
Management position	1,820	7.57	149	Logit (augmented)
Working hours	1,646	16.40	323	Propensity mean matching[a]
Academic employment	1,796	8.79	173	Logit (augmented)
Age	1,966	.15	3	Propensity mean matching[a]
Parenthood	1,851	5.99	118	Logit (augmented)
Marriage	1,851	5.99	118	Logit (augmented)
Company size	1,657	15.85	312	Logit (augmented)
Region of employment	1,803	8.43	166	Logit (augmented)

Data source: DZHW PhD Panel 2014, 1st and 5th waves, [a] propensity mean matching with five nearest neighbours, author's calculations

10 Overall conclusions

The purpose of this thesis was to examine the occupational destinations and professional success among doctoral graduates in Germany. More precisely, it aimed at explaining doctoral graduates' occupational destinations in the first years following their graduation and at examining their professional success by means of different success indicators and as a function of their occupational destinations, with special emphasis on social inequalities. In the following, I discuss the individual papers' results against the background of the overall research topics, derive policy implications, describe this thesis' limitations, and point out directions for future research.

10.1 Summary and discussion of the overall results

To provide new insights into the overall research topics of doctoral graduates' occupational destinations and professional success, this thesis was comprised of five individual papers each with its own research interest(s). On the one hand, these papers provide new insights into their specific research questions. On the other hand, when combined, they also provide general insights into doctoral graduates' occupational destinations and professional success as well as into social inequalities in both aspects.

Paper 1 (Goldan, Bohlen, & Gross, 2023) has examined *social inequalities in doctoral graduates' occupational destinations* by means of postdoctoral dropout from academia and within an intersectional framework. We had expected that female doctoral graduates, those with non-academic parents, and those with a migration background are more likely to drop out from academia than their respective reference groups. In addition, we had expected that these social categories are intersectionally intertwined and additionally increase the risk of dropout. In event history analyses, we found that most doctoral graduates drop out from academia at some point following graduation, but that dropout does not seem to depend on gender, parental academic background, migration background, or their intersections, which contradicted expectations.

Paper 2 (Goldan, Jaksztat, & Gross, 2023a) has investigated *doctoral graduates' occupational destinations* and aimed at explaining their choice between five distinct employment sectors. In line with previous research and against the wide version of the rational choice theory, we have tested individual preferences for certain job attributes, subjective career prospects, external encouragement, objective labour market conditions, and individual career constraints as determinants of doctoral graduates' sector choices. Multinomial logit regression indicated that job preferences, the doctoral subject group, subjective employment prospects inside and outside academia, being encouraged to pursue an academic career, the main funding source of the doctorate, the final grade of the doctorate, and the age at graduation are associated with doctoral graduates' employment sectors in one way or another and jointly influence their sector choices.

Paper 3 (Goldan, Jaksztat, & Gross, 2022) has focused on the *intersection between doctoral graduates' occupational destinations and their professional success*. We have examined the association between doctoral graduates' employment sectors and various objective and subjective indicators of professional success. The analyses have indicated that most doctoral graduates find employment in non-academic sectors, that their professional success varies by employment sector, and that all employment sectors are associated with specific advantages and disadvantages in terms of professional success. Although there is no single employment sector in which doctoral graduates are career-wise completely

"successful", doctoral graduates in the private sectors receive particularly high earnings and are more frequently permanently employed. In contrast, doctoral graduates inside academia are at a disadvantage with regard to some objective success indicators but particularly likely to perceive their employment as adequate.

Paper 4 (Goldan, Jaksztat, & Gross, 2023b) has examined a *subjective indicator of doctoral graduates' professional success* and also taken into account their occupational destinations. More precisely, we have examined the effect of obtaining a permanent employment contract on doctoral graduates' job satisfaction and whether this effect is moderated by their labour market sector. Following the effort-reward imbalance model and rational choice theory, we had expected that obtaining a permanent contract increases doctoral graduates' job satisfaction. Following social comparison theory, we had also expected that this effect is moderated by labour market sector and particularly strong inside academia. Panel fixed-effects regression has confirmed that obtaining a permanent employment contract increases doctoral graduates' job satisfaction and also confirmed the expected moderation effect by labour market sector. We have found that the increase of job satisfaction is statistically significantly stronger among doctoral graduates in the academic sector than among those in the private sector.

Paper 5 (Goldan, 2021) has investigated *social inequalities in an objective indicator of professional success* by means of the gender pay gap among doctoral graduates and its determinants. Again, I have also taken occupational destinations into account by testing whether the gender pay gap differs inside and outside academia. I have derived several doctoral and occupational characteristics from human capital theory and traditional gender roles and beliefs as mediators of the gender pay gap and expected the gap to be moderated by academic employment. Log-linear regression analyses have revealed a substantial and statistically significant gender pay gap that is largely — but not completely — mediated by gender differences in doctoral subjects, industries, professional experience, management positions, and working hours. I also found the expected moderation effect of academic employment on the gender pay gap as there was no gender pay gap inside but only outside academia.

In general, the papers' findings indicate with regard to the *occupational destinations among doctoral graduates* in Germany that the majority of them find employment outside academia with only 30 % being employed inside academia five years following graduation (*papers 2, 3*). Given the high number of completed doctorates in Germany and the low number of permanent positions inside academia, this finding comes as no surprise. Nevertheless, this finding confirms and quantifies a pattern found in previous research (BuWiN, 2013, p. 290; BuWiN, 2017, p. 185; Briedis et al., 2014, pp. 51–56; Enders & Bornmann, 2001; Enders & Kottmann, 2009; Flöther, 2015, 2017; Jaksztat et al., 2017; König et al., 2019; M. Schwabe, 2011) — in this case against the background of new and nationally representative panel survey data on a recent doctoral graduation cohort and at an advanced career stage. The findings also indicate that doctoral graduates outside academia are employed in different sectors and often engage in research activities (*papers 2, 3*). Thus, they seem to be able to effectively use their research skills and scientific working techniques not only inside but outside academia as well. Overall, their occupational destinations seem to depend less on social characteristics (*paper 1*) than on individual preferences, doctoral characteristics, and external conditions (*paper 3*), which is good news and opens up opportunities to stimulate doctoral graduates to make more conscious and well-informed career decisions.

With regard to *doctoral graduates' professional success*, the papers show at a general level that doctoral graduates are not a homogeneous group. Previous research had mostly examined doctoral graduates'

professional success in comparison to other higher education graduates (BuWiN, 2013, pp. 252–288; Enders & Bornmann, 2001, pp. 199–233; Engelage & Hadjar, 2008; Falk & Küpper, 2013; Flöther, 2015; Heineck & Matthes, 2012; König et al., 2019, pp. 36–73; Mertens & Röbken, 2013; Trennt & Euler, 2019). However, by considering differences in professional success within the group of doctoral graduates and by measuring success in terms of various objective and subjective indicators (*papers 3, 4, 5*), this thesis allowed a more detailed look at returns to doctoral education in the German labour market. Previous research on the association between doctoral graduates' occupational destinations and professional success is scarce but what there is suggested is that their professional success depends on their occupational destinations (BuWiN, 2013, p. 293; König et al., 2019, pp. 36–59). Having taken doctoral graduates' occupational destinations systematically into account when examining their professional success, I was able to show that their professional success largely varies by labour market sector (*papers 3, 4, 5*). Yet on the basis of two illustrative success indicators, I found their professional success to also vary by gender (*paper 5*) and by contract type (*paper 4*), i.e., an occupational characteristic.

With regard to *social inequalities in postdoctoral careers*, the papers give no indication of social inequalities inside academia — at least in terms of the inequality dimensions and outcomes studied here. I have found no evidence of social inequality in postdoctoral dropout from academia by gender, parental academic background, migration background, or their intersections (*paper 1*); no gender differences in the probability of being employed inside academia (*paper 2*); and no statistically significant earning differences between female and male doctoral graduates five years following graduation (*paper 5*). However, outside academia, there is evidence of gender differences as, compared to men, women are more frequently employed both in non-research jobs outside academia and in research jobs in the non-academic public sector, but less frequently in research jobs in the private sector (*paper 2*), and as there is a substantial and statistically significant gender pay gap outside academia (*paper 5*). Against the background of regular discussions about social — and especially gender — inequalities in academic careers, these findings are admittedly surprising and need to be challenged by future research. I would not consider my findings as proof of the non-existence of social inequalities inside academia. It may be that measures such as universities' gender mainstreaming and collective wage agreements inside academia effectively prevent gender inequality inside academia, but it may also be that I was not able to find existing inequalities because of methodological limitations. Future research should therefore systematically investigate different potential inequality dimensions and outcomes related to postdoctoral careers inside and outside academia.

All of these analyses were only possible because, with the DZHW PhD Panel 2014, new survey data on postdoctoral careers in Germany was available. The panel design of the data allowed for longitudinal analyses and for measuring predictors prior to outcomes in the case of cross-sectional analyses. Thus, this thesis has widely exploited the potential for analysis of the data in the form of diverse research interests and analytical methods.

Further strengths of this thesis lie in the extensive measurement of doctoral graduates' employment sectors — especially of those outside academia — and of their professional success. In line with previous research (Abele & Spurk, 2009; Abele, Spurk, & Volmer, 2011; Enders & Bornmann, 2001; Engelage & Hadjar, 2008; Engelage & Schubert, 2009; Falk & Küpper, 2013; Flöther, 2015; Judge et al., 1995; Kühne, 2009; Ng et al., 2005; Spurk, 2019), I have considered various objective and subjective indicators, which has done justice to the fact that professional success is a multidimensional construct. Yet in contrast to previous research, I have systematically related doctoral graduates' occupational destinations and professional success to each other and considered potential social inequalities in analyses. Taken together, this thesis has made an empirical contribution to the literature and has shed

new light on postdoctoral careers in Germany with regard to a wide range of illustrative and relevant research questions.

10.2 Policy implications

This thesis' findings hint at different possible starting points for policy implications. *At the level of doctoral training*, there is an ongoing debate about the necessity of reforming doctoral training (cf. section 1.1). This debate revolves around the question of whether doctoral candidates should be provided with opportunities to also acquire qualifications needed outside academia, as most of them will leave academia at some point following graduation (e.g., Hayter & Parker, 2019, p. 558; Kehm, 2020; König et al., 2019, pp. 140–141; Melin & Janson, 2006; U. Schwabe & Jungbauer-Gans, 2021, pp. 112–113; Shin, Kehm, & Jones, 2018, pp. 6–7). This thesis has not directly investigated the necessity of reforming doctoral training and therefore I do not want to presume to speak in favour or against such reforms on the basis of the presented analyses. Nevertheless, this thesis has both generated and emphasized insights into postdoctoral careers and thereby provides an empirical basis that can possibly further enrich the debate. In general, it seems as if such reforms would make sense given that most doctoral graduates leave academia and will not realize an academic career (cf. *papers 1, 2, 3*). Yet at the same time, such reforms entail a risk of devaluing the doctorate as a scientific qualification, and they also do not seem absolutely necessary as doctoral graduates are already well placed in the non-academic labour market (cf. *paper 3*). Yet their career opportunities outside academia could be even better if doctoral training had also prepared them for non-academic jobs. Thus, implementing such reforms would be a difficult balancing act between not devaluing the doctorate as a scientific qualification and adequately preparing doctoral graduates for a variety of postdoctoral careers. This thesis hopefully contributes to raising the awareness of those responsible in higher education and science policy that the majority of doctoral graduates are employed outside academia and that they are professionally quite successful there. If universities and higher education policy-makers should decide to better prepare doctoral candidates for careers outside academia, they could do so by providing (more) opportunities to establish contacts to non-university working contexts already during doctoral training. This could be, for example, in the form of mentoring programmes, research cooperations, teaching projects, knowledge transfer, or science communication.

In any case, universities' departments for academic personnel development could take greater account of the facts that most doctoral graduates are employed outside academia where they have good career prospects and that working conditions inside academia are insecure and precarious. The departments should pass this knowledge on to doctoral candidates to inform them transparently about realistic career prospects both inside and outside academia so that they can make sustainable and informed career decisions. Even though this is already happening at some universities, they should generally refrain from assuming that all doctoral candidates can and will realize an academic career and become professors. Given the disparity between the few permanent positions and professorships inside academia and the high number of doctoral graduations, such a framing can be fatal to a graduate's career. If doctoral candidates and graduates have false hopes of an academic career and are not well informed on the high performance pressures and tough competition for permanent positions inside academia as well as on the provisions of the German law on academic employment, they could fail in realizing an academic career and be forced to leave academia at a point when they are already of advanced age and are scientifically somewhat overqualified for non-academic jobs. As a result, they could be faced with difficulties when trying to gain a foothold in the non-academic labour market. By

contrast, if doctoral graduates are able to assess their academic and non-academic career prospects more realistically, they may decide earlier and more consciously either for or against an academic career. This would avoid academic misinvestments, reduce opportunity costs, and be beneficial for the graduates themselves, the labour force available to the non-academic labour market, and also for academia as the graduates who would pursue an academic career are ideally those who are particularly motivated and suited to it. Note that university professors are typically more familiar with academic than non-academic career paths and are therefore able to offer only limited non-academic career advice to their doctoral candidates and postdocs. Therefore, the main responsibility for advice on career paths outside academia must lie with universities' departments for academic personnel development.

At the level of postdoctoral employment inside academia, this thesis' findings suggest, in line with current debates within the scientific community, that in academic careers greater job security and predictability are desirable to prevent a brain drain from academia to non-academic sectors. *Paper 4* points in this direction as it has shown that permanent employment is positively associated with doctoral graduates' job satisfaction in general and that this association is particularly pronounced inside academia. Therefore, politics should aim at creating more secure jobs and predictable career paths inside academia to attract and keep the best and intrinsically most motivated scientists instead of the most risk-averse and self-sacrificing scientists.

The question is how this can be achieved without "blocking up" the academic system and barring the way for future generations of researchers. One already existing and effective approach is the extensive implementation of junior professorships with tenure track. Another aspect refers to the above-mentioned request that doctoral candidates need to be better informed regarding their career prospects both inside and outside academia. If this were the case, better and more secure working conditions inside academia could be a positive side effect, or rather, by-product. Because if the academic and the non-academic labour market were to compete more openly for the most qualified doctoral graduates, working conditions inside academia would need to become less precarious and insecure in the long term in order not to lose the best scientists to the non-academic labour market.

Interesting food for thought is provided by the 'USB model' (Kretschmer & Teichert, 2021, 2022), which suggests a fundamental reform of academic careers towards three distinct postdoctoral career paths to make academic careers more secure and predictable in general. To be precise, the model suggests that doctoral graduates pursuing an academic career following their graduation would agree on an individual catalogue of criteria aimed at developing their own research profile, at acquiring further qualifications, and at expanding their skills and experiences in teaching and leadership. In the following three-and-a-half years, they would be mentored and would try to meet these criteria. After that period, they would pass a first evaluation against the criteria. In a transparent, quality-assured procedure with external reviewers, a decision would be made on whether the graduates are allowed to stay at university in general. In the case of a negative evaluation, the graduates would be required to leave academia (career path 1). In the case of a positive evaluation, the graduates would have secured a permanent position in the academic mid-level faculty. They could either opt directly for that permanent position (career path 2) or continue to achieve a professorship (career path 3). If they opt for the latter, there is a second and final evaluation two years later that decides whether they have qualified either for the professorship or the permanent position in the academic mid-level faculty. In both cases, the university would retain its experienced scientists. The advantages of this model would be better quality in research and teaching for universities and more predictable academic careers for the graduates

themselves because they would have a secure perspective inside academia earlier in the process and would know exactly what criteria their academic career chances depend on.

At the level of postdoctoral employment outside academia, doctoral graduates tend to already be well absorbed into non-academic employment sectors, which means no call for policy changes is needed at this point. However, there is evidence of gender inequality among doctoral graduates outside academia regarding their likelihood of holding management positions (de Vogel, 2020, pp. 269–321) and earnings (*paper 5*). Thus, female doctoral graduates have in common with women in general that they receive lower returns to their education and training in the labour market than their male counterparts. Doctoral education does not seem to protect women from experiencing gender inequality. For example, regarding the gender pay gap, the most important determinant was gender differences in working hours, which is also a major determinant of the gender pay gap in the general working population in Germany (Mischler, 2021). Coincidently, this illustrates that gender mainstreaming policies could benefit all women regardless of their educational attainment. Having said that, gender is only one of many potential inequality dimensions. Therefore, the question arises as to whether there are maybe also inequalities in other indicators of professional success and/or by other inequality dimensions among doctoral graduates outside academia, and if so, how these could be reduced through policy measures.

10.3 Limitations and directions for future research

To conclude, I would like to outline this thesis' methodological and conceptual limitations and to elaborate on open research questions that offer directions for future research. Several limitations refer to the data and methods used for analyses. *First*, as typical for panel surveys, the DZHW PhD Panel 2014 is an unbalanced panel and affected by panel attrition, which entails a danger of bias that cannot be excluded. However, to reduce at least bias due to missings in the observed cases, missing values have been multiply imputed prior to analyses for each paper.

Second, the scientific use file of the DZHW PhD Panel 2014 so far only covered the period until approximately five years following doctoral graduation, i.e., a mid-term career stage. However, against the background of the German law on academic employment, a longer observation period would have been preferable but will only be available once later survey waves are also published as scientific use files. Because of the law, it is likely that a substantial proportion of those doctoral graduates who are employed inside academia five years following graduation will leave academia in the long term, which affects both their occupational destinations and their professional success. Against this backdrop, future research could, for example, examine doctoral graduates' chances of being appointed to a professorship at a later career stage than five years following graduation. On a side note, future panel surveys among other doctoral graduation cohorts within the DZHW's National Academics Panel Study (Nacaps) will allow my findings to be replicated and verified (or falsified) with more recent cohorts. Nevertheless, this thesis has used the maximum available observation period, and at five years following graduation, this observation period is longer than that of many other studies that refer in one way or another to doctoral graduates' occupational destinations and professional success.

Third, as usual for secondary analysis of existing data, the analyses were to some extent subject to unobserved heterogeneity. In the presented papers, some additional or differently collected items would occasionally have been desirable. For example, in *paper 2*, we were unable to directly model the decision-making process for or against specific employment sectors because subjective perceptions of

costs, returns, and probabilities of success related to employment in each of the sectors under study were not in the data. In other cases, the late or retrospective measurement of some variables was not ideal, e.g., of academic career intentions in *paper 3* and of external encouragement during doctoral training to pursue a specific career path in *paper 2*. These items were only measured in the first survey wave, i.e., approximately one year following graduation. However, at this time they may be biased by experiences gained following graduation and by difficulties in remembering.

Fourth, this thesis has used survey data and not experimental data; therefore, the analyses did not allow to identify causal effects but rather associative relationships between the variables studied. Causal interpretation of the results would only be possible if I had used experimental data — but then the results would have been externally less valid. Yet the predictors studied were clearly exogenous and carefully derived from theory.

Fifth, relying on quantitative survey data, this thesis was inevitably restricted in capturing the subjective perspective of the doctoral graduates. Therefore, qualitative research on doctoral graduates' subjective perception of their own career paths and outcomes could complement this thesis' findings in a meaningful way.

Sixth, this thesis was limited to doctoral graduates in Germany. Therefore, the question arises as to what extent the results are generalizable to other countries. In general, the papers' findings have frequently aligned with those from previous studies among doctoral graduates in other Western European countries and the US. Thus, it seems as if doctoral graduates encounter similar career opportunities in Western countries. However, international comparative studies — similar to the OECD-initiated data collection on Careers of Doctorate Holders in the 2000s (Auriol, 2007, 2010; Auriol, Misu, & Freeman, 2013) — would be necessary to ensure that.

Further limitations of this thesis concern its conceptual framework. With regard to theory, I have confined myself to a few suitable theories established in sociology and labour market research to explain the relationships between the investigated predictors and outcomes, but alternative theoretical explanations would have also been conceivable. Although the theories have provided causal explanations of the relationships, strictly speaking, I could also not test them in a causal way. In addition, I have not directly tested any of the theories but only used them as a tool for deriving testable hypotheses. Therefore, the analyses did not allow to draw conclusions on the theories themselves.

With regard to the investigation level, I have focused on doctoral graduates only. Thereby, I have only considered one side of the coin, yet careers are not only the result of individuals' intentional decisions and actions but also depend on coincidences, external circumstances, and opportunity structures. Therefore, the role of other actors and investigation levels would also have been interesting. Future research could explicitly investigate other actors such as academic and non-academic employers or, in the sense of linked lives, the graduates' relationship and family constellations. Future research could also take into more account the specific contexts within which doctoral graduates realize their careers, e.g., the current labour market situation inside and outside academia, changing employment requirements and demands for doctoral graduates against the background of the technological progress, or doctoral graduates' changing expectations to reconcile and achieve private and professional fulfilment.

With regard to their research interests, the individual papers have shed light on different and illustrative subtopics related to the overall research topics of doctoral graduates' occupational destinations and professional success. Yet against the background of the presented papers, these complex research topics have not been exhaustively explored, which in turn leaves room for future research. Future

research could, for example, identify typical postdoctoral career paths and mobility between sectors. In addition, when studying doctoral graduates' occupational destinations, it could be worthwhile to further differentiate employment inside academia, i.e., to differentiate between academic careers in the strict sense and positions in science management. Future research on doctoral graduates' professional success could investigate more closely returns to doctoral training other than job satisfaction and earnings, e.g., job adequacy, health, and political participation. I would also like to encourage future research to challenge my sometimes surprising findings on the absence of social inequalities in postdoctoral careers, to focus on other social inequality dimensions, e.g., by health or age, and to systematically investigate the association between the formal type of doctoral training and postdoctoral careers as well as between doctoral subject groups and postdoctoral careers. Finally, research on the occupational destinations and professional success of special doctoral groups also seems promising; for example, doctoral candidates who drop out from doctoral training or doctoral graduates who pursue an academic career but eventually fail in obtaining a permanent position inside academia and are forced to transition to the non-academic labour market. In both cases, it would be interesting to examine how these forms of supposed "failure" affect their occupational destinations and later professional success.

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