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Lea Goldan

The Early Career Gender Pay Gap among Doctoral Graduates in Germany

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Um seine aktuellen Forschungsergebnisse verstärkt sichtbar zu machen, hat das Institut für Politikwissenschaft und Soziologie zu Jahresbeginn 2012 die Online-Schriftenreihe WAPS (Würzburger Arbeitspapiere zur Politikwissenschaft und Soziologie) ins Leben gerufen. In WAPS spiegelt sich die gesamte Bandbreite der Forschungsleistung des Instituts wider. Bis Band 8 erschien die Schriftenreihe unter dem Titel „Würzburger Arbeitspapiere zur Politikwissenschaft und Sozialforschung“.

Neben MitarbeiterInnen des Instituts steht die Schriftenreihe auch hervorragenden Studierenden offen, die über die Veröffentlichung ihrer beachtlichen Beiträge an das wissenschaftliche Publizieren herangeführt werden.

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The Early Career Gender Pay Gap among Doctoral Graduates in Germany

Lea Goldan

Abstract

Previous research has shown that female doctoral graduates earn less than male doctoral graduates; however, the determinants of this gender pay gap remain largely unexplored. Therefore, this paper investigates the determinants of the early career gender pay gap among doctoral graduates in Germany. By relying on effects on the supply and demand sides and feedback between them, I theoretically derive determinants of the gender pay gap that comprise doctoral and occupational characteristics. Using data from a representative German panel study of the 2014 doctoral graduation cohort, I analyse the gender pay gap two years after graduation. I apply linear regression on the logarithmic gross monthly earnings and Oaxaca-Blinder decomposition to examine the explanatory contribution of the determinants to the gender pay gap. The analyses reveal that female graduates earn 27.2 % less than male graduates two years after graduation. Male graduates being paid a premium outside academia partly drives this gender pay gap. The considered determinants largely explain the overall gender pay gap, the most important determinants being working hours, doctoral subject, industry, professional experience gained after graduation, company size, and academic employment. The results offer new insights on the determinants of the early career gender pay gap among doctoral graduates and thereby shed light on one dimension of gender inequalities in post-doctoral careers.

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Der Gender Pay Gap von Promovierten in Deutschland am Anfang ihrer Karriere

Lea Goldan

Zusammenfassung

Bisherige Forschung hat gezeigt, dass weibliche Promovierte weniger verdienen als männliche Promovierte. Die Determinanten dieses Gender Pay Gaps sind jedoch noch weitgehend unerforscht. Deshalb untersucht dieser Beitrag die Determinanten des Gender Pay Gaps von Promovierten in Deutschland, und zwar am Anfang ihrer Karriere. Auf der theoretischen Grundlage von Effekten auf der Angebots- und Nachfrageseite sowie Rückkopplungen zwischen diesen beiden Seiten leite ich Determinanten des Gender Pay Gaps ab, die Promotions- und Beschäftigungsmerkmale umfassen. Dabei verwende ich die Daten einer repräsentativen deutschen Panelstudie von Promovierten der Abschlusskohorte 2014 und betrachte den Gender Pay Gap zwei Jahre nach Promotionsabschluss. Ich wende lineare Regressionsanalysen der logarithmierten Bruttomonatseinkommen und eine Oaxaca-Blinder-Dekomposition an, um den Erklärungsbeitrag der Determinanten am Gender Pay Gap zu untersuchen. Die Analysen zeigen, dass weibliche Promovierte zwei Jahre nach der Promotion 27,2 % weniger verdienen als männliche Promovierte. Dieser Gender Pay Gap wird teilweise durch einen Lohnvorteil für männliche Promovierte außerhalb der Wissenschaft verursacht. Die betrachteten Determinanten erklären einen großen Teil des Gender Pay Gaps, dabei sind die Arbeitsstunden, das Promotionsfach, die Branche, die nach der Promotion erworbene Berufserfahrung, die Betriebsgröße und die Beschäftigung innerhalb der Wissenschaft die wichtigsten Determinanten. Zusammenfassend bieten die Ergebnisse neue Einblicke in die Determinanten des Gender Pay Gaps von Promovierten am Anfang ihrer Karriere und nehmen damit eine Dimension von geschlechtsspezifischen Ungleichheiten in den Karrieren von Promovierten in den Blick.

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1 Introduction[1,2]

Previous research in the field of higher education has examined returns on doctoral education and shown that doctoral graduates fare better than other educational groups in terms of earnings, job satisfaction, management positions, and risk of unemployment (e.g., Enders 2002; Engelage and Hadjar 2008; Falk and Küpper 2013; Pedersen 2016; Waite 2017). However, despite their high educational attainment, female doctoral graduates earn less than male doctoral graduates (Amilon and Persson 2013; Bornmann and Enders 2004; Goldan 2019; Schulze 2015; Waite 2017). Although research has demonstrated the existence of a gender pay gap among doctoral graduates, the determinants of that gap remain largely unexplored.

Therefore, this paper examines the determinants of the gender pay gap among doctoral graduates and thereby contributes to the literature on gender inequalities in post-doctoral careers. This paper's research question is: *what are the determinants of the early career gender pay gap among doctoral graduates?* Using data from a representative German panel study of the 2014 doctoral graduation cohort, the paper investigates the *early career* gender pay gap, i.e., two years after graduation, in Germany and whether this gap is due to gender differences in doctoral and occupational characteristics.

Gender pay gaps have a particular impact on both women's lifetime earnings and the economy – especially, among doctoral graduates. First, earnings are very high among doctoral graduates; thus, pay disadvantages among female doctoral graduates add up to a particularly large sum throughout their employment trajectories. Second, at the economic level, doctoral graduates play a crucial role in economic development and innovation in knowledge-based societies (Bogle et al. 2010; Diamond et al. 2014). If female doctoral graduates' earnings are below their productivity, the potential for economic development and innovation is inhibited.

2 The German Context

Some characteristics of doctoral training and the careers of doctoral graduates in Germany are worth mentioning briefly. Women more frequently earn doctorates in subjects such as art (proportion of women: 66.7 % in 2017/18) or agriculture, forestry, nutrition sciences, and veterinary medicine (women: 65.6 %). By contrast, women less frequently pursue doctorates in mathematics and the natural sciences (women: 41.6 %) or engineering (women: 19.1 %; Federal Statistical Office 2019; author's calculations). The doctorate in medicine is very different from other disciplines because the doctorate is usually the standard degree, it is earned during basic studies, and without employment at the university (Berning and Falk 2006, pp. 123–140).

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[1] This is an earlier version of an article that has been accepted for publication by Taylor & Francis in the European Journal of Higher Education, available online: http://doi.org/10.1080/21568235.2020.1835516.

[2] I thank Christiane Gross for her valuable advice throughout the research process, Hannah Nelson-Teutsch and Micha Pastuschka for proofreading, and 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 2019, 7th Conference of the Society for Empirical Educational Research (GEBF) in Cologne 2019, and 2nd Forum on Higher Education and the Labour Market (HELM) in Hanover 2019. Further thanks go to the German Centre for Higher Education Research and Science Studies (DZHW) for both collecting and providing the data.

Since the early 1990s, the total number of students having earned a doctorate has increased worldwide (Auriol 2010). Germany is one of the countries with the highest number of earned doctorates. However, although the number of female doctoral graduates has increased substantially, men still outnumber women in terms of earned doctorates (see Figure 1).

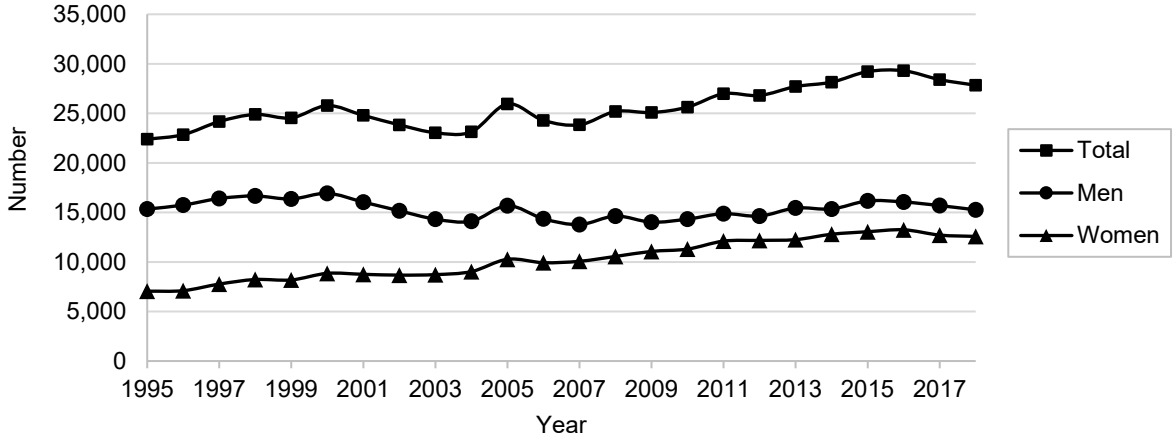

Figure 1: Number of earned doctorates per year by gender in Germany between 1995 and 2018; source: Federal Statistical Office 2019, author's elaboration

One might suspect that the number of female doctoral graduates has increased because of women pursuing doctorates in female-dominated subjects. However, Figure 2 reveals that the proportion of doctorates awarded to women has increased in all subject groups and only slightly in female-dominated subject groups such as the humanities, sports, and art or agriculture, forestry, nutrition sciences, and veterinary medicine. The increase in doctorates awarded to women was highest in legal, economic, and social sciences.

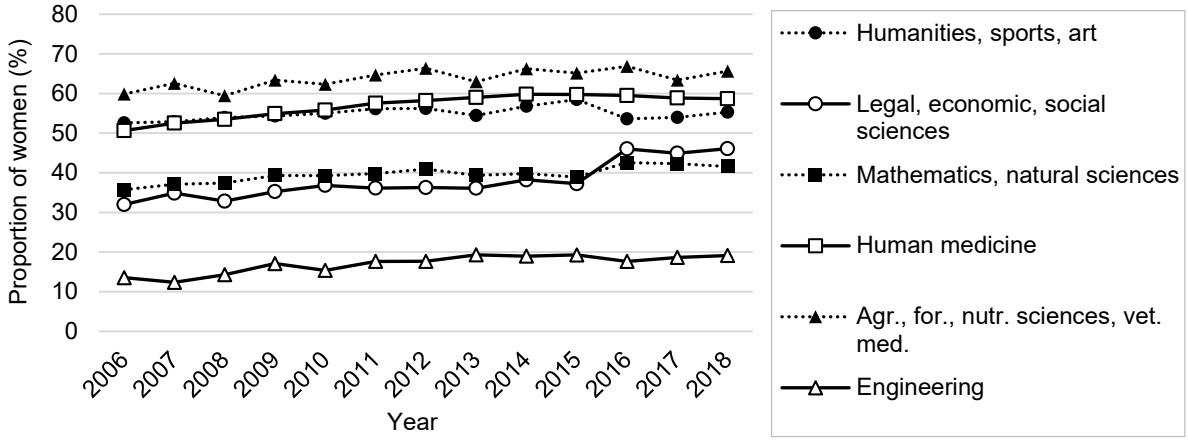

Figure 2: Proportion of doctorates awarded to women by subject group in Germany between 2006 and 2018; source: Federal Statistical Office 2019, author's elaboration

Another distinctive feature are different formal types and funding channels of doctoral training. Depending on the formal type of doctoral training, doctoral candidates gain varying quantities of professional experience during 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. In Germany, women are less likely to be employed during their doctoral training and in particular, to be employed at a university (Federal Statistical Office 2016).

Following graduation, doctoral graduates encounter very good career prospects – both inside and outside academia. Therefore, in contrast to other countries, most doctoral graduates leave academia after graduation (Auriol et al. 2013; Consortium for the National Report on Junior Scholars 2013). However, the gender gap in employment and part-time work for doctoral graduates is higher in Germany than in other countries, and female doctoral graduates are more likely to be unemployed or working part-time (Auriol et al. 2013; Enders 2002; Flöther and Oberkrome 2017).

3 Literature Review

Previous research indicates a gender pay gap among doctoral graduates in Germany, Canada, Italy, Sweden, and the UK (Amilon and Persson 2013; Ballarino and Colombo 2010; Bornmann and Enders 2004; Christie and Shannon 2001; Desjardins and King 2011; Enders and Bornmann 2001; Engelage and Hadjar 2008; Goldan 2019; Schulze 2015; Waite 2017). However, most analyses revealing a gender pay gap among doctoral graduates are only descriptive, and few studies explicitly investigate the gender pay gap (Amilon and Persson 2013; Bornmann and Enders 2004; Goldan 2019; Schulze 2015). Therefore, knowledge about the determinants of the gender pay gap among doctoral graduates is scarce.

Instead, much research examines other aspects related to the gender pay gap among doctoral graduates. First, there is research on the wage premium of doctorates compared to other higher education degrees (Enders and Bornmann 2001; Engelage and Hadjar 2008; Falk and Küpper 2013; Fröhlich 2018; Mertens and Röbken 2013; Pedersen 2016; Waite 2017). Second, there is research on the returns on doctoral education and on occupational trends among doctoral graduates (Auriol 2010; Auriol et al. 2013; Ballarino and Colombo 2010; Desjardins and King 2011; Enders 2002; Enders and Bornmann 2001; Hanks and Kniffin 2014; Neumann and Tan 2011; Passaretta et al. 2019; Pedersen 2016). Third, there is research on the determinants of the gender pay gap among academics (e.g., Blackaby et al. 2005; Braakmann 2013; Brandt 2016; Castagnetti and Rosti 2013; García-Aracil 2007; Leuze and Strauß 2014; Triventi 2013; Waite 2017; Ward 2001). This research indicates that the gender pay gap among academics is largely due to gender differences in study subject, employment trajectory, employment sector, and management position.

The few studies that explicitly examine the gender pay gap among doctoral graduates quantify its size at different career stages. In Germany, Bornmann and Enders (2004) show across several graduation cohorts that female graduates earn between 20 % and 46 % less than male graduates ten to twenty years after graduation depending on the doctoral subject. Goldan (2019) finds an unadjusted gender pay gap of 16 % among doctoral graduates in Germany six years after graduation. According to her analyses, the gender pay gap

among doctoral graduates stems from similar determinants as the gender pay gap among academics, namely, study subject, professional experience, and management position. However, her analyses are not representative of a complete graduation cohort and do not consider doctoral characteristics. Schulze (2015) examines the gender pay gap in one graduation cohort in the UK 3.5 years after graduation and finds it to be 11 %. In Sweden, the gender pay gap among all doctoral graduates was 16 % in 2004 (Amilon and Persson 2013). Both Schulze (2015) and Amilon and Persson (2013) find that the gender pay gap results from men being paid a large premium outside academia and a small premium inside academia.

4 Theoretical Framework

To derive determinants of the early career gender pay gap, I use supply and demand side explanations. Supply side explanations assume that women and men enter the labour market with different qualifications and therefore encounter different employment conditions. Human capital theory is the most common supply side explanation of the gender pay gap and will be discussed with regard to traditional gender roles. Although it may be assumed that female doctoral graduates are particularly career-oriented and therefore less affected by traditional gender roles, note that also among academics and doctoral graduates, gender roles become more traditional in the case of parenthood (Brandt 2018c; Flöther and Oberkrome 2017).

Demand side explanations focus on employers and discrimination against women in the labour market. I deploy the model of tastes for discrimination, the theory of statistical discrimination, expectation states theory, and the theory of gendered organisations.

Although supply and demand side explanations are compelling in isolation, feedback effects closely link them (Blau and Winkler 2018). If women anticipate discrimination, for example, in the form of lower returns on human capital investments, their incentive to acquire particular qualifications is lower. Thus, labour market discrimination also indirectly affects women's investments in human capital and vice versa.

4.1 Supply Side Explanations

According to *human capital theory* (Becker 1964; Mincer 1958, 1962), qualifications, productivity, and pay are linked. Human capital is a person's stock of skills and knowledge acquired through formal education and on-the-job training. Immediate investments in human capital increase future productivity and consequently remuneration. The decision to undertake a human capital investment depends on an economic analysis of the gross benefits and the (in-)direct costs of investment, which can be monetary as well as non-monetary.

Two types of human capital exist: general and (firm-)specific. General human capital consists of broad skills, which are flexibly applicable in many professions and companies. This type is not subject to rapid technological change and thus depreciates less, 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 is more productivity- and pay-enhancing than general human capital. However, specific human capital depreciates faster.

Human capital theory explains the gender pay gap with regard to *traditional gender roles*. Men's traditional gender role is the family breadwinner, whereas domestic responsibility and active parenthood are traditionally attributed to women (Crompton and Harris 2003). These traditional gender roles may lead to gender differences in educational choices and career paths that systematically bias women's opportunities in the labour market. For example, if women anticipate traditional gender roles, they may also anticipate shorter and less continuous work lives and invest in general rather than specific human capital. In addition, due to traditional gender roles, women's employment trajectories may be less continuous than men's. If women more often experience periods of unemployment or work interruptions, their productivity growth stagnates and their acquired human capital depreciates. As a result, they acquire less on-the-job training, are less productive, and lower paid. By contrast, because men fulfil their traditional gender role as the family breadwinner by taking up gainful employment, their incentive to invest in specific human capital and to gain on-the-job training may be higher.

4.2 Demand Side Explanations

Becker's (1957) theoretical *model of tastes for discrimination* explains why employers pay equally qualified women and men differently. Becker assumes that employers tend to discriminate in favour of groups or persons who are similar to them. A discriminatory employer acts 'as if he were willing to pay something, either directly or in the form of a reduced income, to be associated with some persons instead of others' (Becker 1957, p. 14). If employers have tastes for discrimination against women, they act as if associating with women entails non-monetary costs and associating with men entails non-monetary benefits. Becker formalises the individual taste for discrimination as a 'discrimination coefficient'. To discriminatory employers, the cost of employing a man is his pay minus the discrimination coefficient, but the cost of employing a woman with the same qualification is her pay plus the discrimination coefficient. As these employers compensate for higher costs of employing a woman, they will only hire a woman at lower rates of pay than a man.

According to the *theory of statistical discrimination* (Arrow 1973; Phelps 1972), employers' attitude towards women depends on their beliefs about women's average productivity. Incomplete information and uncertainty characterise hiring, promotion, and pay decisions. Because wrong decisions lead to high training and hiring costs, employers try to avoid them; however, employers can only rely on available information – such as gender – to estimate applicants' expected productivity and length of service. Statistical discrimination occurs if employers consider women, on average, to be less productive or less stable employees because of family responsibilities, pregnancy-related work interruptions, or simply because of the small number of women on which they base their estimates. Such considerations result either in not hiring women at all or in hiring them at lower rates of pay than men.

When applied to gender in the employment context, *expectation states theory* (Berger et al. 1974; Correll and Ridgeway 2003) reveals that gender ascriptions assign women a lower status in the labour market than men, thereby legitimating gender inequalities. Individuals categorise others by gender and ascribe gender status beliefs as well as performance expectations to the different gender categories. Gender status beliefs are widely shared cultural beliefs that assess one gender as more status-worthy and competent than another.

Performance expectations are gender-typical competence and behaviour ascriptions. Expectation states theory suggests that society considers women to be lower in social status and less competent than men and to be experts in domestic and nurturing tasks, whereas men are said to be, for example, experts in mechanical tasks. Because of double standards, women also have to perform better than men to be perceived as equally competent.

According to Acker's (1990) *theory of gendered organisations*, both organisations and their internal processes are structured by gender. Organisations prefer a certain ideal type of worker: the 'universal worker'. This worker is neither emotional nor sexual and does not procreate. Hence, the image of the universal worker favours men and excludes women: 'Women's bodies-female sexuality, their ability to procreate and their pregnancy, breast-feeding, and child care, menstruation, and mythic "emotionality" – are suspect, stigmatised, and used as grounds for control and exclusion' (Acker 1990, p. 152). Therefore, men have ex ante a general advantage over women in the employment context.

4.3 Determinants

Referring to the aforementioned theories, I derive determinants of the early career gender pay gap among doctoral graduates that comprise doctoral and occupational characteristics.

Doctoral subject. As already mentioned, there is a gender-typical choice of doctoral subjects, which may lead to gender-typical stocks of the different types of human capital and thereby contribute to the gender pay gap. Against the background of traditional gender roles, I expect women and men to differ in doctoral subjects with women studying more often subjects imparting general human capital (e.g., humanities, art) and men studying more often subjects imparting specific human capital (e.g., engineering, natural sciences). For example, if women anticipate less continuous work lives, they may tend to earn doctorates in subjects imparting general human capital because it depreciates less and facilitates their re-entry into the labour market after work interruptions. Because of the gender-typical choice of doctoral subjects, I expect female doctoral graduates to earn less than male doctoral graduates.

Doctoral performance. I expect gender differences in doctoral performance to contribute to the gender pay gap among doctoral graduates. While pursuing a doctoral degree, doctoral candidates acquire human capital through a variety of activities, e.g. publications and teaching. These human capital acquisitions during doctoral training may affect their later productivity and pay. However, the literature indicates that female doctoral graduates tend to have fewer publications (Jaksztat 2017; Leemann 2002; Long 1990) and lower grades than male doctoral graduates (Consortium for the National Report on Junior Scholars 2013, p. 218). There are different explanations for these gender differences: First, in line with their traditional gender role, female doctoral candidates may be more engaged in domestic and family tasks. Second, because of different skills and interests, women may set other priorities during their doctoral training, e.g., on teaching and supervising students rather than on advancing their own research (Wild and Frey 1996). Third, historically, universities are male organisations (Beaufaÿs and Krais 2005; Teelken et al. 2019). Therefore, women may have fewer role models inside academia, may be disadvantaged compared to men, and may receive less support during doctoral training. Taken together, I expect female graduates to earn less because of lower doctoral performance compared to male graduates.

Professional experience and working hours. The gender pay gap might also result from gender differences in labour market participation. The more on-the-job training a person has completed, the higher his or her productivity and pay. Because women's employment trajectories are in general said to be less continuous and shorter, female doctoral graduates may gain less professional experience, may work fewer hours, and be therefore both less productive and paid less than male doctoral graduates.

Industry. Gender-typical patterns of employment in industries might further contribute to the gender pay gap among 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. Therefore, I expect gender differences in doctoral subjects to lead to gender differences in industries that mediate the gender pay gap among doctoral graduates.

Management position. The holding of management positions might be another determinant. Overall, doctoral graduates are more likely than other educational groups to hold management positions (Consortium for the National Report on Junior Scholars 2013; Enders 2002). However, female doctoral graduates are less likely to hold management positions than male doctoral graduates (Bornmann and Enders 2004). According to expectation states theory, society assigns women a lower social status and poorer management competences, both of which result in women being less likely to be acknowledged as legitimate managers. Because of anticipated discrimination (Fisk and Overton 2019) and working conditions that are often difficult to reconcile with family (e.g., business travel, overtime), women may also aspire to management positions less often than men.

Academic employment. I expect academic employment to moderate the gender pay gap. Previous research on the gender pay gap among doctoral graduates has shown that the overall gender pay gap results from male graduates being paid a large premium outside academia (Amilon and Persson 2013; Schulze 2015). It is likely that the same holds for Germany because most academic jobs are in the public sector, where earnings are lower but also more gender-equitable due to collective agreements than in the private sector. Therefore, I expect a small gender pay gap inside academia and a large gender pay gap outside academia.

Figure 3 illustrates the theoretical model. Except for academic employment, which is expected to moderate the relationship between gender and earnings, all determinants reflect mediating effects on the gender pay gap.

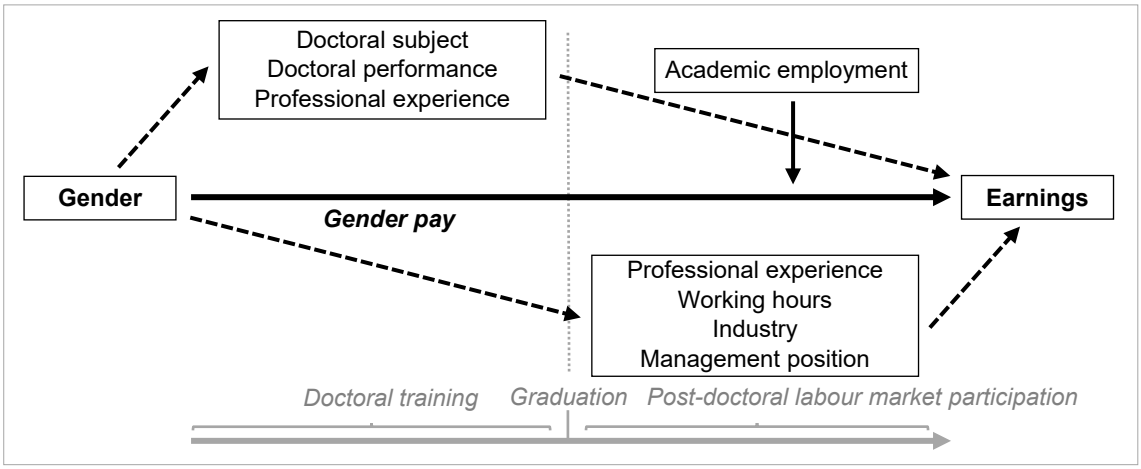

Figure 3: Theoretical model, author's elaboration

5 Data, Variables, and Methods

5.1 Data

I use the first two waves of the PhD Panel 2014[3] (Brandt et al. 2018a; 2018b), 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. The population consists of persons who earned a doctorate at a German university in the winter semester of 2013/14 or summer semester of 2014. The first wave of the survey was realised as a standardised postal survey one year after graduation, and the second wave was realised as a standardised online survey two years after graduation. I use the information of the first wave to operationalise demographics and doctoral characteristics and the information of the second wave for occupational characteristics.

The full sample consists of 3,184 graduates who participated in both waves. To achieve a sample with uniform labour market structures, sample restrictions were necessary. I excluded graduates who earned their doctorate in medicine (664)[4], were currently self-employed (61), or working abroad (116).[5]

Little's test (1988) indicated that missing values were not missing completely at random.[6] Therefore, a complete case analysis was not appropriate, and I multiply imputed the missing values instead, which only requires the missingness mechanism of missing at random. I applied multiple imputation by chained equations with 15 imputations and 70 iterations to replace missing values in all relevant variables; see Table 1 for details on the imputation model and the proportion of missing data for each variable. According to von

[3] 10.21249/DZHW:phd2014:2.0.0

[4] I excluded medical doctorates because of their aforementioned special characteristics.

[5] For practical reasons, the exclusion of additional subgroups was necessary: graduates whose subject had been previously anonymised by the DZHW (23), graduates whose formal type of doctoral training (116) or final grade (19) were unclear, and graduates from two industries with particularly low case numbers (food and hospitality services: 9; other: 16).

[6] The test indicated a x^2 distance of 3575.48 with 2,192 degrees of freedom and a p-value of .000.

Hippel (2007), I excluded cases with a missing value in the dependent variable (349) after imputation. Thus, the final analysis sample consisted of 1,811 cases.

Table 1: Overview of the imputation model

Variables	$N_{complete}$	$N_{imputed}$	$\%_{missing}$	Estimator
Gender	2,153	7	.32	Logit (augmented)
Teaching experience	2,139	21	.97	Logit (augmented)
International experience	2,121	39	1.81	Logit (augmented)
Management position	1,608	552	25.56	Logit (augmented)
Academic employment	1,608	552	25.56	Logit (augmented)
Parenthood	2,030	130	6.02	Logit (augmented)
Marriage	2,034	126	5.83	Logit (augmented)
Company size	1,890	270	12.50	Logit (augmented)
Region of employment	1,893	267	12.36	Logit (augmented)
Doctoral subject	2,147	13	.60	Multinomial logit (augmented)
Formal type of doctoral training	2,131	29	1.34	Multinomial logit (augmented)
Final grade of doctorate	2,158	2	.09	Multinomial logit (augmented)
Industry	1,842	318	14.72	Multinomial logit (augmented)
Gross monthly earnings (log.)	1,811	349	16.16	Propensity mean matching[1]
Number of publications	2,131	29	1.34	Propensity mean matching[1]
Number of talks	1,978	182	8.43	Propensity mean matching[1]
Duration of doctoral training	2,133	27	1.25	Propensity mean matching[1]
Working hours	2,122	38	1.76	Propensity mean matching[1]
Professional experience	2,065	95	4.40	Propensity mean matching[1]
Age	2,156	4	.19	Propensity mean matching[1]

Data source: DZHW PhD Panel 2014, 1st and 2nd wave, [1] propensity mean matching with five nearest neighbours, author's calculations

5.2 Variables

Table 2 gives an overview of the variables and their distributions. The dependent variable is gross monthly earnings two years after graduation, including the monthly share of annual salary bonuses. The resulting earnings were right-skewed; therefore, I use the natural logarithm of gross monthly earnings in the regression analyses. Gender is the main independent variable and is coded 1 for women and 0 for men.

Doctoral subject falls into five subject groups according to the German Federal Statistical Office (2019), with one exception. Because of low case numbers (37), I added arts to humanities. Several indicators show the doctoral performance: the *number of publications* and *given talks*, both standardised by subject group; *teaching experience*; *international experience* in the form of a research stay abroad; the *final grade of the doctorate*; and its *duration*, which is also standardised by subject group. Professional experience during doctoral training is shown through a proxy, namely, five *formal types of doctoral training* referring to the main source of funding, which distinguish between three types of employment (university, non-university research institution, outside academia), doctoral grants, and private funding. Professional experience after graduation is shown through the cumulative *length of employment* in months since graduation. The other occupational characteristics are five *industries* according to the 2010 German classification of occupations (Federal Employment Agency 2011), the holding of a *management position*, and *working hours* per week. I use a *product-term including gender and academic employment* to test, whether academic employment moderates the gender pay gap. The product-term is coded 1 for women who are employed inside academia and 0 for anyone else. My controls are *age*, *parenthood*, *marriage*, *company size* ('big' ≥ 250 employees vs. 'small/medium-sized' < 250 employees), and the *region of employment* (West vs. East Germany).

Table 2 indicates that most of the independent variables and controls show statistically significant differences by gender, which indicates a potential for explaining the gender pay gap.

Table 2: Description of variables

	Proportional and mean values (standard deviation in parentheses)			
	Total	*Female*	*Male*	*Significance*
Gender: female (ref. male)	.47			
Gross monthly earnings (in €)	6023.65	4965.76	6957.28	***
	(9742.71)	(8249.99)	(10810.08)	
Gross monthly earnings (log.)	8.38	8.21	8.52	***
	(.66)	(.64)	(.64)	
Doctoral subject				
- Humanities, art	.22	.30	.15	***
- Legal, economic, social sciences	.18	.14	.21	***
- Mathematics, natural sciences	.43	.41	.44	n.s.
- Agriculture, forestry, nutrition sciences, veterinary medicine	.07	.12	.03	***
- Engineering	.11	.04	.17	***
Formal type of doctoral training				
- Employment at a university	.55	.51	.58	**
- Employment at a non-university research institution	.10	.10	.11	n.s.
- Employment outside academia	.14	.14	.14	**
- Doctoral grant	.17	.20	.14	n.s.
- Private financing	.04	.05	.02	**
Number of publications (stand.)	.03	–.13	.17	***
	(1.03)	(.75)	(1.21)	
Number of talks (stand.)	.00	–.14	.12	***
	(1.02)	(.88)	(1.12)	
Teaching experience: yes (ref. no)	.61	.58	.64	**
International experience: yes (ref. no)	.18	.18	.18	n.s.
Final grade of doctorate				
- Summa cum laude	.26	.23	.30	**
- Magna cum laude	.60	.63	.58	*
- Cum laude or less	.14	.15	.13	n.s.
Duration of doctoral training (in years, stand.)	.03	.07	.00	n.s.
	(1.10)	(1.25)	(.94)	
Professional experience after graduation (in months)	22.00	21.06	22.84	***
	(5.89)	(6.33)	(5.33)	
Industry				
- Manufacturing	.15	.09	.20	***
- Health	.11	.19	.05	***
- Social, cultural services	.28	.33	.24	***
- Commercial, business-related services	.25	.23	.27	n.s.
- IT, natural scientific services	.20	.16	.24	***
Management position: yes (ref. no)	.23	.21	.24	n.s.
Working hours (per week)	40.29	37.87	42.43	***
	(11.12)	(11.75)	(10.08)	
Academic employment: yes (ref. no)	.49	.50	.49	n.s.
Age (in years)	34.75	34.39	35.06	**
	(4.67)	(4.65)	(4.67)	
Parenthood: yes (ref. no)	.36	.32	.40	**
Marriage: yes (ref. no)	.45	.40	.50	***
Company size: big (ref. small/medium)	.64	.58	.70	***
Region of employment: West Germany (ref. East)	.83	.81	.85	*

Significance: * $p < .05$, ** $p < .01$, *** $p < .001$; data source: DZHW PhD Panel 2014, 1st and 2nd wave, multiply imputed data, the results reported for m = 1, N = 1,745, author's calculations

5.3 Analytical Strategy

To answer the research question, I examine the determinants of the gender pay gap in three steps. First, I estimate stepwise log-linear regression models on the logarithmic gross monthly earnings to test whether the determinants mediate the early career gender pay gap (see Table 3). 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 showing the size of the unadjusted gender pay gap. In M2 through M9, I add the controls and mediators 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 and Innes 1989; Wooldridge 2013, pp. 191–194).

Second, I examine the expected moderating effect of academic employment on the gender pay gap in two additional regression models and graphically (see Figure 4). In M10, I integrate the main effect of academic employment. In M11, I add the product-term for gender and academic employment. Because of the product-term, the gender coefficient in M11 is no longer comparable to the main effects 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.

Finally, by using the full model with main effects only (M10), I run an Oaxaca-Blinder decomposition (Blinder 1973; Oaxaca 1973) of the gender pay gap to indicate the exact explanatory contribution of all predictors to the gender pay gap and of each predictor separately (see Table 4).

6 Results

Table 3 provides the regression results on the logarithmic gross monthly earnings, which allows me to test the expected determinants. M1 demonstrates that there is an unadjusted gender pay gap of approximately 27.2 % ($\beta_{M1} = -.318$) among doctoral graduates in Germany two years after graduation, which is statistically highly significant ($p_{M1} = .000$). When introducing the control variables in M2, the gender pay gap decreases to 24.6 % ($\beta_{M2} = -.283$), with company size ($\beta_{M2} = .205$) and region of employment ($\beta_{M2} = .173$) being statistically significantly associated with earnings.

From M3 through M9, the addition of the mediators continuously reduces the gender pay gap. In M3, I add doctoral subjects. As expected, I find that women and men earn doctorates in different subjects and that earnings differ by doctoral subjects. Doctoral graduates who studied humanities or art earn less than graduates in all other subject groups. Doctoral subjects explain a considerable part of the gender pay gap because it narrows to 17.3 % ($\beta_{M3} = -.190$) once the subjects are taken into account.

I expected that women and men would fund their doctoral training through different formal types, thereby gaining different amounts of professional experience during their doctoral training and being paid differently after graduation. However, the gender pay gap barely changes from M3 to M4. Compared to the mean earnings of doctoral graduates with employment at a university, only those of doctoral graduates who have been employed outside academia are statistically significantly higher ($\beta_{M4} = .236$).

In M5, the gender pay gap decreases further to 16.1 % ($\beta_{M5} = -.176$) although teaching experience is the only doctoral performance indicator that is statistically significantly associated with earnings ($\beta_{M5} = .070$). By adding professional experience after graduation in M6, I find the gender pay gap decreases to 14.3 % ($\beta_{M6} = -.154$). As expected, there is a positive relationship between professional experience and earnings ($\beta_{M6} = .014$). Female graduates earn less professional experience after graduation than male graduates and therefore earn less.

Table 3: OLS regression on the logarithmic gross monthly earnings

	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11
Gender: female (ref. male)	–.318*** (.030)	–.283*** (.030)	–.190*** (.031)	–.187*** (.030)	–.176*** (.031)	–.154*** (.031)	–.139*** (.031)	–.139*** (.031)	–.075* (.030)	–.074* (.030)	–.126** (.043)
Doctoral subject (ref. humanities, art)											
- Legal, economic, social sciences			.329*** (.047)	.295*** (.047)	.302*** (.047)	.289*** (.047)	.222*** (.050)	.220*** (.050)	.153** (.048)	.153** (.048)	.153** (.048)
- Mathematics, natural sciences			.302*** (.040)	.305*** (.040)	.323*** (.041)	.333*** (.041)	.222*** (.046)	.222*** (.046)	.161*** (.044)	.165*** (.044)	.166*** (.044)
- Agriculture, forestry, nutrition sciences, veterinary medicine			.038 (.064)	.006 (.064)	.025 (.065)	.011 (.065)	–.089 (.070)	–.090 (.070)	–.154* (.067)	–.152* (.067)	–.149* (.067)
- Engineering			.502*** (.056)	.489*** (.056)	.500*** (.057)	.491*** (.056)	.352*** (.063)	.350*** (.063)	.285*** (.060)	.282*** (.060)	.277*** (.060)
Formal type of doctoral training (ref. employment at a university)											
- Employment at a non-univ. research institution				.033 (.049)	.066 (.051)	.065 (.051)	.060 (.051)	.058 (.051)	.078 (.048)	.086 (.048)	.086 (.048)
- Employment outside academia				.236*** (.048)	.295*** (.052)	.290*** (.051)	.276*** (.051)	.271*** (.051)	.247*** (.049)	.218*** (.050)	.218*** (.050)
- Doctoral grant				–.098* (.040)	–.079 (.041)	–.075 (.041)	–.077 (.041)	–.079 (.041)	–.060 (.039)	–.058 (.039)	–.058 (.039)
- Private financing				–.002 (.079)	.056 (.081)	.048 (.080)	.038 (.080)	.041 (.080)	.060 (.076)	.037 (.077)	.037 (.077)
Number of publications (z-stand.)					.005 (.017)	.004 (.017)	.003 (.017)	.002 (.017)	.000 (.016)	.002 (.016)	.002 (.016)
Number of talks (z-stand.)					.010 (.018)	.004 (.017)	.009 (.017)	.010 (.017)	.011 (.016)	.013 (.016)	.013 (.016)
Teaching experience: yes (ref. no)					.070* (.034)	.059 (.033)	.066* (.033)	.066* (.033)	.073* (.032)	.070* (.032)	.069* (.032)
International experience: yes (ref. no)					–.014 (.038)	–.002 (.038)	.011 (.038)	.010 (.038)	–.002 (.036)	.004 (.036)	.005 (.036)
Final grade of doctorate (ref. summa cum laude)											
- Magna cum laude					–.034 (.035)	–.043 (.035)	–.060 (.035)	–.058 (.035)	–.057 (.033)	–.062 (.033)	–.064 (.033)
- Cum laude or less					–.062 (.051)	–.055 (.051)	–.077 (.051)	–.078 (.051)	–.059 (.048)	–.071 (.048)	–.070 (.048)
Duration of doctoral training (in years, z-stand.)					–.022 (.013)	–.019 (.013)	–.021 (.013)	–.021 (.013)	–.018 (.012)	–.017 (.012)	–.017 (.012)
Professional experience after graduation (in months)						.014*** (.003)	.014*** (.002)	.014*** (.002)	.011*** (.002)	.011*** (.002)	.011*** (.002)

Significance: * p < .05, ** p < .01, *** p < .001; standard error in parentheses; data source: DZHW PhD Panel 2014, 1st and 2nd wave, multiply imputed data, author's calculations

Table 3 (continued)

	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11
Industry (ref. social, cultural services)											
- Manufacturing							.254*** (.055)	.256*** (.055)	.273*** (.053)	.233*** (.055)	.235*** (.055)
- Health							.169** (.058)	.173** (.058)	.168** (.056)	.133* (.057)	.142* (.057)
- Commercial, business-related services							.189*** (.043)	.186*** (.043)	.175*** (.041)	.128** (.045)	.129** (.045)
- IT, natural scientific services							.229*** (.050)	.232*** (.050)	.226*** (.047)	.208*** (.048)	.208*** (.048)
Management position: yes (ref. no)								.045 (.041)	–.010 (.040)	–.009 (.040)	–.007 (.040)
Working hours (per week)									.017*** (.001)	.017*** (.001)	.017*** (.001)
Academic employment: yes (ref. no)										–.094** (.035)	–.140** (.046)
Female*academic employment											.101 (.060)
Age (in years)		.003 (.003)	.008* (.003)	.001 (.003)	.002 (.004)	–.001 (.004)	.002 (.004)	.001 (.004)	.004 (.003)	.004 (.003)	.004 (.003)
Parenthood: yes (ref. no)		–.081* (.038)	–.089* (.037)	–.096** (.037)	–.095* (.037)	–.066 (.037)	–.064 (.037)	–.062 (.037)	–.014 (.036)	–.009 (.036)	–.011 (.036)
Marriage: yes (ref. no)		.060 (.036)	.062 (.035)	.067 (.034)	.063 (.035)	.056 (.034)	.051 (.034)	.048 (.034)	.047 (.033)	.039 (.033)	.037 (.033)
Company size: big (ref. small/medium)		.205*** (.031)	.163*** (.031)	.173*** (.031)	.172*** (.031)	.168*** (.031)	.165*** (.031)	.165*** (.031)	.143*** (.029)	.146*** (.029)	.144*** (.029)
Region of employment: West Germany (ref. East)		.173*** (.042)	.152*** (.041)	.132** (.041)	.127** (.041)	.123** (.041)	.123** (.041)	.123** (.041)	.123** (.039)	.120** (.039)	.121** (.039)
Constant	8.526*** (.021)	8.132*** (.124)	7.718*** (.133)	7.950*** (.138)	7.897*** (.142)	7.668*** (.147)	7.522*** (.148)	7.528*** (.148)	6.846*** (.150)	6.920*** (.152)	6.942*** (.153)
Adjusted R^2	.058	.091	.142	.158	.160	.174	.188	.188	.262	.265	.266
N	1,811	1,811	1,811	1,811	1,811	1,811	1,811	1,811	1,811	1,811	1,811

Significance: * p < .05, ** p < .01, *** p < .001; standard error in parentheses; data source: DZHW PhD Panel 2014, 1st and 2nd wave, multiply imputed data, author's calculations

In M7, industries are taken into account; consequently, the gender pay gap decreases to 13.0 % (β_{M7} = –.139). The coefficient of each industry is positive and statistically significant; therefore, earnings are higher in each industry than in social and cultural services.

M8 introduces management positions, which are not statistically significantly associated with earnings (β_{M8} = .045) and do not contribute to explaining the gender pay gap.

I expected that women and men would be paid differently because of gender differences in working hours. In M9, I find that the gender pay gap decreases to 7.2 % (β_{M9} = –.075). Women work fewer hours and therefore earn less.

As expected, I find in M10 that academic employment does not mediate the gender pay gap. However, in M11, I find that academic employment does moderate the gender pay gap among doctoral graduates, but the coefficient of the product-term is only at the 10 % level statistically significantly different from zero

(β_{M11} = .101; p_{M11} = .093). Therefore, the effect of gender on earnings tends to differ inside and outside academia. The gender coefficient in M11 indicates a gender pay gap of 11.8 % (β_{M11} = –.126) outside academia when controlling for the other predictors.

Figure 4 provides further insight on the moderating effect of academic employment. It shows the predicted values of the logarithmic gross monthly earnings by gender and academic employment derived from M11, i.e., when controlling for the other predictors. Using the 95 % confidence intervals, the figure reveals that male doctoral graduates earn statistically significantly more than female doctoral graduates. Inside academia, earnings do not statistically significantly differ.

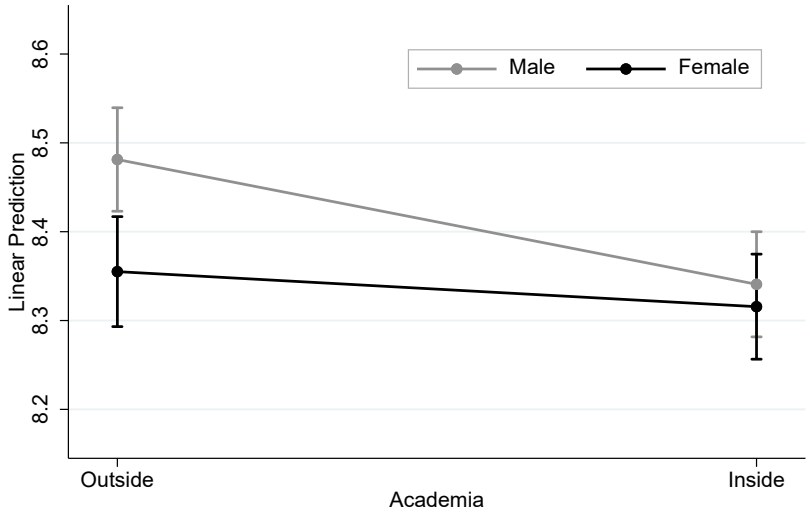

Figure 4: Interaction effect of gender and academic employment on the logarithmic gross monthly earnings in M11 (predicted values and 95 % confidence interval); data source: DZHW PhD Panel 2014, 1st and 2nd wave, multiply imputed data; author's calculations

Table 4 shows the results of the Oaxaca-Blinder decomposition of the full model with main effects only (M10). The results indicate the exact explanatory contribution of each predictor to the gender pay gap. In total, the determinants explain 76.88 % of the gender pay gap; 23.13 % cannot be explained. The most influential predictor is working hours, which explain 24.50 % of the gender pay gap. Because female graduates work fewer hours than male graduates, they earn less. The second most important predictor is doctoral subject, which explains 21.32 % of the gender pay gap. Some of the other predictors also contribute statistically significantly to explaining the gender pay gap: industry (8.75 %), professional experience gained after graduation (6.14 %), and company size (5.94 %).

Table 4: Oaxaca-Blinder decomposition of M10

	Coefficient	Standard error	%
Estimated logarithmic gross monthly earnings of male doctoral graduates	8.526***	.021	
Estimated logarithmic gross monthly earnings of female doctoral graduates	8.208***	.022	
Gender difference in estimated logarithmic gross monthly earnings	.318***	.030	100.000
Thereof unexplained	.074*	.030	23.125
Thereof explained	.245***	.020	76.875
- Doctoral subject	.068***	.011	21.322
- Formal type of doctoral training	.005	.005	1.575
- Number of publications	.001	.004	.192
- Number of talks	.004	.004	1.126
- Teaching experience	.005	.003	1.421
- International experience	.000	.000	.005
- Final grade of doctorate	.004	.003	1.397
- Duration of doctoral training	.001	.001	.389
- Professional experience after graduation	.020***	.005	6.140
- Industry	.028**	.010	8.747
- Management position	–.000	.002	–.096
- Working hours	.078***	.012	24.503
- Academic employment	.003	.003	.947
- Age	.003	.003	.816
- Parenthood	–.001	.003	–.214
- Marriage	.004	.003	1.210
- Company size	.019***	.005	5.938
- Region of employment	.005	.003	1.459

Significance: * p < .05, ** p < .01, *** p < .001; standard errors in parentheses; data source: DZHW PhD Panel 2014, 1st and 2nd wave, multiply imputed data, author's calculations

7 Conclusions

This paper investigated the determinants of the early career gender pay gap in one doctoral graduation cohort in Germany and whether it is due to gender differences in doctoral and occupational characteristics. I found that female doctoral graduates earn 27.2 % less than male doctoral graduates in Germany two years after graduation. This early career gender pay gap is substantive and likely to reduce the lifetime earnings of female doctoral graduates. The size of the gender pay gap measured in terms of gross monthly earnings is a little higher than in studies with data on gross hourly wages, other countries, or later career stages (Amilon and Persson 2013; Bornmann and Enders 2004; Goldan 2019; Schulze 2015).

Another result is that gender differences in doctoral and occupational characteristics do mediate the gender pay gap among doctoral graduates. Overall, the determinants explained three quarters (76.88 %) of the gender pay gap. As expected and mostly consistent with previous research, working hours, doctoral subject, industry, and professional experience gained after graduation contributed to explaining the gender pay gap. Against expectations, I found no mediating 'effect' of the formal types of doctoral training, doctoral performance, and management position. The latter finding conflicts with Goldan (2019) who did find that female doctoral graduates hold management positions less often than male doctoral graduates and therefore earn less. However, this paper's finding that management position had no mediating effect might be due to examining the early career gender pay gap. Two years after graduation, only few doctoral graduates hold a management position. Hence, I suppose that the holding of management positions will only become relevant at later career stages.

Although the considered predictors largely explained the gender pay gap, this does not necessarily mean that women's lower earnings are self-inflicted and that women simply could make different decisions

throughout their educational and occupational trajectories. Given the theoretical framework, the findings instead indicate that the gender pay gap might be at least partly driven by anticipated or de facto discrimination against women. Most likely, the gender pay gap results from mutually influencing effects on the supply and demand sides and feedback between them. Future research should examine more closely this mixture of intertwined effects.

Conforming with Amilon and Persson (2013) and Schulze (2015), I found that academic employment tends to moderate the gender pay gap among doctoral graduates in Germany. The overall gender pay gap was driven by male graduates being paid a premium outside academia. By contrast, lower earnings did not affect female graduates who stayed in academia after graduation, at least two years after graduation. In the German case, this finding can be traced to the public sector setting of academic jobs, where pay is more gender-equitable due to collective agreements. 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 doctoral graduates' outcomes and employment trajectories.

The present study has some limitations, some of which offer directions for further research. First, this paper refers to earnings at an early career stage. Due to the publication of the subsequent survey waves of the PhD panel 2014, future research will be able to study the gender pay gap up to five years after graduation. Second, for reasons of data availability, the analyses were restricted to one graduation cohort within one country. Despite these shortcomings, the paper's findings match those of previous studies of the gender pay gap among doctoral graduates and thus seem quite reliable.

To conclude, this paper offered new insights on the determinants of the early career gender pay gap among doctoral graduates in Germany. Thereby, it enhances research on gender inequalities in post-doctoral careers and contributes to the existing literature on the gender pay gap among doctoral graduates.

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