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The role of sex segregation in the gender wage gap among university graduates in Germany

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Abstract

In this paper we examine the gender wage gap among university graduates in Germany from 1997 to 2013 based on the DZHW (the German Centre for Higher Education Research and Science Studies) Absolventenpanel. We focus in particular on the effect of female presence in a subject or occupation on wage inequality. Earlier research has shown not only that female-dominated university subjects or occupations pay less, but also that men face a higher wage penalty than women when they graduated in a female-dominated subject and experience a lower penalty for working in a female-dominated occupation. For the five waves considered, we confirm the very strong negative association between female presence in a subject or occupation and wages. However, no consistent pattern emerges with regard to whether men's or women's wages suffer larger penalties. There is also no time trend observable with regard to the wage penalty that is associated with female-dominated fields. We further show that significant gender wage gaps exist within fields of studies, especially in male-dominated fields like engineering and natural science.

Introduction

In industrialized countries, women's economic situation in the labor market has substantially changed over the last half century (see, e.g., Blau/Kahn 2017). Despite the persistence of social gender roles that assign men and women not only different characteristics but also obligations (women still bear the main responsibility for household chores and childcare), women have significantly changed their work behavior and, e.g., strongly increased their labor market participation. Women have also not only caught up with men in terms of education, they are now even more likely to have a university degree than men. Less progress has been made with respect to sex segregation. While women have entered many occupational fields as well as fields of study, segregation persists until today. This is the case despite political efforts to increase the number of women in male-dominated fields, in particular STEM-fields, that are also motivated by a shortage of workers in these domains. In this paper, we focus on Germany, a country where the segregation into fields of study is exceptionally high (Charles/Bradley 2009). Germany is also one of the EU-countries with strong occupational segregation (Sparreboom 2014). Women's low numbers in male-dominated fields are of concern because earnings tend to be higher there (see, e.g., Levanon et al. 2009; Harris 2021). Thus, occupational segregation is an important contributor to the gender wage gap, which is particular large in Germany. For example, in 2019, with a wage differential of 19.2%, Germany was the EU-country with the fourth highest gender pay gap after Estonia, Latvia and Austria (Eurostat 2021).

In this paper we examine data from the German Centre for Higher Education Research and Science Studies (DZHW, formerly HIS) for the graduate cohorts 1997-2013 to evaluate the wage effects of female-dominated fields. There are two main reasons why it is of particular interest to examine the gender wage gap among university graduates. First, at the stage of labor market entry, university graduates are very homogeneous with respect to their human capital.[1] Typically, these young adults have no family obligations and, thus, had no career interruptions yet; they have little job experience and, thus, do not differ much with respect to their on-the-job training. Because they only enter the labor market, their earnings are not affected by previous promotion decisions or wage negotiation outcomes. Consequently, when examining this group, we have to worry less about differences in characteristics that may be observed by employers and determine wages while they remain unobserved by the researcher. Second, apart from this methodological reason, entry wage

[1] As Weichselbaumer and Winter-Ebmer (2004) have shown in their meta-analysis, studies that focus on a particularly homogeneous group of workers, like new entrants to the labor market, yield significantly lower gender wage differentials.

differences are also economically important because first jobs set the tone for future careers and are therefore consequential for future earnings. This is not only because lower wages typically come with lower raises. Also, pay increases are added to the initial base wage. Hence, starting one's work career with a discriminatory low wage can accumulate to a marked income gap over one's lifetime. Finally, outside offers from other firms are also often based on previous earnings, additionally amplifying the importance of entry wages (Graham et al. 2000: 11).

Our paper is inspired by Leuze and Strauß (2009) who focused on the 1997 graduate cohort in the DZHW data to examine the effect of female-dominated fields of study as well as occupations on the gender wage gap. Apart from a strong negative association between female-dominated subjects/occupations and hourly wages, the authors found their hypotheses confirmed that, first, men experience a stronger wage penalty than women when graduating in a female-dominated field of study, and, second, women are more penalized for entering female-dominated professions than men.

In this paper we revisit these issues also for later cohorts. We do so for multiple reasons: First, over the last decades attempts have been made to increase the number of women in particular in STEM-fields, which, if successful, may have led to some desegregation and a decrease in the gender wage gap among university graduates. Second, attempts have been made to revalue the work primarily done by women and recent literature suggests to some success. For example, using US census data, Busch (2018) found the devaluation of female-dominated occupations to slowly decline from 1960 to 2010. Third, Francesconi and Parey (2018) have shown that in the DZHW data there is some fluctuation concerning the gender wage gap among university graduates over the years that does not quite match the relative stability, and periodically moderate decline, of the overall gender wage gap in Germany since the late 1990s (Gallego Granados/Wrohlich 2018). For this reason, results based on one particular cohort of graduates may not hold more generally and, thus, lead to erroneous conclusions.

In our study that is based on multiple cohorts of graduates represented in the DZHW data, we confirm the very strong negative association between female presence in a subject or occupation and wages. However, no consistent pattern emerges with regard to whether men's or women's wages suffer larger penalties. There is also no time trend discernable with respect to the wage penalty for female-dominated fields. We further show that significant wage gaps exist within fields of study, especially in some male-dominated fields like engineering and natural science.

Our paper is structured as follows: In the next section, we review the literature on the gender wage gap among university graduates. We then give an overview over theories that have been used to explain why men and women choose different fields, why female-dominated occupations pay low wages, and why pay penalties may differ for men and women. We also refer to some related empirical literature. Next, we describe our data, also with respect to female shares within fields of study and occupations over time. After a short Methods section, we present our results. The final section concludes.

Gender gaps among university graduates

In recent years, the potential advantages of examining gender wage gaps among graduates at the start of their careers motivated several studies. Only few studies found similar wages upon graduation that drifted apart over the years to come (for example, Albrecht et al. (2018) and Bertrand et al. (2010) for professionals with a business (or economics) degree in Sweden and the USA). Most studies identified gender wage gaps already upon labor market entry, for the U.S. (e.g., Graham et al. 2000, McDonald/Thornton 2008) as well as for Germany (Behr/Theune 2018; Bredtmann/Otten 2014; Francesconi/Parey 2018; Leuze/Strauß 2009; Reimer/Schröder 2006). For example, Reimer and Schröder (2006) showed that within the particularly homogenous group of social science graduates from just one German university, females earned 5% less at their first job – a number that actually increased to 7% once controlling for human capital characteristics. Bredtmann and Otten (2014) examined business and economics graduates from one other university. From an approx. 8% wage differential, about 2 percentage points could be explained by differences in endowments. Using data from the nationwide 2001 DZHW graduate panel, Behr and Theune (2018) found that upon labor market entry, men earn higher wages at all percentiles of the wage distribution. Concerning other labor market outcomes than wages, Wieschke (2008) showed for the German state of Bavaria that female university graduates enter the labor market at less favorable terms (e.g., they are less likely to hold a permanent contract or an executive position at their first job), so that their job satisfaction is lower. This explains why female graduates change their job more frequently.

The importance of subject of degree on the gender wage differential has been emphasized by various studies (e.g., McDonald/Thornton 2008; Graham et al. 2000; Chevalier 2007). For example, Sánchez-Mangas and Sánchez-Marcos (2021) examined first job wages for college graduates in 11 European countries and found that the gender wage gap strongly differs between fields, with subjects from STEM and Health yielding substantial

unexplained wage penalties for women. Studies did not only look at gender wage gaps in different fields, but also sought to explain to what degree subject choice could explain gender wage gaps. For instance, Machin and Puhani (2003) found for the United Kingdom and Germany that subject choice makes a significant part (8-20%) of the gender wage gap (looking at people at different stages of their career). Focusing at first jobs only, Braakmann (2013) identified that field of study even explained up to 70% of the gender wage gap of German university graduates from the cohort of 1997.[2]

To the best of our knowledge, Francesconi and Parey (2018) are the only authors who previously made use of the entire set of student cohorts who have been surveyed by the DZHW in Germany from 1989–2009.[3] They estimated various gender gaps among recent university graduates and found that, amongst others, women started their studies with somewhat better school grades, but finished with slightly poorer grades than men. This may be due to a larger number of university dropouts among men. With regards to income, the authors found an average earnings penalty for women of 29 log points, with the field of study being the most important factor explaining this gap.

In this paper we revisit the findings from Leuze and Strauß (2009), who used the DZHW data on the 1997 graduate cohort to examine the effect of female-dominated fields of study as well as occupations on the gender wage gap. They found a negative association between female-dominated majors/occupations and hourly wages, with a male advantage among individuals who graduated in a female-dominated major, and a female advantage among individuals working in female-dominated occupations. In this paper, we examine for a series of graduate cohorts whether these findings hold more generally.

Theoretical and empirical background on sex segregation and pay

Segregation into male- and female-dominated fields

Numerous reasons have been suggested to explain why people segregate into different fields according to their sex. One of the oldest explanations has been proposed in the context of human capital theory. When women interrupt their careers for family reasons and thus spend less time in the labor market than men, this affects their human capital decisions, Mincer and Polacheck (1978) famously argued. In particular, the expectation of career interruptions may induce women to choose occupations, in which the depreciation of human capital is low

[2] Also, for Germans who did not study but finished their vocational training, their field of training matters greatly for the gender wage gap (of which it explains 60-68% according to Braakmann (2010)).
[3] We were able to also include the cohort of 2013 that was recently released.

(Polachek 1981). Evidence concerning different depreciation rates is mixed. For example, England (1982) found that the depreciation rates did not differ between male- and female-dominated occupations; also, women with more years out of the labor force were not more likely working in female-dominated occupations. Some more recent literature (Görlich/Grip 2008, Li 2013) argued to the contrary. For example, Görlich and Grip (2008) found that in Germany the short-run depreciation rates are lower in occupations with a high female share, at least in high-skilled occupations. Of course, given that women spend much more time in the labor market these days than in the second half of the 20th century, considerations as those brought forward by Mincer and Polacheck (1978) as well as Polachek (1981) may be less relevant today.

Also other characteristics than human capital depreciation rates may make particular occupations more attractive for women than for men. For example, women may value occupations that allow for more flexible work schedules, making it easier to balance work and household chores (e.g., Bertrand 2018). It is also possible that women prefer female-dominated fields as these come with a lower risk of sexual harassment (Folke/Rickne forthcoming). Sociologists have drawn on gender role theory to explain why men and women segregate into different fields. Even today, gender norms associate women and femininity "with care, service, expressivity, empathy, and nurturing, and masculinity with instrumentality, rationality, impersonality, physical strength, and technical sophistication" (Snyder/Green 2008: 296). Because occupational fields (or fields of study, that is) get sex-typed just like individuals, and the presumed characteristics of the "average" job holder are often considered job requirements (Clarke 2020), men are frequently perceived to better fit the requirements of male-dominated jobs, while women are believed to better suit into female-dominated occupations. This mechanism has been described by the "lack of fit"-model (e.g., Heilman/Caleo 2018). That employers have job-specific preferences concerning the gender of their staff has also been illustrated in experiments that have found discrimination against male applicants in female-dominated jobs and discrimination against women in (some) male-dominated occupations (Yavorsky 2019; Weichselbaumer 2004). Such discrimination is particularly problematic for women, because male-dominated jobs tend to pay more than those dominated by women. Possible reasons for this (e.g., compensating differentials, occupational crowding, and the devaluation of women's work) are discussed in the following.

Low pay in female-dominated fields

Compensating differentials (Rosen 1986) may cause lower wages in traditionally female occupations, if these offer more non-monetary amenities. In this case job characteristics differ between male- and female-dominated fields (usually unobserved in the data) and drive the wage gap. For example, women may not only gravitate towards jobs with more flexible hours to reconcile work with care duties, they may also be more willing than men to sacrifice pay for this job characteristic (Wiswall and Zafar 2018). As Goldin (2014) famously argued, male-dominated fields often require excessive work hours which are highly rewarded but are difficult to reconcile with household chores.

Also gender norms may drive a wage gap between occupations. For example, women tend to cluster in fewer fields of work (e.g., office work, sales, health, education), possibly because they are socially viewed as suitable for them. However, if there is a high labor supply because a large fraction of women flocks into these fields, wages go down due to crowding (Bergmann 1974). But gender norms do not only encourage employment in a gender congruent field, they also ascribe men the role of the breadwinner within the (heterosexual) household. As women are not seen as the household's main income provider, they may be able to choose jobs, where compensation includes more social/cultural (intrinsic) than economic (extrinsic) rewards (Ochsenfeld 2014). If men prefer extrinsic rewards and, thus, choose higher paying jobs (e.g., Zafar 2013), this may also explain the wage differential between male- and female-dominated occupations. In a recent study for Austria, however, Bacher et al. (2022) found that while women have stronger preferences for intrinsic rewards, this difference could not explain the gender wage gap. Because a preference for intrinsic work value actually increased earnings, controlling for this preference widened the gender wage gap.

One other explanation for why individuals in female-dominated fields receive lower wages has been proposed by "devaluation theory" (e.g., England et al. 1994, England et al. 2007). "Devaluation theory" states that society values work which is done by women less than work that is done by men. In other words, society "devaluates" work which is primarily done by women. This cultural bias occurs because women are considered to be less competent (Levanon et al. 2009: 868) and hold a lower status than men in society (Correll/Ridgeway 2003, Ridgeway 2011). As a result, occupations in which predominately women are employed are considered to require less competence and are regarded as "less worthy". They also pay lower wages – even if they require the same skills and effort of labor. For this

reasons, advocates of devaluation theory call for comparable worth policies with the goal to secure equal payment for jobs that involve equal skills and effort (England 1992).

A couple of studies have examined whether the feminization of an occupation leads to lower wages over time as devaluation theory would predict. For example, Levanon et al. (2009) examined U.S. census data from 1950–2000. Using a fixed effects model with lagged independent variables, the authors found that an increased share of women reduced the wages within an occupation.[4] More recently, using an instrumental variables approach, Harris (2022) illustrated for the U.S. that if the female share within an occupation rose by 10 percent, the wages for women in this profession fell by 7 percent in the following year, and for men by 8 percent. Over a 10 years perspective, however, the gender difference became more pronounced as wages dropped by 9 percent for men and 14 percent for women. These studies provide strong support for the devaluation theory.

Further studies find a negative effect of female shares on rewards without establishing a causal relationship between feminization of occupations and lower wages. These papers, which differ with respect to their methodology and available data, have been conducted for various countries; for example, for the US (England et al. 2007, Busch 2018, Cohen/Huffman 2003), Britain (Murphy/Oesch 2016), Germany (Murphy/Oesch 2016, Hausmann et al. 2014, Leuze/Strauß 2014) and Switzerland (Murphy/Oesch 2016). Our paper belongs to this genre of studies, as we examine the relationship between the share of women in a field and wages for German graduates without focusing on the causal link in this correlation. Furthermore, we are interested whether men and women are punished equally in female-dominated fields.

Wage penalties for men and women in female-dominated fields

While wages are generally low in female-dominated fields, men and women may not be penalized *equally* for entering these (see Leuze/Strauß 2014). Indeed, it would be plausible that males who choose female-dominated *fields of study* are sanctioned more heavily than women. After all, they do not only voluntarily select a poorly paid low status field, they also violate their conventional gender role by doing so.[5] For a man to enter a field dominated by women is associated with a "stigma" (e.g., Williams 1992: 262). As other contexts have shown, a “stigma” leads to higher levels of discrimination, when it is perceived to be voluntarily chosen (Kricheli-Katz 2013). However, concerning female-dominated

[4] In a previous study, based on the U.S. Current Population Survey, the authors found only slight evidence for the devaluation hypothesis (England et al. 2007).
[5] Notably, also women violate their gender role when studying masculine subjects, but because masculine fields are more valued by society, women who enter them may be less sanctioned.

occupations, Williams (1992) has argued, that while third parties may perceive men moving into these fields as losing in status, *within* their job, men's gender and assumed higher standing may be "construed as a *positive* difference" (259). Thus, males may be able to ride a "glass escalator" to move up the career ladder, possibly due to their organization's attempt to better reconcile the gender of the employee and the job.[6] Indeed, for example Hultin (2003) has shown that in female-dominated jobs, men have much better promotion possibilities than women with similar characteristics. It may also be that because men are considered more status worthy (Correll/Ridgeway 2003),[7] they are pushed into more supervisory and management positions within their occupational field.

As this section has shown, various theoretical and empirical contributions point towards lower wages in female-dominated fields. In this paper, we do not only examine whether this relation holds among university graduates in Germany, but also whether it holds equally for men and women. Drawing on the literature, we expect higher penalties for men for graduating in a female-dominated subject, and higher penalties for women for working in a female-dominated occupation. By using a rich data set which spans over the time period from 1997 to 2013, we also examine whether the negative association between wages and female domination within a field changes over time.

Data

The data come from the German Centre for Higher Education Research and Science Studies (DZHW), which, every four years, surveys higher education graduates who have finished their degree within the previous year. The survey was first conducted in 1989 and includes questions about survey participants' student experiences as well as job and family related questions. The most current data available covers graduates from the year 2013. For the year 1989, in contrast to later years, the wage information is given as a categorical variable and the data for the year 1993 does not provide any information on the occupation of the current job. We therefore exclude those two cohorts and work with the data from 1997 onwards.[8] The original sample consists of 45,091 graduates; however, for a substantial fraction of these the

[6] In more recent work, Williams (2013) has emphasized that the concept of the glass escalator relies on "traditional work organizations" that provide job security and career ladders, which are increasingly sparse. Snyder and Green (2008) again have pointed to "horizontal" sex segregation (as opposed to "vertical" sex segregation implied by a glass escalator) that may take place in female-dominated fields.

[7] Expectation states theory (e.g., Correll/Ridgeway 2003) also argues that because of men's high status in society a higher future performance is anticipated from them.

[8] Note that as a result our cohorts differ from those of Franesconi and Parey (2018). In their study, they also restricted their sample to full time workers only. Because a sizable fraction of employees, in particular females, do not work full time, we included them in our sample and controlled for part time work instead.

information on earnings and/or hours worked is missing. Additionally, we exclude people who are self-employed and work less than 10 hours. We, thus, end up with 26,854 observations of whom 55.9% are women and 44.1% are men.

Table 1 depicts the average wages for women and men in their current job (one year after graduation, time of the survey) for the years 1997 to 2013. These are calculated based on the monthly gross income (including pro rata 13th and 14th salaries) and the working hours per week. They are further adjusted for inflation (base year 2015) to be able to compare the wage levels across time.[9] The average wages for graduates fluctuate and range from 15.4€ during the great recession (in 2009) to 18.7€ in 2013. The gender wage gap is relatively constant around 4€/hour.

Table 2 provides further descriptive statistics concerning fields of study, educational as well as work history, job and firm specific characteristics as well as family life for the pooled sample (all years) for all individuals as well as for men and women separately. Concerning the field of study, we grouped the numerous "subjects" in which students can graduate into this broader category. We, thus, distinguish between ten fields of study (*humanities, education, health, agriculture, engineering, arts, natural science, law, social science and economics & business administration*). A detailed mapping of subjects and fields of study is presented in the Appendix (Table A1). As Table 2 illustrates, the different fields of study attract men and women to different degrees, with engineering, humanities, and education standing out for their particularly uneven representation of male and female students. The p-values in the final column indicate that in our large data set many of our covariables, like holding a management position or undergoing an internship at the time of the survey, differ between men and women on a statistically significant level. The large sex differences in the share of men and women who work in the public sector, in firms with less than 500 employees, or part-time are particularly noteworthy.

In addition to the DZHW data, we use data from the German Federal Statistical Office (Statistisches Bundesamt) on gender-specific student enrolment[10] as well as data from the Federal Employment Agency (Bundesagentur für Arbeit) for information on occupational segregation. These two data sets allow us to calculate the female shares (and, thus, the potential dominance of one sex) of subjects and occupations for the different cohorts. Our different data sets mainly contain the same classifications concerning occupations (KldB) and

[9] The data for the consumer price indices come from the German Federal Statistical Office (Statistisches Bundesamt 2021).
[10] We draw on this data because of the sometime small number of observations per year and subject in the DZHW data.

subjects and could therefore be directly matched. Only for the wave 2009 we needed to adapt some of the data. This is because in the year 2010 a new classification of occupations, namely KldB2010, replaced the former KldB1988. In 2009, the DZHW graduate panel already applied the KldB2010 to categorize occupations, while the data from the Federal Employment Agency still used the KldB1988. To map the different classification systems we used a key, which is provided by the Federal Employment Agency.[11] Following Leuze and Strauß (2014), we categorized subjects and occupations, which have a female share smaller or equal to 30 percent as male-dominated. Integrated subjects and occupations have a female share between 30 and 70 percent, and if the female share is greater than or equal 70 percent, the subject or occupation is classified as female-dominated. Table A1 in the Appendix provides a detailed list of female shares per subject. A summary of the distribution of men and women across female-, male-dominated and integrated subjects can be found in Table A2.

Segregation over time

In the following, we illustrate to what degree the level of gender segregation has changed within subjects and occupations over time. Figure 1 depicts the female shares for subjects for the years 1998 and 2013 (approximating the graduation years of our first and last student cohort).[12] The figure illustrates the female shares (as provided by the German Federal Statistical Office) for all subjects which were represented in the DZHW data. The dashed line depicts the identity line. Subjects above the 45° line increased their female share between 1998 and 2013. In line with increasing numbers of women striving for higher education, Figure 1 documents that over the observed period, most subjects increased their relative numbers of female students. Across subjects, the female share increased by 4 percentage points on average.

The colored circles depict those subjects in which the female share of students increased by at least 8 percentage points. The highest gain was made in dentistry (+14 pp.) followed by high gains in architecture, economics and business administration, physics, medicine and industrial engineering (+11 pp.). The subject "natural sciences interdisciplinary" sticks out by its originally high share of female students and its large decline over time (-22 pp.). However, note that it represents only a residual category, where interdisciplinary subjects which also cover mathematics and/or natural science fields are grouped together. It is

[11] Unfortunately, not every occupation of the old categorization had a unique match with the new classification. If the key assigned occupations in the new category to more than one category in the old classification, the female share was calculated based on the average of all assigned occupations.

[12] Note that because no data was available for 1997, the year in which our first cohort of graduates finished their degree, we used data for 1998.

also populated by only few students and the number of students has further declined over time.[13]

Figure 2 visualizes the change of female shares (as provided by the German Federal Employment Agency) between 1997 and 2009 for all occupations that graduates represented in the DZHW held.[14] Again, we see an increase in female representation in the majority of occupations. Across occupations, the female share rose by one percentage point on average. The colored circles mark those occupations with the highest changes in female shares (by at least 10 percentage points). The occupations with the highest relative increase of women were veterinarian (+ 19 pp.) and machine cleaning (+ 18 pp.). In contrast to the fields of study, there is also a large fraction of occupations with a decreasing share of females. The occupation photo lab technician (- 28 pp) and the participation in the family business ("help FB not agriculture") (-19 pp.) experienced the largest drop.

We also calculated the Duncan Segregation Index (Duncan/Duncan 1955), which provides the most well-known indicator for the un/equal distribution of the sexes, for both subjects and occupations. It indicates how many men or women would have to switch fields to reach an equal gender representation. A Duncan index of 0 means that women and men are represented equally, 1 indicates that there is a full segregation between women and men. We find that the Duncan Segregation Index did not change much over the considered years for both subjects and occupations. In our sample, across years, the Duncan Index for Segregations is around 0.3 for subjects and 0.6 for occupations. While the index is virtually constant over time as far as subjects of studies are concerned, the index for occupations experienced a slight decline from 0.623 in 1997 to 0.581 in 2009. Thus, despite the rising number of women in higher education and a large fraction of women participating in the labor market, sex segregation persists today.

Method

We test whether there is a correlation between female-dominated occupations/subjects and wages by estimating the following linear regression model, first for each year separately, then for the pooled sample:

[13] The subject, which is among the smallest covered, consists of three different *courses of studies*: "history of mathematics", "interdisciplinary studies with a focus on natural sciences" and "study area: natural science/general science" (Lernbereich Naturwissenschaft/Sachunterricht), which is selectable within the teacher training for primary education. The latter *course of studies* lost 41 percent of its students over the observed period and also the originally high share of females dropped significantly (from 0.856 to 0.773). This leads to an overall decline in female students within the subject "natural sciences interdisciplinary".

[14] Note that this figure excludes the cohort of 2013, because a new classification of occupations was introduced in the data.

$$ln\,Y_i = \beta_0 + \alpha_1 F_i + \gamma_1 FS_i + \gamma_2 IS_i + \gamma_3 FO_i + \gamma_4 IO_i + \boldsymbol{X}_i\beta_1 + \varepsilon_i \quad (1)$$

As a depended variable we use the logarithmic hourly wage.[15] F_i is a female dummy and its coefficient α_1 captures the wage penalty for women. In our model, the coefficients of interest are γ_1- γ_4, as they depict the relationship between the representation of women in subjects/occupations and wages. We use the dummies *female-dominated subject* (FS), *integrated subject* (IS), *female-dominated occupation* (FO) and *integrated occupation* (IO) to model this relationship. We further control for a large set of covariables $\boldsymbol{X}_i$ capturing the field of study, various job and firm specific characteristics, education and work history as well as family life. For example, the *job specific characteristics* include information on whether the job is an internship, a part-time job, or a management job. *Firm specific characteristics* capture whether an employer belongs to the public sector, has more than 500 employees, and is located in East Germany. *Education specific characteristics* include information about the highest tertiary degree obtained (Bachelor, PhD or other), whether a graduate is still enrolled in a PhD program, his/her final grade at university and age at graduation. Concerning the *work history* of a graduate, the covariables capture whether an individual worked prior or during his/her studies, his/her months unemployed, months of paternal leave and months of overall work experience. Additionally, the *family specific characteristics* include dummy variables for marital status, for having children and for whether (at least) one parent has a high school diploma (Abitur).

To examine whether men or women are penalized more for participating in a female-dominated or integrated field, we extend model (1) by including a set of interaction terms:

$$\begin{aligned} ln\,Y_i = {} & \beta_0 + \alpha_1 F_i + \gamma_1 FS_i + \gamma_2 IS_i + \gamma_3 FO_i + \gamma_4 IO_i + \boldsymbol{X}_i\beta_1 + \eta_1 FS_i * F_i + \eta_2 IS_i * F_i \\ & + \eta_3 FO_i * F_i + \eta_4 IO_i * F_i + (F_i * \boldsymbol{X}_i)\beta_2 + \varepsilon_i \end{aligned} \quad (2)$$

Our coefficients of interest in this regard are η_1- η_4, as they examine to what degree women's wages are affected differently than those of men by a particular representation of women in a field. A negative coefficient indicates that women are penalized more strongly than men for

[15] Note that in accordance with most of the literature, we only use data from the first year after graduation so that we can eliminate any gendered wage effects that may accumulate with job experience. In contrast to our approach, Leuze and Strauß (2014) also use data that are collected by the DZHW 5 years after graduation and, consequently, use a random effects panel regression model. As a result, their empirical findings for the year 1997 are not strictly comparable to ours. However, we also used their approach to replicate their findings for 1997 and came to similar results.

being in a more female-dominated field. We also include controls for our covariables $\boldsymbol{X}_i$ interacted with the sex of the individual. The variable ε_i depicts the error term.

Results

In a first step, we plot the average conditional wages (in log points) based on our regression model (2): Figure 3 shows these wages for the different subject types, figure 4 for different occupational types. We estimated our regression model as depicted in equation (2) and calculated the predicted wages for each of our observations. The average wages presented in figure 3 and 4 are based on these predicted wages and calculated for six different subcategories: Men or women in female-, male-dominated or integrated subjects (or occupations). In figure 3, we see that, according to our model, men earn more than women in all subject types (male-dominated, integrated, female-dominated). Also, within one sex, wages are always highest for graduates from male-dominated subjects, followed by integrated and female-dominated subjects. As a result, the average conditional wages are highest for men who graduated in male-dominated subjects and lowest for women who graduated in female-dominated subjects. For occupations, we find a similar scenario. In figure 4, we see that men earn the highest wages when working in male-dominated occupations, lower wages in integrated occupations, and the lowest wages in female-dominated occupations. Our model also predicts that women tend to earn most in male-dominated followed by integrated and female-dominated occupations. Only in the years 2009 and 2013, female average conditional wages are similar in male-dominated and integrated occupations. In almost all years, women earn less than men within one occupational type. Only in 2013, our model predicts that men and women received similarly low wages in female-dominated occupations.

While figures 3 and 4 give an overview of different average conditional wages depending on the type of occupation or subject over the years, in the next step, we present the findings from our linear regression model. Table 3 presents the results for the five different cohorts of graduates (1997-2013) and provides detailed information on how the female wage penalty changes across different specifications and which of the coefficients of interest are statistically significant. Column (1) shows the "raw" gap, while column (2) includes the field of study (education, health, agriculture, engineering, arts, natural sciences, law, social sciences, economics and business administration, ref: humanities) in which individuals have graduated. Column (3) further includes dummies capturing whether the subject in which an individual has graduated is female-dominated or integrated (ref: male-dominated), in column (4) dummies capture whether the individual is employed in a female-dominated or integrated

job (ref: male-dominated). Column (5) includes both sets of "sex segregation" dummies and column (6) additionally controls for a large set of individual characteristics (concerning education and work history as well as family specific characteristics), job specific characteristics (internship, part-time, management position) and firm specific characteristics (public/private sector, company location East/West Germany, large firm). In the final column (7), the full specification additionally includes interaction terms between the female dummy and all covariables.

As column (1) shows, the "raw" gender gap among university graduates fluctuated between 25 and 28 log points (or 22-24 %)[16] for the cohorts 1997-2005 and has declined to 23.5 log points (21%) for the 2009 and 2013 cohort. Controlling for the field of study explains a large portion of that gap (column 2). In most years, adding this variable reduces the coefficient of the female dummy by approximately 10 log points; in 1997 it is reduced by half. As column (3) illustrates, wages are substantially lower for graduates who studied a female-dominated or integrated subject instead of one that is male-dominated. The effects are very large, but also fluctuate significantly between the different time periods. While, for example, in 1997, graduating in a female-dominated subject reduced wages by 16 log points (15%), this effect amounted to 44 log points (35%) in 2013. Also, the sex segregation of occupations strongly affects wages. According to column (4), female-dominated jobs pay 26-35 log points (23-29%) less than male-dominated occupations. Penalties also exist for integrated occupations, but are much lower. Including the sex-type of field of study and occupation simultaneously (column 5) reduces the gender wage gap (compared to column 2) by approximately 5-7 log points. The remaining wage differential amounts to 7-10% for the different time periods. Other individual or firm-specific characteristics explain relatively little. After their inclusion (column 6), the gender wage gap amounts to 5-6% and is remarkably constant over time. While this wage differential is much lower than the raw gap, it is still substantial considering that it compares young graduates with identical qualification and similar individual characteristics who work at similar firms.

When we include the interaction terms in column 7, we find no clear gendered pattern concerning the effects of female-dominated subjects: in some years the interaction term female subject*female is insignificantly positive, in others negative. Only in one year, 2013, there is a statistically significant gender difference, as women who completed a female- instead of a male-dominated subject experience a wage penalty of 27 log points while there is

[16] $(e^{-0.254} - 1)*100 = 22.4$

no statistically significant penalty for men. Also, when comparing the penalties that men and women experience for studying an integrated subject, there is no consistent discernible gender difference over the years.[17] Therefore, we find no support in our empirical setting for the hypothesis that men are more stigmatized than women when they graduate in a female-dominated academic subject as suggested by Leuze and Strauss (2014).

Concerning the effect of sex-segregated occupations, if there is a "glass escalator" (Williams 1992) for men, we would expect that they are punished less for entering a female-dominated occupation. This would also be the case if men are pushed into somewhat higher positions than women (unobservable in the data) because they are considered more status worthy (Correll/Ridgeway 2003). This is not what our results in column (7) show. In no single year do we find statistically significant differences between the effects that a female-dominated occupation has on female versus male wages (i.e., a significant coefficient for the interaction term [FO * female]). We therefore cannot confirm the "glass escalator" or "status expectation" hypothesis.[18] There is only some evidence that women are punished more than men for entering an "integrated occupation" (for the years 1997, 2001, and 2005).

Table 4 shows the full set of results for the pooled data (1997-2013) including year dummies.[19] Columns (1) – (6) follow the same structure as in table 3 and confirm for the pooled sample that female-dominated and integrated subjects/occupations pay less than male-dominated ones. The results for the fully interacted model are presented in the last two columns: Column (7) "Main Effects" displays the main effects of the covariables, while column (7 cont.) "IA Effects" presents the interaction effects between the respective covariable and the female dummy. Concerning the interaction terms of being female and having graduated in a female-dominated subject or working in a female-dominated occupation (our variables of interest), we do not find significant sex differences also in this pooled sample. However, while there is no significant sex difference for graduating in an integrated subject, we find a wage penalty for working in an integrated occupation only for women (column 7 cont.) but not for men (column 7).

Concerning the covariates, the findings show that most fields of study yield higher earnings than the humanities (reference category). Incomes are particular high for

[17] Only in the year 2001, when men are more strongly punished for studying an integrated subject than women, this difference is marginally significant.
[18] Of course, if the glass escalator does not elevate male employees immediately upon job entry, but operates over longer time periods, we may not be able to capture its effect among new graduates.
[19] We include the same covariables as in the yearly setting except for the final university grade, because this information is not available for 1997. We also redid the analysis including the final university grade and dropping the year 1997 (not shown), which did not significantly change the findings.

engineering, economics and business administration, natural science and health (column 2). Note that because only university graduates are examined, the less qualified health workers who are known for being poorly paid are not included here. In their first year after graduation, graduates with a law degree earn less because after graduating from university, they still have to complete a two-year legal clerkship (Rechtsreferandariat) and pass another state examination before they fully finish their education. With respect to education specific characteristics (column 6), Bachelor graduates earn approx. 14 and PhDs 9 log points less than master graduates (reference category). Individuals, who are older upon graduation earn somewhat more. This effect is mainly driven by women (column 7 cont.). Concerning job specific characteristics, internships pay lower hourly wages, while management positions pay more – the latter is particularly true for women, who receive a premium of 10 log points for working in management, while men only make additional 5 log points. With regard to firm specific characteristics, we find that women benefit from being employed in the public sector, while there is no effect for men. Wages are significantly higher for large firms (+ 16 log points) and lower in the region of the former German Democratic Republic (approx. -14 log points). Concerning the work history of employees, months of unemployment are associated with somewhat lower wages and months of work experience are related to higher wages. If individuals worked during (or prior to) their studies, their wages are higher. The effect of months as homemakers is significantly negative. Finally, our results show that the people in our sample who are married and/or have children earn significantly higher wages (the interaction effects for women are relatively large and negative, but statistically insignificant).

Note that in our procedure we used listwise deletion to handle missing values, which means that we dropped observations from our sample if they had missing values for one of the covariables. Because in each column in both, Table 3 and 4, we added new covariables to our specification, our sample decreases from column (1) to (7).[20] However, to rule out the possibility that the results of a particular specification depend on the particular sample examined, in Tables A3 and A4 in the Appendix, we also included the results for different specifications based on the reduced sample from column (7) and found similar dynamics as we detected in Table 3 und 4.

[20] Even though we have fewer observations and thus larger standard errors when using listwise deletion, the method is the best fit when observations are not missing at random (Allison 2011).

Wage gaps within fields

We have previously established that fields of study explain a large part of the gender wage gap among university graduates. In our last step, we now analyze the wage gaps *within* different fields of study. Table 5 summarizes the results for the years 1997-2013.[21]

In Table 5 we report average male and female log wages within each field as well as the size of the observed wage gap. We further show which part of the gap can be explained by using the full set of covariables described before. However, different from the original setting, we do not include female shares of occupations and subjects, but control for the different subjects themselves.[22] The findings in Table 5 are estimated using a Blinder-Oaxaca decomposition (Blinder 1973, Oaxaca 1973) with a pooled regression as the baseline for the coefficients (Jann 2008).

We find the highest raw wage gaps in those two fields that have the lowest share of women: engineering (18 log points) and natural sciences (22 log points). These are followed by high wage gaps in education (15 log points) as well as in economics and business administration (13 log points). The smallest observed wage gaps are within the field of law (5 log points), in which overall wages are also the lowest.[23] The highest unexplained wage gap can be found in economics and business administration (9 log points), engineering as well as in natural sciences (7 log points). For graduates from the natural sciences a particularly large part of the wage gap can be explained by gender specific differences in endowments. Interestingly, the unexplained wage gap in law is quite high at 6 log points, despite the low raw gap in the field. This is the case because in law women have similar endowments than men, so nothing of the raw gap can be explained. While the unexplained wage gap cannot be equated with the level of labor market discrimination, it captures the size of the wage gap which cannot be explained with the human capital variables used in our model. If our model misses crucial variables of interest, the size of the unexplained gap may overstate the level of discrimination. Variables that might be relevant in this context are preferences for flexible working hours or overtime work, the ability to commute, as well as individual characteristics such as competitiveness or negotiation skills (for a detailed discussion of potential factors

[21] Note that because we do not have any information on the final university grade for 1997, we excluded the variable from the analysis. In a version not shown, we have also excluded the year 1997 and included the variable final grades, which did not significantly alter the findings.

[22] We do not control for occupations, not only because employment in a particular occupation may itself be driven by discrimination, but also because our occupational categories change over the time span covered in this pooled data.

[23] Remember that, by state regulation, law graduates have to complete a two-year legal internship after finishing their degree, causing these low entry wages.

affecting the wage gap see Blau/Kahn 2017).[24] However, if covariables within our model are themselves affected by discrimination, the unexplained gap would underestimate the level of discrimination. For example, entry barriers into specific occupations or study subjects, as well as discrimination within professions or fields of study may affect human capital variables and, therefore, influence the wage gap. We cannot rule out that these concerns affect the wage gap in some fields more than others.

Overall, our findings show that women make relatively high wages when studying a subject in the field of engineering or natural sciences, in particular when compared to, e.g., the humanities or the arts. However, the gender wage gap within the field is among the highest for STEM subjects. When women compare themselves to their peers and worry about their relative earnings (Duesenberry 1949), these large gender wage gaps – in addition to other potential job disamenities – may make these fields unattractive to women despite their overall high wages.[25]

Conclusion and Discussion

Our findings support the hypothesis that a higher female share of workers within an occupation is associated with lower wages. The same is true for subjects with a high share of female students. This negative correlation of female shares of workers/students and wages that we find, is in accordance with devaluation theory and a lower status that is given to work conducted by women. However, also other reasons may be responsible for the negative association between female shares and wages. First, even though women's labor market participation has drastically increased since the 1970s, sex differences in labor market commitment remain, e.g., because women more often take a career break due to parenthood. If the depreciation of human capital is lower in some fields than others, these may be more attractive for women who expect to interrupt their labor market participation at some stage (Polachek 1981). For example, if female-dominated-jobs require less specialized training (Tam 1997), they may be more attractive for women, who expect to interrupt their careers.

Second and relatedly, omitted variables could bias the results. For example, different career attitudes and job characteristics could be responsible for the differences in earnings. According to the theory of compensating differentials (Rosen 1986), if a job offers non-financial amenities such as flexible hours or working from home (which are especially valued

[24] Note that if characteristics are unobservable in which women do better than men on average, then discrimination is understated.

[25] As Blundell (2021) recently found in a hypothetical choice experiment, many women are willing to forgo income to avoid an employer with a high gender pay gap.

by mothers), it may pay lower wages – as long as there are enough workers who sufficiently value these non-financial benefits. Unpleasant working conditions, on the other hand, have to be compensated by higher wages. For example, jobs that require long hours pay significantly higher wages as remuneration (Goldin 2016). Long hours, thus, may not only drive sex segregation but also cause differences in wages between male and female-dominated professions. For example, Leuze and Strauß (2016) confirmed for Germany that occupational long hours increase wages. Reimer and Schröder (2006), however, did not find that controlling for job attitudes of employees (that measured what they valued in a job, e.g., income, work/life balance, work content) decreased the gender wage gap.

Third, while devaluation theory suggests that an occupation is devalued and wages fall when women enter the profession, it may also be that this causality is reversed, and low wages lead to the feminization of a profession – because men are not available for these jobs. According to queuing theory (Reskin/Roos 1990) employers rank potential employees according to their place in the societal hierarchy and hire people with higher social status first. Therefore, high paying jobs are filled with men first – women may then have to turn to occupations with lower pay. Some longitudinal studies have tested the "queuing" against the "devaluation" theory and typically found stronger evidence for the latter (England et al. 2007, Levanon et al. 2009). Last, low wages in female-dominated occupations can also occur because of crowding (Bergmann 1971, 1974). If women are crowded into a few occupational fields, the oversupply of female employees in these occupations pushes down wages. Such crowding may result, e.g., from discrimination or traditional gender norms.

In our setting, we cannot distinguish between these potential reasons. However, we are able to confirm a negative association between female-dominated subjects/occupations and wages for German university graduates across multiple cohorts that finished their studies between 1997 and 2013. We do not find a clear time trend but in our data, there is no indication that the devaluation of female-dominated fields has decreased over the years as suggested by Busch (2018).

In our study, we were also interested in whether men's or women's wages suffer larger penalties as a result of a high female share in a field. In contrast to Leuze and Strauss (2014), we did not find conclusive evidence that wage penalties accompanied with a high share of females are different for women and men. Overall, we found that women earn *less* than men in male-dominated fields, but it is *not* true that women earn *more* than men in female-dominated fields, as would be suggested by a "lack of fit" framework that attributes women a worse fit to male-dominated fields but a better fit to female-dominated fields. Indeed, women

tend to earn less than men more generally, so a different explanation is required. Apart from unobserved heterogeneity, discrimination may be one possible reason for our findings. Employers may still regard women as "secondary earners" and pay them relatively little as a result. It may also be that because women's work is socially devalued, not only female-dominated fields are more poorly paid compared to male-dominated fields, but also women are paid less than men.

We finally showed that significant wage gaps exist within fields of study, especially in some male-dominated STEM fields like engineering and natural science. If women care about their relative incomes and compare themselves to their peers, these large gender wage gaps will not help make these fields attractive to women despite their high wages.

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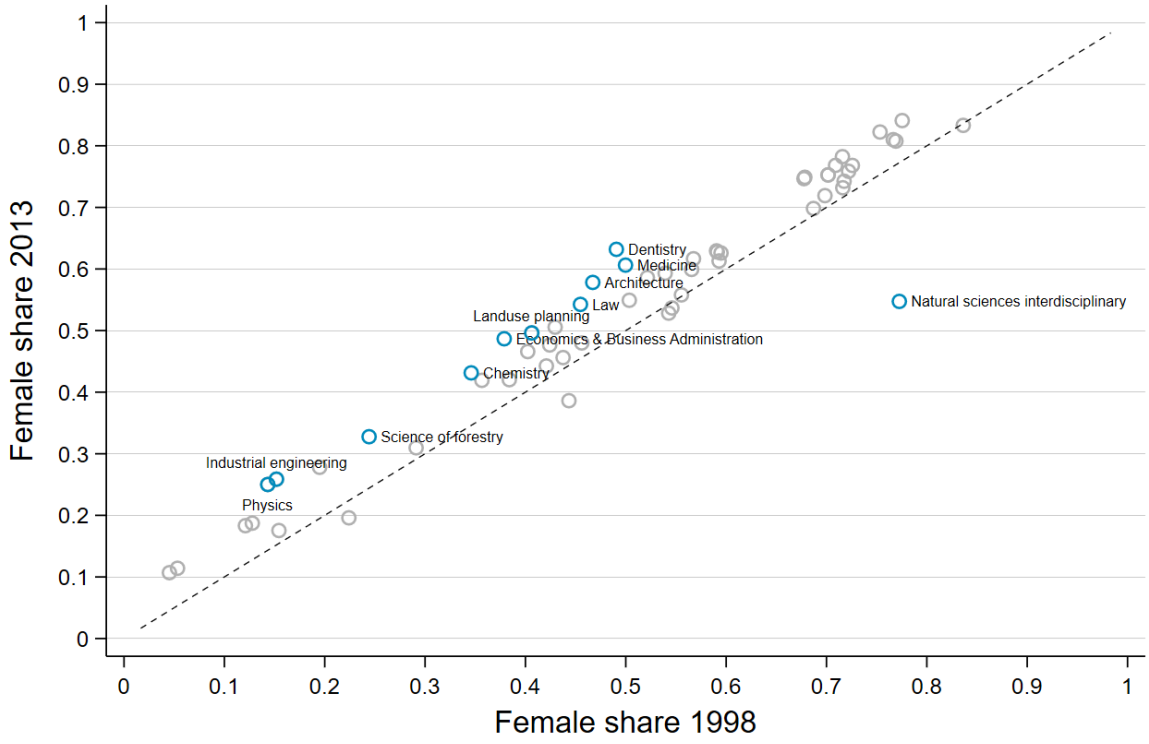
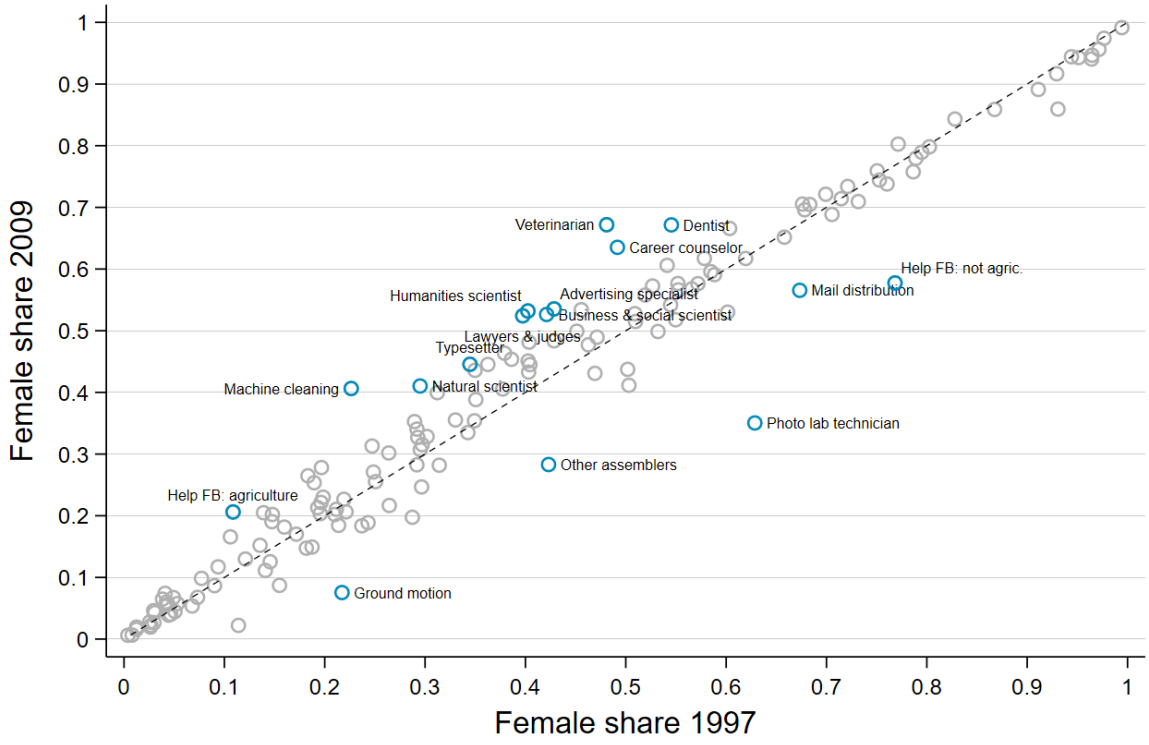
Figures

Figure 1: Sex segregation in subjects 1998 and 2013



Notes: The data used to calculate the female shares within subjects come from the German Federal Statistical Office.

Figure 2: Sex segregation in occupations 1997 and 2009



Notes: "Help FB" stands for Help in family business. The data used to calculate the female shares within occupations come from the Federal Employment Agency.

Figure 3: Average conditional wages for different subject types by sex, 1997–2013

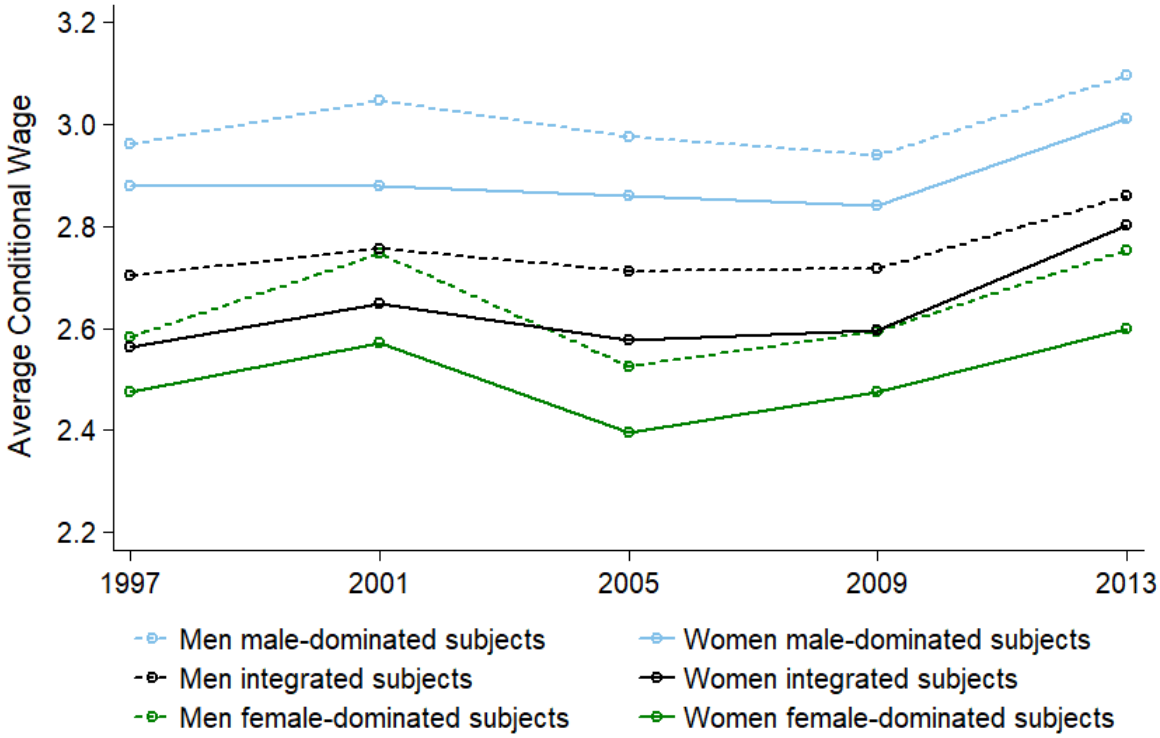
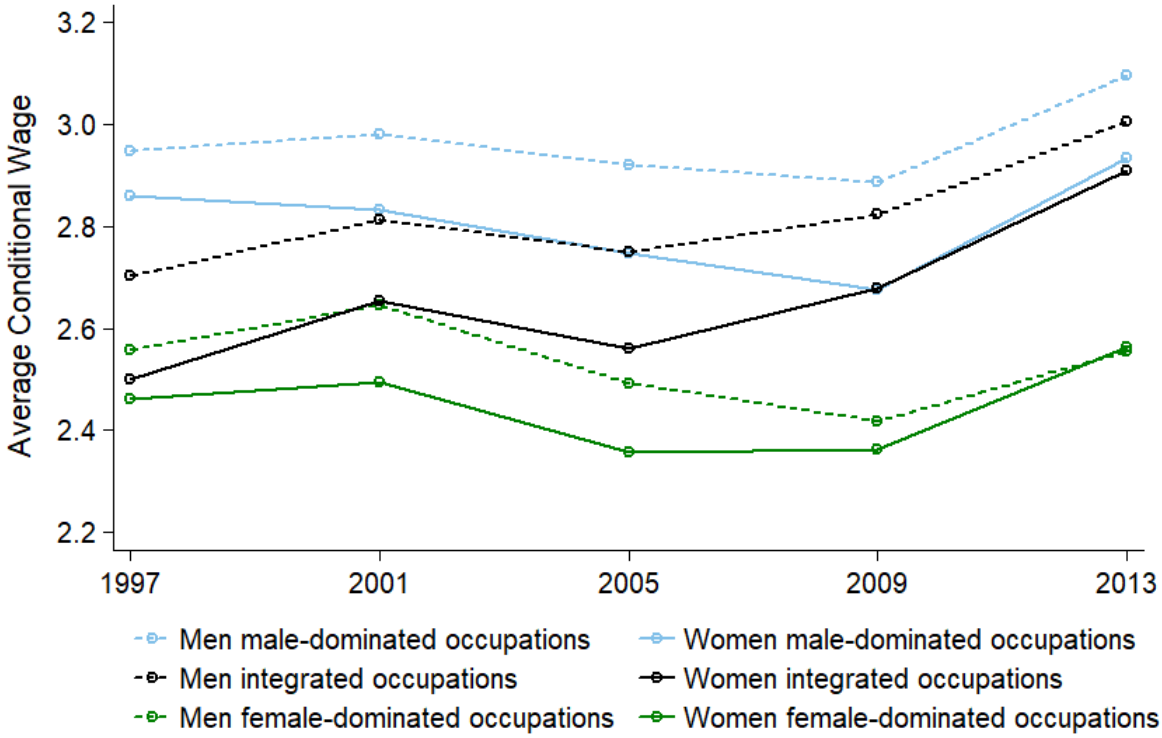


Figure 4: Average conditional wages for different occupational types by sex, 1997–2013



Tables

Table 1: Male and female average wages and standard deviations from 1997 to 2013

	1997		2001		2005		2009		2013	
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
All	16.47	6.67	17.65	7.88	15.83	7.12	15.39	7.00	18.72	7.69
Male	18.15	6.48	20.05	7.97	18.05	6.80	17.43	6.93	21.05	7.64
Female	14.18	6.24	15.93	7.35	14.16	6.89	14.09	6.73	17.07	7.28

Notes: The gross hourly wages were calculated based on the survey responses from the DZHW graduate panel. The survey participants were asked about their monthly income, 13th and 14th salaries, bonuses, and their weekly working hours. If they received any annual earnings in addition to their monthly income, we added them proportionately. Hourly wages were calculated as: salary / 4.35 / weekly working hours. The wages were further adjusted for inflation [$wage_{adjusted}$ = ($wage_{non\text{-}adjusted}$ / consumer price index for the respective year) * 100] with the base year 2015. The data for the consumer price indices come from the German Federal Statistical Office (Statistisches Bundesamt 2021).

Table 2: Descriptive statistics – means of covariables (pooled sample, all years)

	All	Male	Female	p-values
Female	0.56			
Fields of studies				
Humanities	0.11	0.05	0.16	0.000
Education	0.05	0.01	0.08	0.000
Health	0.10	0.07	0.13	0.000
Agriculture	0.03	0.03	0.04	0.000
Engineering	0.24	0.40	0.12	0.000
Arts	0.02	0.01	0.03	0.000
Natural Science	0.17	0.19	0.14	0.000
Law	0.04	0.04	0.04	0.554
Social Science	0.08	0.05	0.11	0.000
Economics & Business Administration	0.15	0.15	0.15	0.216
Education specific characteristics				
Highest degree: Bachelor	0.11	0.10	0.12	0.000
Highest degree: PhD	0.01	0.01	0.01	0.118
Current PhD student	0.14	0.16	0.13	0.000
Age at graduation	26.66	27.06	26.35	0.000
Final grade university (1-4)	1.90	1.90	1.90	0.619
Job specific characteristics				
Paid Internship	0.17	0.11	0.22	0.000
Management position	0.17	0.19	0.16	0.000
Part-time job (less than 35h)	0.20	0.16	0.24	0.000
Working hours	36.01	36.88	35.32	0.000
Firm specific characteristics				
Public sector	0.46	0.38	0.53	0.000
Big firm: More than 500 employees	0.35	0.41	0.30	0.000
Location company: East Germany	0.16	0.14	0.17	0.000
Work history				
Working prior to university	0.35	0.37	0.34	0.000
Working during university	0.41	0.44	0.38	0.000
Unemployment duration (in months)	0.93	0.93	0.93	0.778
Work experience (in months)	13.72	13.77	13.68	0.256
Time as homemaker (in months)	0.26	0.10	0.39	0.000
Family specific characteristics				
Married (yes/no)	0.14	0.14	0.14	0.102
Children (yes/no)	0.09	0.09	0.08	0.002
Parent with Abitur (yes/no)	0.61	0.58	0.62	0.000
Number of Observations	26854	11850	15004	

Notes: The variables unemployment duration, work experience and time as homemaker are only available from graduation onwards. Potentially prior unemployment spans, work experience or periods of household/family work are not covered in the data. The data come from the DZHW graduate panel.

Table 3: OLS estimates for gross hourly wages, 1997-2013

		(1)	(2)	(3)	(4)	(5)	(6)	(7)
1997[*)]	Female	-0.274***	-0.135***	-0.112***	-0.102***	-0.0888***	-0.0621***	-0.434***
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.002)
	Female subject			-0.159***		-0.0744*	-0.0727**	-0.147**
				(0.000)		(0.050)	(0.050)	(0.018)
	Female subject*Female							0.105
								(0.193)
	Integrated subject			-0.221***		-0.177***	-0.107***	-0.113***
				(0.000)		(0.000)	(0.000)	(0.000)
	Integrated subject*Female							0.00155
								(0.973)
	Female occupation				-0.264***	-0.257***	-0.120***	-0.127***
					(0.000)	(0.000)	(0.000)	(0.004)
	Female occupation*Female							-0.0265
								(0.629)
	Integrated occupation				-0.131***	-0.116***	-0.0388**	0.00979
					(0.000)	(0.000)	(0.025)	(0.650)
	Integrated occupation*Female							-0.115***
								(0.001)
	N	4605	4603	4603	4354	4354	3749	3749
	Controls for:							
	Field of Study		Yes	Yes	Yes	Yes	Yes	Yes
	Full Controls						Yes	Yes

		(1)	(2)	(3)	(4)	(5)	(6)	(7)
2001	Female	-0.254***	-0.154***	-0.118***	-0.125***	-0.101***	-0.0491***	-0.531***
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.004)	(0.002)
	Female subject			-0.232***		-0.0988***	-0.104***	-0.199***
				(0.000)		(0.001)	(0.007)	(0.007)
	Female subject*Female							0.137
								(0.121)
	Integrated subject			-0.287***		-0.243***	-0.161***	-0.229***
				(0.000)		(0.000)	(0.000)	(0.000)
	Integrated subject*Female							0.108*
								(0.054)
	Female occupation				-0.349***	-0.352***	-0.106***	-0.0838
					(0.000)	(0.000)	(0.001)	(0.170)
	Female occupation*Female							-0.0323
								(0.659)
	Integrated occupation				-0.145***	-0.124***	-0.0559**	0.0113
					(0.000)	(0.000)	(0.026)	(0.771)
	Integrated occupation*Female							-0.100**
								(0.048)
	N	5800	5800	5800	5469	5469	1856	1856
	Controls for:							
	Field of Study		Yes	Yes	Yes	Yes	Yes	Yes
	Full Controls						Yes	Yes

		(1)	(2)	(3)	(4)	(5)	(6)	(7)
2005	Female	-0.279***	-0.166***	-0.109***	-0.134***	-0.0923***	-0.0660***	-0.203*
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.086)
	Female subject			-0.418***		-0.341***	-0.217***	-0.164***
				(0.000)		(0.000)	(0.000)	(0.001)
	Female subject*Female							-0.0964
								(0.111)
	Integrated subject			-0.334***		-0.300***	-0.197***	-0.187***
				(0.000)		(0.000)	(0.000)	(0.000)
	Integrated subject*Female							-0.0357
								(0.306)
	Female occupation				-0.288***	-0.229***	-0.0760***	-0.0777**
					(0.000)	(0.000)	(0.000)	(0.036)
	Female occupation*Female							-0.0200
								(0.649)
	Integrated occupation				-0.106***	-0.0635***	-0.0506***	-0.0181
					(0.000)	(0.000)	(0.000)	(0.345)
	Integrated occupation*Female							-0.0595**
								(0.034)
	N	7055	7055	7055	6633	6633	6053	6053
	Controls for:							
	Field of Study		Yes	Yes	Yes	Yes	Yes	Yes
	Full Controls						Yes	Yes

		(1)	(2)	(3)	(4)	(5)	(6)	(7)
2009	Female	-0.235***	-0.144***	-0.107***	-0.106***	-0.0887***	-0.0593***	-0.201
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.113)
	Female subject			-0.273***		-0.143***	-0.109***	-0.100*
				(0.000)		(0.000)	(0.001)	(0.071)
	Female subject*Female							-0.0230
								(0.748)
	Integrated subject			-0.276***		-0.246***	-0.167***	-0.160***
				(0.000)		(0.000)	(0.000)	(0.000)
	Integrated subject*Female							-0.00991
								(0.863)
	Female occupation				-0.333***	-0.301***	-0.116***	-0.152***
					(0.000)	(0.000)	(0.000)	(0.000)
	Female occupation*Female							0.0630
								(0.215)
	Integrated occupation				-0.0498***	0.00204	0.00221	0.0151
					(0.009)	(0.922)	(0.910)	(0.559)
	Integrated occupation*Female							0.000969
								(0.981)
	N	5623	5623	5623	5334	5334	4635	4635
	Controls for:							
	Field of Study		Yes	Yes	Yes	Yes	Yes	Yes
	Full Controls						Yes	Yes

		(1)	(2)	(3)	(4)	(5)	(6)	(7)
2013	Female	-0.235***	-0.127***	-0.0884***	-0.0920***	-0.0708***	-0.0489***	-0.126
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.469)
	Female subject			-0.438***		-0.261***	-0.196***	0.0261
				(0.000)		(0.000)	(0.000)	(0.770)
	Female subject*Female							-0.265**
								(0.011)
	Integrated subject			-0.299***		-0.239***	-0.174***	-0.170***
				(0.000)		(0.000)	(0.000)	(0.000)
	Integrated subject*Female							-0.00692
								(0.897)
	Female occupation				-0.297***	-0.253***	-0.208***	-0.219***
					(0.000)	(0.000)	(0.000)	(0.000)
	Female occupation*Female							0.0211
								(0.740)
	Integrated occupation				-0.0528***	-0.0261	-0.0453**	-0.0374
					(0.004)	(0.156)	(0.013)	(0.101)
	Integrated occupation*Female							0.00416
								(0.916)
	N	3771	3764	3764	3617	3617	3058	3058
	Controls for:							
	Field of Study		Yes	Yes	Yes	Yes	Yes	Yes
	Full Controls						Yes	Yes

Notes: P-values in parenthesis (*** p <0.01, ** p <0.05, * p <0.1). Full Controls include in addition to fields of study (education, health, agriculture, engineering, arts, natural science, law, social science, economics & business administration; ref: humanities): education specific characteristics (highest degree, current PhD student, age at graduation, final grade university), job specific characteristics (internship, management position, part-time job), firm specific characteristics (public sector, big firm, location company), work history (working prior to university, working during university, unemployment duration, work experience, time as homemaker) and family specific characteristics (married, children, parent with *Abitur*). All data come from the DZHW graduate panel except for the female shares within subjects (German Federal Statistical Office), female shares within occupations (Federal Employment Agency), as well as the data on the consumer price index (German Federal Statistical Office).

***)** Full Controls include final university grade for all years but 1997 (not available).

Table 4: OLS estimates for gross hourly wages, 1997-2013 pooled

	(1)	(2)	(3)	(4)	(5)	(6)	(7) Main Effects	(7) cont. IA Effects [a)]
Female	-0.255***	-0.146***	-0.105***	-0.110***	-0.0844***	-0.0568***	-0.267***	
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	
Representation women in subject								
Female-dominated subject			-0.306***		-0.188***	-0.159***	-0.131***	-0.0544
			(0.000)		(0.000)	(0.000)	(0.000)	(0.101)
Integrated subject			-0.292***		-0.246***	-0.173***	-0.165***	-0.0212
			(0.000)		(0.000)	(0.000)	(0.000)	(0.316)
Representation women in occupation								
Female-dominated occupation				-0.317***	-0.291***	-0.129***	-0.161***	0.0293
				(0.000)	(0.000)	(0.000)	(0.000)	(0.212)
Integrated occupation				-0.112***	-0.0820***	-0.0258***	0.00369	-0.0499***
				(0.000)	(0.000)	(0.001)	(0.722)	(0.001)
Fields of study								
Education		0.101***	0.103***	0.176***	0.154***	0.0959***	0.139***	-0.0523
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.172)
Health		0.416***	0.415***	0.375***	0.392***	0.227***	0.236***	-0.0196
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.516)
Agriculture		0.253***	0.239***	0.164***	0.193***	0.0279	-0.000942	0.0425
		(0.000)	(0.000)	(0.000)	(0.000)	(0.134)	(0.975)	(0.265)
Engineering		0.527***	0.285***	0.394***	0.250***	0.103***	0.112***	-0.0513
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.113)
Arts		0.0879***	0.0829***	0.0656***	0.0901***	-0.0410*	-0.0408	-0.00603
		(0.000)	(0.001)	(0.006)	(0.000)	(0.092)	(0.403)	(0.915)
Natural Science		0.382***	0.276***	0.330***	0.288***	0.120***	0.107***	0.0201
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.495)

	(1)	(2)	(3)	(4)	(5)	(6)	(7) Main Effects	(7 cont.) IA Effects [a)]
Law		-0.214***	-0.214***	-0.256***	-0.216***	-0.0904***	-0.0597*	-0.0450
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.050)	(0.245)
Social Science		0.268***	0.269***	0.331***	0.334***	0.166***	0.127***	0.0487
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.111)
Economics & Business Administration		0.524***	0.525***	0.460***	0.508***	0.250***	0.255***	-0.0144
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.621)
Education specific characteristics								
Highest degree: Bachelor						-0.138***	-0.131***	-0.00893
						(0.000)	(0.000)	(0.610)
Highest degree: PhD						-0.0940***	-0.0693	-0.0571
						(0.003)	(0.128)	(0.343)
Current PhD student						0.00429	-0.0132	0.0402*
						(0.674)	(0.369)	(0.051)
Age at graduation						0.00546***	0.00102	0.00772***
						(0.000)	(0.498)	(0.000)
Job specific characteristics								
Paid internship						-0.606***	-0.632***	0.0332
						(0.000)	(0.000)	(0.135)
Management position						0.0738***	0.0480***	0.0504***
						(0.000)	(0.000)	(0.000)
Part-time job						-0.0145	-0.0128	-0.000292
						(0.122)	(0.420)	(0.988)
Firm specific characteristics								
Public sector						0.0339***	-0.0175	0.0861***
						(0.000)	(0.106)	(0.000)
Big firm: More than 500 employees						0.161***	0.154***	0.00765
						(0.000)	(0.000)	(0.482)

	(1)	(2)	(3)	(4)	(5)	(6)	(7) Main Effects	(7 cont.) IA Effects [a)]
Location company: East Germany						-0.143***	-0.146***	0.00889
						(0.000)	(0.000)	(0.537)
Work history								
Working prior to university (yes/no)						0.0104*	0.0119	-0.00465
						(0.065)	(0.116)	(0.678)
Working during university (yes/no)						0.0473***	0.0551***	-0.0142
						(0.000)	(0.000)	(0.157)
Unemployment duration (in months)						-0.00730***	-0.00802***	0.00159
						(0.000)	(0.000)	(0.458)
Work experience (in months)						0.00515***	0.00490***	0.000310
						(0.000)	(0.000)	(0.697)
Time as homemaker (in months)						-0.00664***	-0.00590	0.000274
						(0.002)	(0.206)	(0.959)
Family specific characteristics								
Married (yes/no)						0.0190**	0.0250**	-0.0106
						(0.019)	(0.022)	(0.503)
Children (yes/no)						0.0370***	0.0486***	-0.0336
						(0.001)	(0.000)	(0.126)
Parent with Abitur (yes/no)						-0.000759	-0.00141	0.000857
						(0.884)	(0.841)	(0.934)
Constant	2.841***	2.415***	2.683***	2.565***	2.729***	2.589***		2.722***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)		(0.000)
Number of Observations	26854	26845	26845	25407	25407	19799		19799

Notes: The two columns (7) present the results from the fully interacted model, with the first column reporting the main effects and the second column presenting the interaction effects.

[a)] IA Effects stands for Interaction Effects and captures the effects of the interaction terms [covariable * female].

P-values are presented in parenthesis (*** p <0.01, ** p <0.05, * p <0.1). All columns include year dummies. All data come from the DZHW graduate panel except for the female shares within subjects (German Federal Statistical Office), female shares within occupations (Federal Employment Agency), as well as the data on the consumer price index (German Federal Statistical Office).

Table 5: Gender wage gaps for different fields of study, 1997-2013 pooled

	Male log wages	Female log wages	Observed Wage Gap	Explained	Unexplained	N
Agriculture	2.633	2.553	0.081	0.026	0.055	733
			(0.016)	(0.277)	(0.009)	
Arts	2.501	2.379	0.122	0.102	0.020	434
			(0.048)	(0.022)	(0.707)	
Economics & BA	2.935	2.809	0.126	0.037	0.089	3172
			(0.000)	(0.000)	(0.000)	
Education	2.556	2.411	0.146	0.114	0.032	1010
			(0.001)	(0.001)	(0.258)	
Engineering	2.969	2.788	0.182	0.111	0.071	4982
			(0.000)	(0.000)	(0.000)	
Health	2.835	2.774	0.061	0.005	0.055	2194
			(0.011)	(0.772)	(0.001)	
Humanities	2.402	2.308	0.094	0.058	0.036	2279
			(0.000)	(0.001)	(0.086)	
Law	2.225	2.171	0.055	-0.003	0.058	757
			(0.114)	(0.913)	(0.009)	
Natural Science	2.833	2.615	0.218	0.152	0.066	3418
			(0.000)	(0.000)	(0.000)	
Social Science	2.659	2.587	0.073	0.062	0.011	1877
			(0.001)	(0.000)	(0.580)	

Notes: P-values in parenthesis. All data come from the DZHW graduate panel except for the data on the consumer price index (German Federal Statistical Office).

Appendix

Table A1: Field of studies, subjects and female shares within subjects for the year 2013

Field of study	Subject	Female share 2013	
Education	Education	0.78	Female
	Special education	0.82	Female
Humanities	Language and culture	0.74	Female
	Protestant theology	0.60	Integrated
	Catholic theology	0.55	Integrated
	Philosophy	0.44	Integrated
	History	0.46	Integrated
	Library science	0.75	Female
	Lingustics and literature	0.75	Female
	Classical philology	0.59	Integrated
	German studies	0.77	Female
	English studies	0.72	Female
	Romance studies	0.81	Female
	Slavic studies	0.76	Female
	Non-European languages	0.63	Integrated
	Cultural studies	0.75	Female
Health	Psychology	0.75	Female
	Sport science	0.39	Integrated
	Health sciences	0.73	Female
	Medicine	0.61	Integrated
	Dentistry	0.63	Integrated
	Veterinary medicine	0.84	Female
Agriculture	Landscape planning	0.56	Integrated
	Agrarian food science	0.48	Integrated
	Forestry	0.33	Integrated
	Food and household science	0.83	Female
Engineering	Industrial engineering	0.26	Male
	Engineering	0.20	Male
	Mining	0.18	Male
	Mechanical engineering	0.18	Male
	Electrical engineering	0.11	Male
	Traffic engineering	0.11	Male
	Architecture	0.58	Integrated
	Regional planning	0.50	Integrated
	Construction	0.28	Male
	Land surveying	0.31	Integrated
	Industrial engineering	0.21	Male
Arts	Arts	0.81	Female
	Visual arts	0.54	Integrated
	Design	0.61	Integrated
	Performing arts	0.63	Integrated
	Music	0.53	Integrated
Natural Sciences	Natural sciences interdisciplinary	0.55	Integrated
	Mathematics	0.47	Integrated
	Computer science	0.19	Male
	Physics, astronomy	0.25	Male
	Chemistry	0.43	Integrated
	Pharmacy	0.70	Integrated

	Biology	0.62	Integrated
	Geoscience	0.42	Integrated
	Geography	0.48	Integrated
Law	Law	0.54	Integrated
Social Sciences	Law, business and social sciences, general	0.63	Integrated
	Political sciences	0.42	Integrated
	Social sciences	0.59	Integrated
	Social work	0.77	Female
Economics & BA	Public administration	0.51	Integrated
	Economics & Business Administration	0.49	Integrated

Notes: The data come from the German Federal Statistical Office.

Table A2: Share of men and women in female-dominated, male-dominated and integrated subjects and occupations for the years 1997–2013

		Subjects			Occupations		
		Female-dominated	Integrated	Male-dominated	Female-dominated	Integrated	Male-dominated
1997	Male	0.06	0.43	0.51	0.07	0.37	0.56
	Female	0.30	0.60	0.09	0.32	0.47	0.21
	All	0.16	0.50	0.33	0.17	0.41	0.42
2001	Male	0.09	0.43	0.47	0.09	0.40	0.51
	Female	0.33	0.48	0.20	0.27	0.42	0.31
	All	0.23	0.46	0.31	0.20	0.41	0.39
2005	Male	0.08	0.45	0.48	0.07	0.39	0.54
	Female	0.36	0.53	0.10	0.30	0.48	0.21
	All	0.24	0.50	0.26	0.20	0.44	0.36
2009	Male	0.10	0.47	0.43	0.12	0.49	0.38
	Female	0.44	0.50	0.06	0.39	0.52	0.09
	All	0.31	0.49	0.20	0.29	0.51	0.20
2013	Male	0.05	0.43	0.52	0.14	0.45	0.41
	Female	0.28	0.61	0.11	0.43	0.47	0.10
	All	0.18	0.53	0.28	0.31	0.46	0.23

Notes: Female shares are based on data from the German Federal Statistical Office (subjects) and from the Federal Employment Agency (occupations). The shares of men and women within female-dominated, male-dominated and integrated subjects and occupations are calculated based on the DZHW graduate panel.

Table A3: OLS estimates for gross hourly wages, 1997-2013

		(1)	(2)	(3)	(4)	(5)	(6)
1997[*)]	Female	-0.264***	-0.124***	-0.103***	-0.0928***	-0.0790***	-0.0621***
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
	Female subject			-0.141***		-0.0714*	-0.0727**
				(0.001)		(0.087)	(0.050)
	Integrated subject			-0.196***		-0.163***	-0.107***
				(0.000)		(0.000)	(0.000)
	Female occupation				-0.249***	-0.242***	-0.120***
					(0.000)	(0.000)	(0.000)
	Integrated occupation				-0.110***	-0.0966***	-0.0388**
					(0.000)	(0.000)	(0.025)
	N	3749	3749	3749	3749	3749	3749
2001	Female	-0.203***	-0.151***	-0.121***	-0.131***	-0.111***	-0.0491***
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.004)
	Female subject			-0.219***		-0.118**	-0.104***
				(0.000)		(0.018)	(0.007)
	Integrated subject			-0.283***		-0.257***	-0.161***
				(0.000)		(0.000)	(0.000)
	Female occupation				-0.278***	-0.284***	-0.106***
					(0.000)	(0.000)	(0.001)
	Integrated occupation				-0.0909***	-0.0660**	-0.0559**
					(0.001)	(0.019)	(0.026)
	N	1856	1856	1856	1856	1856	1856
	Controls for:						
	Field of Study		Yes	Yes	Yes	Yes	Yes
	Full Controls						Yes

		(1)	(2)	(3)	(4)	(5)	(6)
2005	Female	-0.287***	-0.174***	-0.114***	-0.137***	-0.0941***	-0.0660***
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
	Female subject			-0.435***		-0.357***	-0.217***
				(0.000)		(0.000)	(0.000)
	Integrated subject			-0.333***		-0.299***	-0.197***
				(0.000)		(0.000)	(0.000)
	Female occupation				-0.289***	-0.227***	-0.0760***
					(0.000)	(0.000)	(0.000)
	Integrated occupation				-0.111***	-0.0683***	-0.0506***
					(0.000)	(0.000)	(0.000)
	N	6053	6053	6053	6053	6053	6053
2009	Female	-0.240***	-0.144***	-0.108***	-0.104***	-0.0882***	-0.0593***
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
	Female subject			-0.263***		-0.130***	-0.109***
				(0.000)		(0.000)	(0.001)
	Integrated subject			-0.268***		-0.235***	-0.167***
				(0.000)		(0.000)	(0.000)
	Female occupation				-0.336***	-0.308***	-0.116***
					(0.000)	(0.000)	(0.000)
	Integrated occupation				-0.0483**	-0.000388	0.00221
					(0.012)	(0.985)	(0.910)
	N	4635	4635	4635	4635	4635	4635
	Controls for:						
	Field of Study		Yes	Yes	Yes	Yes	Yes
	Full Controls						Yes

		(1)	(2)	(3)	(4)	(5)	(6)
2013	Female	-0.216***	-0.116***	-0.0797***	-0.0791***	-0.0592***	-0.0489***
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)
	Female subject			-0.392***		-0.227***	-0.196***
				(0.000)		(0.000)	(0.000)
	Integrated subject			-0.279***		-0.223***	-0.174***
				(0.000)		(0.000)	(0.000)
	Female occupation				-0.293***	-0.254***	-0.208***
					(0.000)	(0.000)	(0.000)
	Integrated occupation				-0.0581***	-0.0335*	-0.0453**
					(0.002)	(0.068)	(0.013)
	N	3058	3058	3058	3058	3058	3058
	Controls for:						
	Field of Study		Yes	Yes	Yes	Yes	Yes
	Full Controls						Yes

Notes: P-values in parenthesis (*** p <0.01, ** p <0.05, * p <0.1). Full Controls include in addition to fields of study (education, health, agriculture, engineering, arts, natural science, law, social science, economics & business administration; ref: humanities): education specific characteristics (highest degree, current PhD student, age at graduation, final grade university), job specific characteristics (internship, management position, part-time job), firm specific characteristics (public sector, big firm, location company), work history (working prior to university, working during university, unemployment duration, work experience, time as homemaker) and family specific characteristics (married, children, parent with *Abitur*). All data come from the DZHW graduate panel except for the female shares within subjects (German Federal Statistical Office), female share within occupations (Federal Employment Agency), as well as and the data on the consumer price index (German Federal Statistical Office).

*) Full Controls include final university grade for all years but 1997 (not available).

Table A4: OLS estimates for gross hourly wages, 1997-2013 pooled

	(1)	(2)	(3)	(4)	(5)	(6)
Female	-0.248***	-0.146***	-0.104***	-0.110***	-0.0829***	-0.0568***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Representation women in subject						
Female-dominated subject			-0.310***		-0.203***	-0.159***
			(0.000)		(0.000)	(0.000)
Integrated subject			-0.284***		-0.245***	-0.173***
			(0.000)		(0.000)	(0.000)
Representation women in occupation						
Female-dominated occupation				-0.297***	-0.267***	-0.129***
				(0.000)	(0.000)	(0.000)
Integrated occupation				-0.0950***	-0.0636***	-0.0258***
				(0.000)	(0.000)	(0.001)
Fields of study						
Education		0.111***	0.116***	0.173***	0.155***	0.0959***
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Health		0.453***	0.450***	0.403***	0.416***	0.227***
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Agriculture		0.242***	0.223***	0.150***	0.174***	0.0279
		(0.000)	(0.000)	(0.000)	(0.000)	(0.134)
Engineering		0.510***	0.269***	0.381***	0.231***	0.103***
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Arts		0.0874***	0.0775***	0.0483*	0.0673**	-0.0410*
		(0.002)	(0.006)	(0.080)	(0.017)	(0.092)
Natural Science		0.365***	0.256***	0.302***	0.253***	0.120***
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

	(1)	(2)	(3)	(4)	(5)	(6)
Law		-0.186***	-0.193***	-0.224***	-0.193***	-0.0904***
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Social Science		0.273***	0.273***	0.322***	0.324***	0.166***
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Economics & Business Administration		0.503***	0.497***	0.436***	0.475***	0.250***
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Full Controls						Yes
Constant	2.847***	2.432***	2.698***	2.570***	2.739***	2.589***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Number of Observations	19799	19799	19799	19799	19799	19799

Notes: P-values are presented in parenthesis (*** p <0.01, ** p <0.05, * p <0.1). All columns include year dummies. Full Controls include in addition to fields of study (education, health, agriculture, engineering, arts, natural science, law, social science, economics & business administration; ref: humanities): education specific characteristics (highest degree, current PhD student, age at graduation, final grade university), job specific characteristics (internship, management position, part-time job), firm specific characteristics (public sector, big firm, location company), work history (working prior to university, working during university, unemployment duration, work experience, time as homemaker) and family specific characteristics (married, children, parent with *Abitur*). All data come from the DZHW graduate panel except for the female shares within subjects (German Federal Statistical Office), female share within occupations (Federal Employment Agency), as well as and the data on the consumer price index (German Federal Statistical Office).