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# ABSTRACT

# Women in Management and the Gender Pay Gap*

We analyze the impact of women's managerial representation on the gender pay gap among employees on the establishment level using German Linked-Employer-Employee-Data from the years 2004 to 2018. For identification of a causal effect we employ a panel model with establishment fixed effects and industry-specific time dummies. Our results show that a higher share of women in management significantly reduces the gender pay gap within the firm. An increase in the share of women in first-level management e.g. from zero to above 33 percent decreases the adjusted gender pay gap from a baseline of 15 percent by 1.2 percentage points, i.e. to roughly 14 percent. The effect is stronger for women in second-level than first-level management, indicating that women managers with closer interactions with their subordinates have a higher impact on the gender pay gap than women on higher management levels. The results are similar for East and West Germany, despite the lower gender pay gap and more gender egalitarian social norms in East Germany. From a policy perspective, we conclude that increasing the number of women in management positions has the potential to reduce the gender pay gap to a limited extent. However, further policy measures will be needed in order to fully close the gender gap in pay.

| JEL Classification: | J16, J31, J71 |
|---|---|
| Keywords: | gender pay gap, women in management, board diversity, two-way fixed effects, linked employer-employee data |

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# 1 Introduction

Women remain underrepresented in top-level management positions across countries and most industries. Policies to increase the representation of women in these roles are discussed controversially in business, politics, public institutions, and other parts of society. In part, such measures are motivated by the idea that they may not just increase gender equality in the targeted positions but also involve spillover effects that help decrease other gender gaps, such as, for example, those in pay, hiring, and promotions. These spillover effects could work through channels such as female managers[1] being more concerned with gender equality, thus implementing policies to decrease gender gaps and promoting a more gender-equal organizational climate. Also, women in management may serve as role models and mentors for female employees, thereby increasing their productivity, negotiation skills, and likelihood to climb up the career ladder. The presence of women in powerful positions may furthermore constitute a stereotype-disconfirming experience to all employees, thereby decreasing prejudices and implicit biases that perpetuate existing gender gaps.

Whether a higher representation of women in management positions actually decreases gender gaps in the labor market is therefore a highly topical question. In this paper, we use Linked-Employer-Employee-Data from the years 2004 to 2018 to study the impact of women's managerial representation on the gender pay gap among subordinates on the establishment level. We use a relatively long establishment panel that is representative of the German economy both in terms of establishment sizes and industries and that contains information on women's representation both on the highest (first-) level and on second-level management. Therefore, we can explicitly account for the proximity of managers to their subordinates. Further, performing models of different functional form, we can test for the existence of non-linear effects of the share of women in management on the gender pay gap within a firm. Moreover, in separate analyses for East and West Germany, we can investigate the effects of female managers on the firm-specific gender pay gap in labor markets with very different degrees of gender inequalities. Finally, the observation period from 2004 to 2018 is particularly interesting in the German context: After an increase in the share of female managers from 2004 to 2012, Germany experienced a period of stagnation from 2012 to 2014. Partly reacting to this stagnation, a gender quota for supervisory boards of large publicly listed companies was introduced in 2015 and the public debate about the low representation of women in leadership positions of the corporate sector gained impetus.

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[1]We understand that individuals' gender identity can deviate from their sex assigned at birth. Unfortunately, the data set used in this study, only contains a binary indicator for gender. Therefore, for this study we use both the terms woman and female to refer to individuals labelled as women in the data.

For identification of causal effects, we exploit the panel structure of the data set which allows us to determine the impact of a higher share of women in first- and second-level management on the wages of men and women within an establishment in a fixed-effects regression framework, including establishment fixed effects as well as industry-specific time fixed effects. In this way, we control for unobserved time-constant establishment heterogeneity and, thus, selection of women into lower-paying firms, as well as differences in industry-wide trends of addressing gender gaps.

The results of our empirical analysis based on a representative sample of German companies from 2004 to 2018 show significant effects of women's managerial representation on the gender pay gap: an increase in the share of women in first-level management from zero to above 33 (66) percent decreases the adjusted gender pay gap from a baseline of 15 percent by 1.2 (3.2) percentage points. Women in second-level management have an even larger effect on the gender pay gap: an increase in their share from zero to more than 33 (66) percent decreases the gender pay gap by about 3 (6) percentage points. In a separate analysis for East and West Germany, we find very similar patterns in both parts of the country. Even in East Germany, where the gender pay gap is much lower and social norms towards gender roles in the labor market are more egalitarian, female managers have a statistically significant impact on the establishment-specific gender pay gap. Finally, we find larger effects for companies without collective bargaining agreements as compared to those with collective bargaining agreements for first-level management. Robustness checks show that potential bias from heterogeneity in treatment effects does not drive the results in our application.

Several empirical studies have analyzed the effect of women in management on the gender pay gap in the past. For example, the introduction of gender board quotas has been exploited to identify spillover effects of a higher share of women at the supervisory level to women employees' labor market outcomes at lower ranks. The empirical evidence from these studies is, however, not clearcut (Bertrand et al., 2019; Maida et al., 2019). In part, this may be due to the relatively short time horizon under consideration. Company-wide policies agreed on at the supervisory level may take time to be implemented by the firm's management and take effect at different levels of the hierarchy. Moreover, non-executive board members might not have a direct or indirect effect on employees of the respective firms because of their rare interactions with employees. Managers that are in closer contact in day-to-day business with employees and make personnel decisions on hiring, salaries, and promotions at lower levels of the company hierarchy or, as leaders of small firms, may have a more direct and immediate impact on pay and career progression of their subordinates. Therefore, an increased share of women in these positions may prove to be effective for reducing gender gaps among subordinates also

in the shorter run. Using personnel data of a large manufacturing firm, Drechsel-Grau et al. (2020) find gender gaps in bonus payments of subordinates to be smaller for female than for male managers. Cardoso et al. (2010) find that female leaders of small-sized Portuguese firms reduce the gender pay gap among their employees. Similarly, Bhide (2020) finds a man-to-woman change of top executive to reduce the gender pay gap relative to a man-to-man change in a sample of small German establishments. Hirsch (2013) finds that increasing the women's share in first- and second-level management decreases the gender pay gap in a cross section of German companies. This result is also confirmed by Zimmermann (2022) using panel data from 2004 to 2012.

We conclude from our results that increasing women's managerial representation has the potential to reduce the gender pay gap to a certain extent. Our results corroborate previous findings that daily interaction with the manager seems to play an important role: women benefit from the interaction with a female manager. We show that this is true even in East Germany, which has a much more gender egalitarian labor market than West Germany. The gender composition of management, however, is clearly not the only driver of the existing high gender pay gap in Germany. Further policy measures will be needed in order to fully close the gender gap in pay.

## 2 Theoretical considerations and previous literature

The share of women in management can affect the gender pay gap within the firm through a variety of channels that are related to the different reasons for the existing gender wage inequalities. First, to the extent that the existing gender pay gap within the firm is caused by explicit discrimination against women and to the extent to which this discrimination is more prevalent and pronounced among male than female managers, a higher share of women in management will decrease this explicit discrimination, thereby reducing gender inequalities within the firm. Moreover, female managers might affect gender pay inequalities in their firm if they practice a more gender-equal way to reward performance (Flabbi et al., 2019; Theodoropoulus et al., 2022) or if they promote and adopt corporate equal opportunity programs or pay transparency policies.

Gender inequalities, however, are not only driven by explicit discrimination, but are often rooted in implicit and unconscious biases and gender stereotypes (see Ellemers, 2017 for a comprehensive overview). In particular, these factors that drive interpersonal interactions are embedded in the structural contexts of corporations, where access to opportunities and power is still unequally distributed among men and women (Amis et al., 2020; Kanter, 1977a).

For example, following the theory of homophilous preferences, managers are more inclined to award, promote, and support employees of their own social group, such as their own gender (Ertug et al., 2022).

If present, women in management positions could serve as mentors for their female subordinates (Kunze et al., 2017) and provide network opportunities that are beneficial for the promotion of their careers (Cullen and Perez-Truglia, 2023). Furthermore, there might be positive manager-worker interaction effects (Zimmermann, 2022), e.g. female managers might serve as role models and motivate female employees, as well as increase their performance and aspirations (Beaman et al., 2009). Finally, the mere presence of women in powerful positions might constitute a stereotype-disconfirming experience for all workers in the firm, thereby diminishing implicit biases and gender stereotypes in this entity and, consequently, increasing gender equality on a general level (Adriaans et al., 2023).

In our empirical analysis, we are not able to disentangle all these potential mechanism or identify their quantitative importance. However, we can shed some light on the variation of the impact of female managers by organizational context. In particular, we can differentiate between the share of women in first-level and second-level management, providing evidence on the relative importance of closeness of contact between the manager and the employees. Moreover, we will estimate models of different functional forms to detect potential non-linearities in the effects of the share of female managers on the gender page gap. Finally, we will perform separate analyses for East and West Germany to detect heterogeneities by surrounding cultural norms regarding the role of men and women at the workplace, as well as separate analyses for companies with and without collective bargaining coverage. In this way, we can differentiate the analyses by the level of managers' discretion in the payment of their workers.

## 3  Data

We use the Linked-Employer-Employee-Data (LIAB Cross-Sectional Model 2 9317) of the German Institute of Employment Research (IAB) for our empirical analysis. The data set combines the yearly survey of German establishments (Establishment Panel) with administrative data from social security records of individuals employed at the respective establishments. The Establishment Panel contains information on the business and employment situation as well as the expectations of a representative sample of German establishments.[2] The individual-level data of the LIAB Cross-Sectional Model contains information on daily earnings, education,

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[2]An establishment is a regionally and economically separate unit with employees. This means that branches of one company are considered separately if they are in different districts or if they exercise different economic activities (see Gensicke et al., 2022).

occupation, experience, and other characteristics of all individuals employed at the establishments on a specific cutoff date (June 30) in each year.

The Establishment Panel is supplemented with questions on women's representation in first- and second-level management as part of the modules on women in management positions for the years 2004, 2008, 2012, 2014, 2016, and 2018. Based on these years, we construct a panel data set. We impose the following sample restrictions:

- We restrict our sample to private-sector plants only.[3]

- Since we are interested in the impact of female managers on the wages of their subordinates, we do not include individuals in manager and supervisor roles as identified by the 4th digit of the KldB 2010 Classification of Occupations in our analysis.

- We restrict the sample to workers between the ages 20 and 65.

- Since the LIAB dataset contains information on daily wages but no details on daily hours worked, we restrict our sample to full-time employees.[4]

Daily wages in the LIAB dataset are right-censored at the contribution assessment ceiling, which varies by year and between East and West Germany. This affects 15.2 percent of men and 6.5 percent of women. Wages above the contribution assessment ceiling need to be imputed in order to obtain unbiased estimates (Gartner, 2005). For this wage imputation, we follow the 2-step procedure of Dauth et al. (2020), which uses tobit regressions on observable characteristics (step 1) and leave-one-out-means[5] (step 2) similarly as in Card et al. (2013). We run the regressions separately by year, gender, East and West Germany. Figure A1 shows the gap in the mean and the standard deviation of log daily wages before and after imputation by gender and region. The gaps in mean log wages of 0.02 to 0.04 and in the standard deviation of 0.03 to 0.06 are consistent with those of Card et al. (2013).

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[3]For this purpose, we follow Dauth et al. (2020) in constructing a 1-digit industry code. We drop observations from the industries Education, Health and Social Work, Non-industrial organizations and public administration. Furthermore, we drop observations from services industries that are public corporations ("Körperschaften des öffentlichen Rechts") or if the establishment is mainly or exclusively publicly owned.

[4]As a robustness check, we also run our main analysis for the full sample of employees, including full-time and part-time workers. The results do not change much, see section 6.

[5]These are mean wages over worker and plant without the respective observation under consideration. Thus, they function as firm- or worker-fixed effects within the imputation regression.

# 4 Empirical Strategy

We exploit the panel structure of the LIAB dataset to estimate the effect of women's representation in both first- and second-level management on the gender pay gap among subordinates. The representation of women in management may be correlated with unobserved establishment characteristics, such as the importance of gender equality in the workplace culture, that also affect the gender pay gap in the respective establishment. By including establishment fixed effects, we can control for time-constant unobserved heterogeneity. In addition, we include industry-specific time dummies to control for potential differences in industry-wide trends of addressing gender gaps. Thus, identification in this model comes from changes in the share of female managers within each establishment over time that are beyond industry-wide developments. The resulting regression model of the impact of women's representation in first-level management is of the form

$$
\begin{aligned}
w_{ijt} = \; & \beta_0 + \beta_1 wom_i + \beta_2 wmanag\_fl_{jt} + \beta_3 wmanag\_fl_{jt} \times wom_i \\
& + X_{it}(\gamma + \gamma_{wom} wom_i) + Y_{jt}(\delta + \delta_{wom} wom_i) \\
& + D_{ind,t}(\lambda + \lambda_{wom} wom_i) + c_j + \epsilon_{ijt}
\end{aligned}
\tag{1}
$$

where $w_{ijt}$ is the natural logarithm of the wage of individual $i$ at time $t$ in establishment $j$, $wom_i$ indicates whether individual $i$ is a woman, $wmanag\_fl_{jt}$ is the share of women first-level managers in establishment $j$ at time $t$. $X_{it}$ is a set of individual characteristics, including experience, tenure, and education. $Y_{jt}$ is a set of establishment characteristics, including size and the presence of a collective wage agreement. $c_j$ is a set of establishment fixed effects and $D_{ind,t}$ are industry-specific time dummies. $\epsilon_{ijt}$ is the error term, which we cluster at the establishment level. The coefficient of interest is $\beta_3$ capturing the effect of women's managerial representation on the gender pay gap through the interaction of $wmanag\_fl_{jt}$ and $wom_i$. In order to interpret $\beta_1$ as the average adjusted gender pay gap in the sample, we center all regressors around their means.

The corresponding regression model for second-level management includes two additional regressors, $wmanag\_sl_{jt}$ (share of women in second-level management) and $wmanag\_sl_{jt} \times wom_i$.

$$
\begin{aligned}
w_{ijt} = \; & \beta_0 + \beta_1 wom_i + \beta_2 wmanag\_fl_{jt} + \beta_3 wmanag\_fl_{jt} \times wom_i \\
& + \beta_4 wmanag\_sl_{jt} + \beta_5 wmanag\_sl_{jt} \times wom_i \\
& + X_{it}(\gamma + \gamma_{wom} wom_i) + Y_{jt}(\delta + \delta_{wom} wom_i) \\
& + D_{ind,t}(\lambda + \lambda_{wom} wom_i) + c_j + \epsilon_{ijt}
\end{aligned}
\tag{2}
$$

The variables of interest, $wmanag\_fl_{jt}$ and $wmanag\_sl_{jt}$ are shares, i.e. range between 0 and 1 (see Figure 3). One possibility is to include this continuous variable linearly in the regression model. Potentially, however, the impact of women in management on gender pay gaps in the establishment does not increase linearly but jumps at certain thresholds. For example, the critical mass theory (Kanter, 1977b) argues that single women as members of a group are considered as tokens and cannot change the way the group is working or the strategic decisions of the group. It is argued that the critical mass consists of at least a third of the members of the minority group (Joecks et al., 2013). Thus, we add another specification of equations 1 and 2 where we model the share of women among managers as a categorical variable with 4 values, (i) zero, (ii) greater than zero and up to 33 percent, (iii) greater than 33 percent and up to 66 percent, (iv) or greater than 66 percent.

# 5 Results

## 5.1 Descriptive Statistics

Table 1 presents descriptive statistics of our final dataset separately by employee gender. The table shows that, on average, women earn less than men (see subsection 5.1.1.). While there are some small differences in age and education, there are larger gender differences in duration in employment and job tenure. Moreover, on average, women work in smaller establishments. Further, there is considerable gender-based job segregation: on average, female employees face a higher share of female coworkers as well as female managers in their establishments than male employees.

Table 1: Descriptive Statistics

|  | Men | Women | Difference |
|---|---|---|---|
| Daily wage, imputed | 137.7 | 107.9 | 29.74*** |
| Age | 42.69 | 41.47 | 1.216*** |
| College degree | 0.171 | 0.177 | -0.00682*** |
| 12 years highschool or vocational degree | 0.759 | 0.735 | 0.0244*** |
| Number of days in employment | 6501.0 | 5498.0 | 1003.1*** |
| Number of days in job | 4013.2 | 3072.3 | 940.9*** |
| Number of employees at establishment | 8055.7 | 4499.0 | 3556.7*** |
| Share of women employees | 0.225 | 0.466 | -0.241*** |
| Share of women first-level management | 0.0688 | 0.143 | -0.0739*** |
| Share of women second-level management | 0.119 | 0.250 | -0.130*** |
| Observations | 5,741,318 | | |

### 5.1.1 Gender pay gap

Figure 1 shows the raw gender pay gap in the sample over the time period 2004 to 2018. Overall, the raw gender pay gap decreased from 22.5 percent in 2004 to 19.3 percent in 2018.[6] Throughout the whole observation period, the raw gender pay gap is much lower in East (10.7 percent in 2018) than in West Germany (22.6 percent in the same year, see Figure A2 in the Appendix). This finding is reported by a large body of literature (Schrenker et al., 2020) and attributed inter alia to the higher share of full-time working women and to more gender egalitarian social norms in East Germany (Rosenfeld et al., 2004).

Figure 1: Raw gender pay gap over time
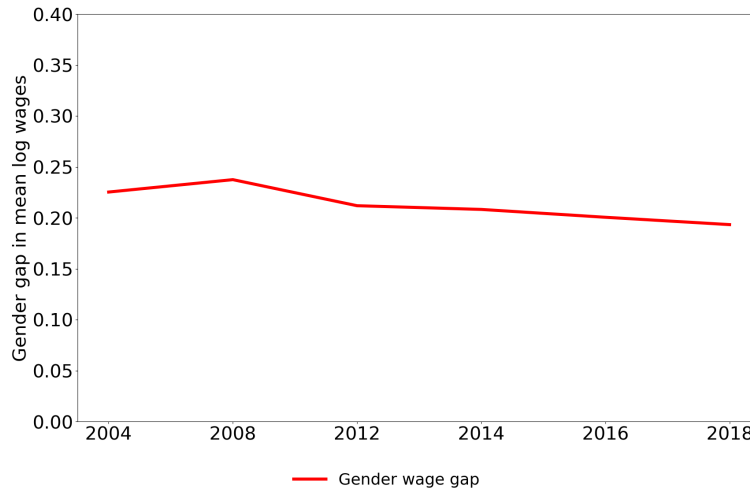


### 5.1.2 Women's managerial representation

Figure 2 shows the average share of women in first- and second-level management over all establishments (orange line) as well as weighted averages for male and female employees in our sample (blue and grey line, respectively) from 2004 to 2018. On average, women's representation in both, first- and second-level management has slightly increased over time. At the beginning of the observation period, in 2004, the share of female managers over the sample of establishments in the highest management level was about 17 percent. It increased up to almost 20 percent in the year 2012 and then increased further, however at a slower rate, up to

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[6]The gender pay gap in our dataset is larger than the German Federal Statistical Office's estimation of the raw gender pay gap, which decreased from 24 to 21 percent in West Germany and varied between 6 and 9 percent in East Germany between 2006 and 2018. The main reason for this discrepancy is rooted in differences in the underlying dataset. The Federal Statistical Office determines the raw gender pay gap from the structure of earnings survey ("Verdienststrukturerhebung"), which measures hourly instead of daily wages (Fuchs et al., 2019), therefore accounts for differences in daily working hours between men and women also within the group of full-time employees. Further, we explicitly exclude the public sector from our sample, where many salaries are determined by collective bargaining agreements and the gender pay gap is smaller.

about 21 percent in 2018. This development of the share of women in first-level management over time is also found in other studies (Kirsch et al., 2022). In second-level management, the share of women was higher than in first-level management over the whole observation period - it increased from about 26 percent in 2004 to about 36 percent in 2018.

When we separately look at the share of female managers for male (blue line) and female employees (grey line) in our sample, we find that both lines are below the (unweighted) share of female managers over all establishemnts (orange line). This is due to the fact that smaller firms have a higher share of women in management than larger firms (Kohaut et al., 2019). We further see that female employees in our sample face a higher share of female managers in their establishment on average than male employees for both first- and second-level management. This is in line with gender-based occupational segregation in the German labor market.

In Figure 3, we show the distribution of women in first- and second-level management based on a categorical variable, indicating the share of employees in companies with zero women in management, the share of employees in companies with up to 33%, greater than 33%, and up to 66%, or greater than 66% women in first or second-level management, respectively. Most companies (73 percent in 2019) still do not have any women in first-level management. In contrast, most companies (51 percent in 2018) have between 1 and 33 percent women in second-level management. In both management levels, however, the share of establishments with more than two-thirds of all members being women, is very small.

Figure 2: Average share of women among first- and second-level management positions faced by employees by employee gender

(a) Whole sample



- First-level management - Over male employees
- First-level management - Over establishments
- First-level management - Over female employees

(b) Restricted sample of establishments with second-level management



- First-level management - Over men employees
- Second-level management - Over women employees
- Second-level management - Over men employees
- First-level management - Over establishments
- First-level management - Over women employees
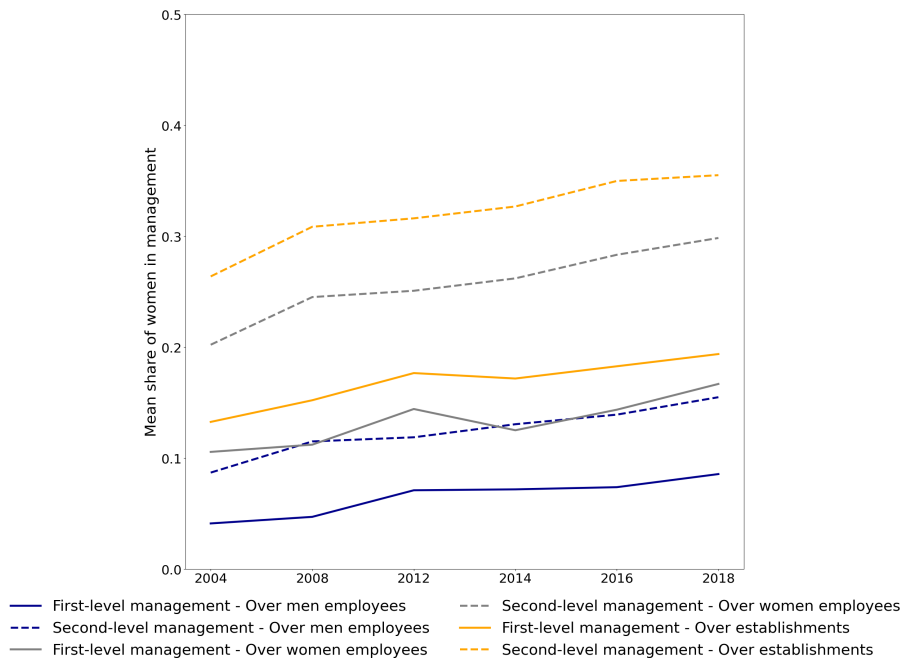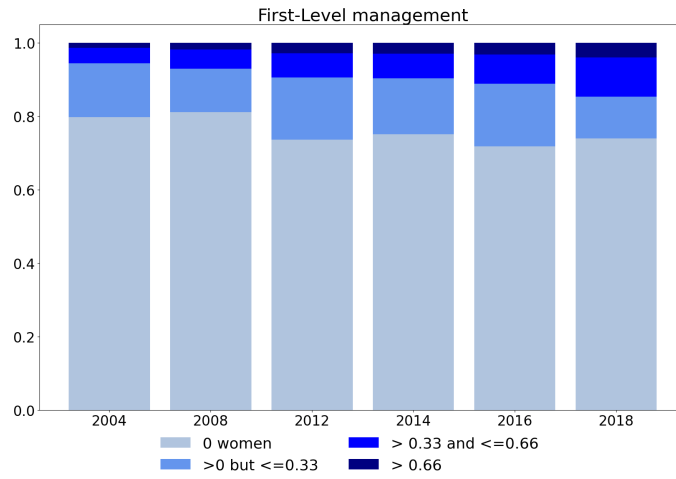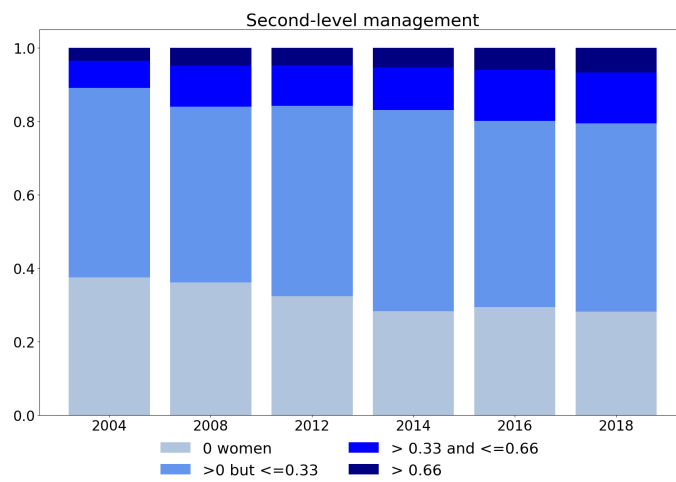- Second-level management - Over establishments
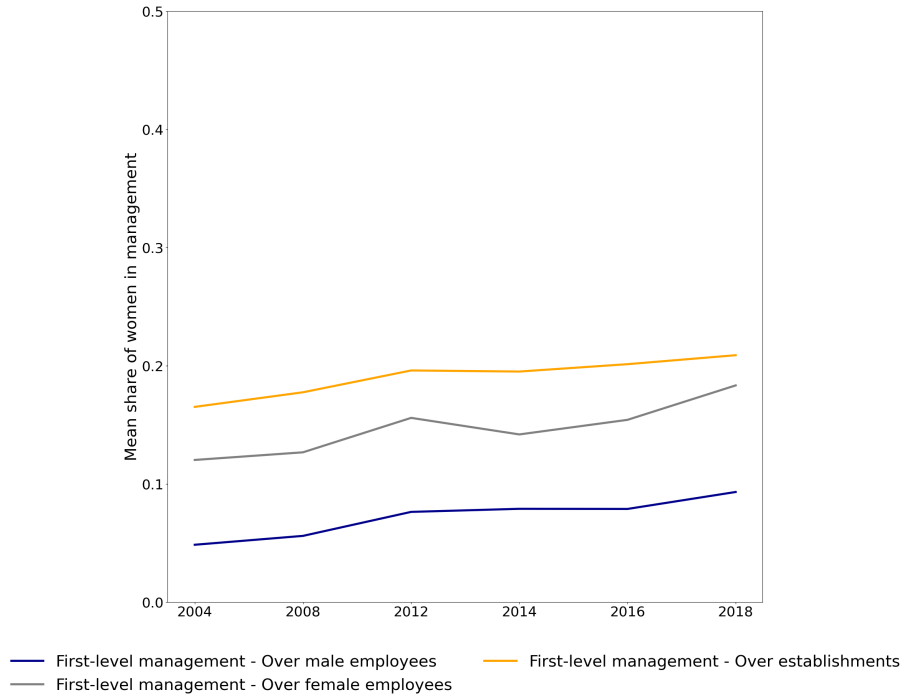
Figure 3: Share of employees in each category of women's representation in first- and second-level management

(a) First-level management



(b) Second-level management



Notes: Numbers for second-level management calculated using restricted sample of establishments with second-level management.

## 5.2 Estimation results

In the following, we present estimation results of the effect of women's managerial representation on the gender pay gap for both, first- and second-level management. Moreover, we present our results separately for East and West Germany, as well as for establishments with and without collective bargaining coverage.

### 5.2.1 First-level management

Table 2 presents the estimation results of equation (1), where the share of female managers is included linearly as a continuous variable. In the model that only controls for observable establishment characteristics (column (1)), we find a negative relationship between daily wages and the share of women in first-level management. This negative effect, however, is partly offset for female employees through a positive interaction effect. This suggests that, in establishments managed by women, all employees, but particularly men, earn less than in establishments managed by men. This finding is in line with the cross-sectional analysis of the 2008 LIAB data in Hirsch (2013).

Once we include establishment fixed effects (columns (2)-(4)), however, we find that the negative relationship between wages and the share of female managers disappears. Thus, the negative relationship seems to be driven by time-constant unobserved establishment heterogeneity. On the other hand, the coefficient of interest, i.e. the coefficient of the interaction between female worker and the share of female managers, $\beta_3$, remains substantial in size and highly significant. In our preferred specification, which includes establishment fixed effects, a linear time trend, and industry-specific time dummies (column (4)), the estimate of $\beta_3$ amounts to 2.9 log points. This implies that assuming a linear relationship an increase in the women's share in first-level management by 10 percentage points, e.g. from 10 to 20 percent, decreases the gender pay gap from 16.6 percent by approximately 0.3 percentage points.

Table 2: First-level management estimation results

|  | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Woman | -0.167** | -0.146** | -0.163** | -0.166** |
| Women in first-level management | -0.107** | 0.004 | -0.000 | 0.010 |
| Woman * Women in first-level management | 0.087** | 0.052** | 0.049** | 0.029** |
| Control for individual and firm covariates | Yes | Yes | Yes | Yes |
| Establishment fixed effects | No | Yes | Yes | Yes |
| Time dummies | No | No | Yes | No |
| Industry-specific time dummies | No | No | No | Yes |
| N | 3517320 | 3517320 | 3517320 | 3517320 |

$^*$ $p < 0.05$, $^{**}$ $p < 0.01$

In Table 3, we show the results of the model with a categorical specification of the share of women in first-level management. As in the model with the linear specification, we find a negative relationship between the share of women in first-level management and the wages within the establishment - at least if the share of female managers exceeds 33 percent (column (1)). This negative association vanishes, however, once we control for establishment fixed effects. In our preferred specification that includes establishment fixed effects, time dummies, and industry-specific time dummies (column 4), we find that a positive share of female managers below 33 percent does not affect the gender pay gap within the establishment (reference category: no women in first-level management). However, if the share of female managers is more than a third, we find a positive impact on the wages of female employees. This effect is even higher when the share of female managers is more than two-thirds. Our results imply that a change in the women's share in first-level management from 0 or below one-third to above one-third decreases the gender pay gap by 1.2 percentage points, i.e. from about 15 to 14 percent. An increase in the women's share to more than 66 percent of the first-level management decreases the gender pay gap by almost 3 percentage points, i.e. to roughly 12 percent.

These results actually hint at a non-linear relationship between the share of female representation in first-level management and the gender pay gap. It seems that a critical mass of more than a third of women in first-level management is needed to find effects on the gender pay gap within the establishment.

Table 3: First-level management estimation results - categorical specification

|  | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Woman | -0.176** | -0.150** | -0.163** | -0.149** |
| $> 0$ and $\leq 33\%$ women first-level mgmt | -0.009 | 0.008 | 0.007 | 0.012* |
| $> 33\%$ and $\leq 66\%$ women first-level mgmt | -0.046** | 0.001 | 0.001 | 0.006 |
| $> 66\%$ women first-level mgmt | -0.103** | -0.001 | -0.006 | 0.006 |
| Woman * $> 0$ and $\leq 33\%$ women first-level mgmt | 0.025* | 0.002 | 0.001 | -0.001 |
| Woman * $> 33\%$ and $\leq 66\%$ women first-level mgmt | 0.034** | 0.021** | 0.020** | 0.012** |
| Woman * $> 66\%$ women first-level mgmt | 0.083** | 0.051** | 0.053** | 0.032** |
| Control for individual and firm covariates | Yes | Yes | Yes | Yes |
| Establishment fixed effects | No | Yes | Yes | Yes |
| Time dummies | No | No | Yes | No |
| Industry-specific time dummies | No | No | No | Yes |
| N | 3517320 | 3517320 | 3517320 | 3517320 |

$^{*}$ $p < 0.05$, $^{**}$ $p < 0.01$

Notes: All coefficients for the categorical variable estimated with zero women in management as reference category.

### 5.2.2 Second-level management

For women in second-level management, we find even stronger effects on the gender pay gap than for women in first-level management. Conditioning on the share of women in first-level management, we find a negative impact of the women's share in second-level management on the gender pay gap among subordinates within the same establishment in all models (1) to (4). This holds in both the linear and the categorical specifications of the share of female managers.

In the linear model that includes establishment fixed effects and industry-specific time dummies (Table 4, Model 4) the estimated coefficient amounts to 6.3 log points. *Ceteris paribus*, an increase in the women's share of second-level management by 10 percentage points thus decreases the gender pay gap by approximately 0.63 percentage points, which is more than twice the effect of the same increase of women in first-level management.

Table 4: Second-level management estimation results

|  | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Woman | -0.167** | -0.149** | -0.150** | -0.148** |
| Share of women first-level management | -0.083** | 0.005 | -0.009 | 0.014 |
| Woman * Share of women first-level management | 0.070** | 0.037** | 0.037** | 0.023** |
| Share of women second-level management | -0.125** | 0.001 | -0.014 | 0.002 |
| Woman * Share of women second-level management | 0.090** | 0.080** | 0.083** | 0.063** |
| Individual and firm covariates | Yes | Yes | Yes | Yes |
| Establishment fixed effects | No | Yes | Yes | Yes |
| Time dummies | No | No | Yes | No |
| Industry-specific time dummies | No | No | No | Yes |
| N | 3126769 | 3126769 | 3126769 | 3126769 |

$^{*}$ $p < 0.05$, $^{**}$ $p < 0.01$

Table 5: Second-level management estimation results - categorical specification

|  | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Woman | -0.193** | -0.164** | -0.166** | -0.163** |
| > 0 and ≤ 33% women first-level mgmt | -0.017 | 0.006 | 0.001 | 0.009 |
| > 33% and ≤ 66% women first-level mgmt | -0.033** | 0.004 | -0.003 | 0.007 |
| > 66% women first-level mgmt | -0.073** | -0.001 | -0.012 | 0.005 |
| Woman * > 0 and ≤ 33% women first-level mgmt | 0.026* | -0.000 | -0.000 | -0.002 |
| Woman * > 33% and ≤ 66% women first-level mgmt | 0.028** | 0.015** | 0.014** | 0.010* |
| Woman * > 66% women first-level mgmt | 0.060** | 0.037** | 0.038** | 0.024** |
| > 0 and ≤ 33% women second-level mgmt | 0.005 | 0.008 | -0.000 | 0.003 |
| > 33% and ≤ 66% women second-level mgmt | -0.054** | -0.000 | -0.006 | -0.002 |
| > 66% women second-level mgmt | -0.103** | -0.004 | -0.013* | 0.000 |
| Woman * > 0 and ≤ 33% women second-level mgmt | 0.017* | 0.012* | 0.013** | 0.013** |
| Woman * > 33% and ≤ 66% women second-level mgmt | 0.045** | 0.036** | 0.038** | 0.029** |
| Woman * > 66% women second-level mgmt | 0.090** | 0.071** | 0.071** | 0.056** |
| Individual and firm covariates | Yes | Yes | Yes | Yes |
| Establishment fixed effects | No | Yes | Yes | Yes |
| Time dummies | No | No | Yes | No |
| Industry-specific time dummies | No | No | No | Yes |
| N | 3126769 | 3126769 | 3126769 | 3126769 |

$^*$ $p < 0.05$, $^{**}$ $p < 0.01$

Notes: All coefficients for the categorical variable estimated with zero women in management as reference category.

When we model the share of women in second-level management as a categorical rather than a continuous variable, we find similar results (Table 5). Actually, the share of women in second-level management almost linearly affects the gender pay gap: We find that if the share of women increases from zero to between 1 and 33 percent, the gender pay gap is reduced by 1.3 percentage points, conditional on the share of women in first-level management. If the share of women in second-level management increases from 0 to above one-third, the gender pay gap is reduced by 3 percentage points, whereas it is reduced by almost 6 percentage points if the share of women in second-level management is increased from 0 to more than two-thirds.

Note that, in this specification, the positive effect of the share of women in first-level management remains significant. This means that both women in first and second-level management have a separate impact on the gender pay gap. Taken together, these effects are sizeable: For example, if an establishment increases both the share of women in first and second-level management from zero to between 33 and 66 percent, the gender pay gap would decrease by 4 percentage points. In the (rather unlikely) case that an establishment would increase both variables from 0 to above 66 percent, the gender pay gap would decrease by almost 8 percentage points (baseline: 16 percent).

So far, our results suggest that women in second-level management, who are in closer contact with employees on a day-to-day basis, are more important for reducing gender inequalities in wages among their subordinates. Moreover, while we find non-linearities in the impact of female managers in first-level management on the gender pay gap within their establishment, the share of women in second-level management seems to have a linear impact on an establishment's gender pay gap.

## 5.3 Differences between East and West Germany

When we estimate our preferred model (which includes the share of women in first- and second-level management as a categorical variable) separately for East and West Germany, we find very similar patterns in both parts of the country (Table 6). In East and West Germany, the effect of second-level female managers is higher than first-level female managers. Most coefficients are a bit higher in West Germany, however, even in East Germany, where the gender pay gap is much lower, female managers have a statistically significant impact on the establishment-specific gender pay gap.

Table 6: First-level and second-level management estimation results for establishments - categorical specification

(a) West

|  | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Woman | -0.206** | -0.180** | -0.181** | -0.177** |
| > 0 and ≤ 33% women first-level mgmt | -0.0187 | 0.0096* | 0.0037 | 0.0123 |
| > 33% and ≤ 66% women first-level mgmt | -0.0379** | 0.0026 | -0.0055 | 0.0055 |
| > 0.66 women first-level mgmt | -0.0956** | -0.0096 | -0.0239* | 0.0004 |
| Woman * > 0 and ≤ 33% women first-level mgmt | 0.0198 | -0.0025 | -0.0026 | -0.0040 |
| Woman * > 33% and ≤ 66% women first-level mgmt | 0.0273** | 0.0159** | 0.0155** | 0.0119* |
| Woman * > 66% women first-level mgmt | 0.0662** | 0.0484** | 0.0483** | 0.0393** |
| > 0 and ≤ 33% women second-level mgmt | 0.0073 | 0.0100 | 0.0005 | 0.0019 |
| > 33% and ≤ 66% women second-level mgmt | -0.0399** | -0.0009 | -0.0085 | -0.0052 |
| > 66% women second-level mgmt | -0.103** | -0.0082 | -0.0165* | -0.0031 |
| Woman * > 0 and ≤ 33% women second-level mgmt | 0.0192* | 0.0133* | 0.0148** | 0.0156** |
| Woman * > 33% and ≤ 66% women second-level mgmt | 0.0401** | 0.0360** | 0.0380** | 0.0285** |
| Woman * > 66% women second-level mgmt | 0.0964** | 0.0751** | 0.0759** | 0.0595** |
| Individual and firm covariates | Yes | Yes | Yes | Yes |
| Establishment fixed effects | No | Yes | Yes | Yes |
| Time dummies | No | No | Yes | No |
| Industry-specific time dummies | No | No | No | Yes |
| N | 2,492,355 | 2,492,355 | 2,492,355 | 2492355 |

$^{*}$ $p < 0.05$, $^{**}$ $p < 0.01$

(b) East

|  | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Woman | -0.144** | -0.110** | -0.110** | -0.101** |
| > 0 and ≤ 33% women first-level mgmt | 0.0227 | -0.0186 | -0.0189* | -0.0135 |
| > 33% and ≤ 66% women first-level mgmt | -0.0377** | 0.0050 | 0.0028 | 0.0086 |
| > 66% women first-level mgmt | -0.0544** | 0.0063 | -0.0030 | 0.0122 |
| Woman * > 0 and ≤ 33% women first-level mgmt | 0.0456** | 0.0125 | 0.0132* | 0.0114* |
| Woman * > 33% and ≤ 66% women first-level mgmt | 0.0345* | 0.0151** | 0.0121* | 0.0102* |
| Woman * > 66% women first-level mgmt | 0.0531** | 0.0217* | 0.0262** | 0.00932 |
| > 0 and ≤ 33% women second-level mgmt | 0.0169 | 0.0048 | 0.0014 | 0.0036 |
| > 33% and ≤ 66% women second-level mgmt | -0.0652** | -0.0013 | -0.0013 | -0.0007 |
| > 66% women second-level mgmt | -0.102** | -0.0007 | -0.0078 | 0.0024 |
| Woman * > 0 and ≤ 33% women second-level mgmt | 0.0062 | 0.0039 | 0.0038 | 0.0020 |
| Woman * > 33% and ≤ 66% women second-level mgmt | 0.0442** | 0.0322** | 0.0332** | 0.0261** |
| Woman * > 66% women second-level mgmt | 0.0758** | 0.0611** | 0.0609** | 0.0440** |
| Individual and firm covariates | Yes | Yes | Yes | Yes |
| Establishment fixed effects | No | Yes | Yes | Yes |
| Time dummies | No | No | Yes | No |
| Industry-specific time dummies | No | No | No | Yes |
| N | 634,414 | 634,414 | 634,414 | 634414 |

$^{*}$ $p < 0.05$, $^{**}$ $p < 0.01$

Notes: All coefficients for the categorical variable estimated with zero women in management as reference category.

### 5.3.1 Differences by collective bargaining coverage

In a next step, we separate our sample by coverage of a collective bargaining agreement. First, we find that in companies without collective bargaining agreement (Panel (b) in Table 7), the adjusted gender pay gap is considerably higher than in companies with collective bargaining agreement (Panel (a)). In these companies, also the effect of the share of first-level female managers on the gender pay gap is lower than in those without collective bargaining agreement. In our preferred model with a categorical variable, the coefficient on having between 33 percent and 66 percent (more than 66 percent) women in first-level management is 0.013 (0.045) for establishments without collective bargaining agreements while only amounts to 0.007 (0.026) for those with collective bargaining agreements (Table 7). As far as the share of female managers in second-level management is concerned, we do not find differences between establishments with and without collective bargaining agreements (Table 8).

Table 7: First-level management estimation results for establishments with and without collective bargaining agreement - categorical specification

(a) With collective bargaining agreement

|  | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Woman | -0.152** | -0.135** | -0.152** | -0.153** |
| > 0 and ≤ 33% women first-level mgmt | -0.008 | 0.010 | 0.009 | 0.012 |
| > 33% and ≤ 66% women first-level mgmt | -0.039** | 0.005 | 0.004 | 0.010* |
| > 66% women first-level mgmt | -0.101** | 0.009 | 0.005 | 0.011 |
| Woman * > 0 and ≤ 33% women first-level mgmt | 0.018 | 0.000 | -0.001 | -0.002 |
| Woman * > 33% and ≤ 66% women first-level mgmt | 0.027** | 0.019** | 0.015** | 0.007 |
| Woman * > 66% women first-level mgmt | 0.071** | 0.044** | 0.045** | 0.026** |
| Control for individual and firm covariates | Yes | Yes | Yes | Yes |
| Firm-fixed effects | No | Yes | Yes | Yes |
| Time dummies | No | No | Yes | No |
| Industry-specific time dummies |  |  |  |  |
| N | 2657377 | 2657377 | 2657377 | 2657377 |

$^{*}$ $p < 0.05$, $^{**}$ $p < 0.01$

(b) Without collective bargaining agreement

|  | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Woman | -0.244** | -0.200** | -0.226** | -0.221** |
| > 0 and ≤ 33% women first-level mgmt | 0.004 | -0.007 | -0.003 | -0.001 |
| > 33% and ≤ 66% women first-level mgmt | -0.057** | -0.011* | -0.009* | -0.004 |
| > 66% women first-level mgmt | -0.097** | -0.020* | -0.025** | -0.018** |
| Woman * > 0 and ≤ 33% women first-level mgmt | 0.031* | 0.009 | 0.007 | 0.004 |
| Woman * > 33% and ≤ 66% women first-level mgmt | 0.044** | 0.026** | 0.024** | 0.013** |
| Woman * > 66% women first-level mgmt | 0.087** | 0.064** | 0.063** | 0.045** |
| Control for individual and firm covariates | Yes | Yes | Yes | Yes |
| Firm-fixed effects | No | Yes | Yes | Yes |
| Time dummies | No | No | Yes | No |
| Industry-specific time dummies |  |  |  |  |
| N | 859,943 | 859,943 | 859,943 | 859,943 |

$^{*}$ $p < 0.05$, $^{**}$ $p < 0.01$

Notes: All coefficients for the categorical variable estimated with zero women in management as reference category.

Table 8: Second-level management estimation results for establishments with and without collective bargaining agreement - categorical specification

(a) With collective bargaining agreement

|  | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Woman | -0.172** | -0.148** | -0.150** | -0.148** |
| > 0 and ≤ 33% women first-level mgmt | -0.017 | 0.009 | 0.003 | 0.012 |
| > 33% and ≤ 66% women first-level mgmt | -0.026* | 0.009 | 0.000 | 0.012* |
| > 66% women first-level mgmt | -0.063** | 0.005 | -0.008 | 0.010 |
| Woman * > 0 and ≤ 33% women first-level mgmt | 0.023 | -0.002 | -0.002 | -0.003 |
| Woman * > 33% and ≤ 66% women first-level mgmt | 0.022* | 0.014* | 0.013* | 0.009 |
| Woman * > 66% women first-level mgmt | 0.044* | 0.032** | 0.034** | 0.018* |
| > 0 and ≤ 33% women second-level mgmt | 0.008 | 0.013 | 0.001 | 0.005 |
| > 33% and ≤ 66% women second-level mgmt | -0.052** | 0.004 | -0.005 | -0.002 |
| > 66% women second-level mgmt | -0.102** | -0.001 | -0.010 | 0.001 |
| Woman * > 0 and ≤ 33% women second-level mgmt | 0.020* | 0.010 | 0.012* | 0.013* |
| Woman * > 33% and ≤ 66% women second-level mgmt | 0.043** | 0.033** | 0.036** | 0.028** |
| Woman * > 66% women second-level mgmt | 0.090** | 0.069** | 0.070** | 0.055** |
| Individual and firm covariates | Yes | Yes | Yes | Yes |
| Firm-fixed effects | No | Yes | Yes | Yes |
| Time dummies | No | No | Yes | No |
| Industry-specific time dummies | No | No | No | Yes |
| N | 2398137 | 2398137 | 2398137 | 2398137 |

$^*$ $p < 0.05$, $^{**}$ $p < 0.01$

(b) Without collective bargaining agreement

|  | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Woman | -0.255** | -0.220** | -0.220** | -0.212** |
| > 0 and ≤ 33% women first-level mgmt | 0.007 | -0.013 | -0.016* | -0.009 |
| > 33% and ≤ 66% women first-level mgmt | -0.051** | -0.010 | -0.013* | -0.006 |
| > 66% women first-level mgmt | -0.086** | -0.010 | -0.016 | -0.007 |
| Woman * > 0 and ≤ 33% women first-level mgmt | 0.024 | 0.008 | 0.007 | 0.007 |
| Woman * > 33% and ≤ 66% women first-level mgmt | 0.039** | 0.019** | 0.019** | 0.010* |
| Woman * > 66% women first-level mgmt | 0.074** | 0.045** | 0.045** | 0.034** |
| > 0 and ≤ 33% women second-level mgmt | -0.005 | -0.006 | -0.007 | -0.004 |
| > 33% and ≤ 66% women second-level mgmt | -0.051** | -0.010 | -0.011* | -0.007 |
| > 66% women second-level mgmt | -0.096** | -0.011 | -0.014 | -0.006 |
| Woman * > 0 and ≤ 33% women second-level mgmt | 0.004 | 0.013* | 0.013* | 0.013** |
| Woman * > 33% and ≤ 66% women second-level mgmt | 0.037** | 0.042** | 0.042** | 0.030** |
| Woman * > 66% women second-level mgmt | 0.072** | 0.074** | 0.074** | 0.054** |
| Individual and firm covariates | Yes | Yes | Yes | Yes |
| Firm-fixed effects | No | Yes | Yes | Yes |
| Time dummies | No | No | Yes | No |
| Industry-specific time dummies | No | No | No | Yes |
| N | 728,632 | 728,632 | 728,632 | 728,632 |

$^*$ $p < 0.05$, $^{**}$ $p < 0.01$

Notes: All coefficients for the categorical variable estimated with zero women in management as reference category.

# 6 Robustness Checks

## 6.1 Inclusion of Part-time workers

The LIAB data only contains information on daily wages, as well as a discrete variable indicating part-time or full-time work, but not the exact hours worked. Therefore, computing hourly wages is not possible. Thus, we restrict our main analysis presented in section 5 to full-time employees. However, since the share of women working part-time is very high, whereas part-time among men is very rare in Germany (Ilieva et al., 2022), it is not clear whether our results obtained from a sample of full-time workers hold for the whole workforce. In particular, selection into full-time and part-time work affects the gender pay gap among full-time employees if it depends on both earnings expectations as well as social norms regarding the role of men and women in the labor market. Further, women's managerial representation may be related to selection into and out of part-time work. For example, female managers might be more inclined to implement policies aimed at the reconciliation of family and career in order to encourage women to stay in full-time positions. In a similar manner, they may also encourage men to challenge gender stereotypes and take on part-time jobs. In these cases, women with lower earnings prospects would remain in full-time work (compared to the counterfactual case of not having the policy and encouragement of the manager in place) while men with higher earnings prospects would decide to switch to part-time work. Accordingly, the gender gap in hours worked would decrease but the gender pay gap among full-time employees would rise and bias our estimates of the causal effects of female managers on the unexplained gender pay gap towards zero.

To analyze whether these potential selection mechanisms drive our results obtained for the sample of full-time workers, we estimate a model including all full-time and part-time workers. Estimation results of this model (Table 9) show that the effect of women's managerial representation in first- and second-level management are of similar magnitude as in our main estimation.

Table 9: Robustness of estimates to including part-time workers - First- and Second-level management

|  | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Woman | -0.214** | -0.182** | -0.183** | -0.178** |
| > 0 and ≤ 33% women first-level mgmt | -0.016 | 0.006 | -0.000 | 0.008 |
| > 33% and ≤ 66% women first-level mgmt | -0.036** | 0.001 | -0.006 | 0.005 |
| > 66% women first-level mgmt | -0.081** | -0.008 | -0.021** | 0.000 |
| Woman * > 0 and ≤ 33% women first-level mgmt | 0.032* | 0.004 | 0.004 | 0.003 |
| Woman * > 33% and ≤ 66% women first-level mgmt | 0.030** | 0.017** | 0.016** | 0.011** |
| Woman * > 66% women first-level mgmt | 0.076** | 0.047** | 0.048** | 0.033** |
| > 0 and ≤ 33% women second-level mgmt | 0.003 | 0.009 | -0.001 | 0.002 |
| > 33% and ≤ 66% women second-level mgmt | -0.062** | -0.004 | -0.011* | -0.005 |
| > 66% women second-level mgmt | -0.111** | -0.015 | -0.024** | -0.007 |
| Woman * > 0 and ≤ 33% women second-level mgmt | 0.023** | 0.015** | 0.016** | 0.017** |
| Woman * > 33% and ≤ 66% women second-level mgmt | 0.044** | 0.040** | 0.042** | 0.033** |
| Woman * > 66% women second-level mgmt | 0.097** | 0.080** | 0.081** | 0.061** |
| Individual and firm covariates | Yes | Yes | Yes | Yes |
| Establishment fixed effects | No | Yes | Yes | Yes |
| Time dummies | No | No | Yes | No |
| Industry-specific time dummies | No | No | No | Yes |
| N | 3660607 | 3660607 | 3660607 | 3660607 |

$^{*}$ $p < 0.05$, $^{**}$ $p < 0.01$

Notes: All coefficients for the categorical variable estimated with zero women in management as reference category.

## 6.2 Right-censoring of wages

Daily wages in the LIAB dataset are right-censored at the contribution assessment ceiling and wages above the contribution assessment ceiling need to be imputed. To ensure that our results are not entirely driven by imputed wages, we repeat our analysis while excluding these from the estimation. Excluding all right-censored observations reduces our sample size from about 3.7 million observations to about 2.7 million. Comparing these results to the main estimation based on all full-time workers (Table 5), we find that the gender pay gap is, in general, lower (12.5 log points as compared to 16.3 log points), which is in line with previous findings showing a particularly high gender pay gap at the top of the wage distribution (Gallego Granados et al., 2019). The main coefficients of interest, however, i.e. the interaction terms between female managers and female workers, are similar in size as compared to our main specification. The only exception is the coefficient of the share of female managers between 1 and 33 percent in first-level management, which is almost zero and not statistically significant in this specification.

Table 10: First- and Second-level management estimation results without imputed wages

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Woman | -0.154** | -0.129** | -0.130** | -0.125** |
| $> 0$ and $\leq 33\%$ women first-level mgmt | -0.016 | 0.007 | -0.001 | 0.006 |
| $> 33\%$ and $\leq 66\%$ women first-level mgmt | -0.027** | 0.008 | 0.000 | 0.007* |
| $> 66\%$ women first-level mgmt | -0.070** | 0.006 | -0.009 | 0.000 |
| Woman * $> 0$ and $\leq 33\%$ women first-level mgmt | 0.025* | 0.002 | 0.002 | 0.000 |
| Woman * $> 33\%$ and $\leq 66\%$ women first-level mgmt | 0.018* | 0.009* | 0.007* | 0.002 |
| Woman * $> 66\%$ women first-level mgmt | 0.051** | 0.026** | 0.028** | 0.018** |
| $> 0$ and $\leq 33\%$ women second-level mgmt | 0.005 | 0.010 | -0.000 | -0.001 |
| $> 33\%$ and $\leq 66\%$ women second-level mgmt | -0.051** | 0.002 | -0.005 | -0.004 |
| $> 66\%$ women second-level mgmt | -0.102** | 0.000 | -0.011* | -0.008 |
| Woman * $> 0$ and $\leq 33\%$ women second-level mgmt | 0.015* | 0.008 | 0.009* | 0.009* |
| Woman * $> 33\%$ and $\leq 66\%$ women second-level mgmt | 0.038** | 0.025** | 0.027** | 0.022** |
| Woman * $> 66\%$ women second-level mgmt | 0.078** | 0.057** | 0.058** | 0.048** |
| Individual and firm covariates | Yes | Yes | Yes | Yes |
| Establishment fixed effects | No | Yes | Yes | Yes |
| Time dummies | No | No | Yes | No |
| Industry-specific time dummies | No | No | No | Yes |
| N | 2701681 | 2701681 | 2701681 | 2701681 |

$^*$ $p < 0.05$, $^{**}$ $p < 0.01$

Notes: All coefficients for the categorical variable estimated with zero women in management as reference category.

## 6.3 Robustness of two-way fixed effects estimation (TWFE) under heterogeneous treatment effects

In the models presented in Section 5, we estimate the impact of women's managerial representation on the gender pay gap at the establishment level in a fixed-effects regression framework with both establishment-fixed effects as well as industry-specific time fixed effects. A stream of literature (as surveyed in De Chaisemartin et al. (2022)) shows that, under heterogeneity of treatment effects over time or between groups, two-way fixed-effects estimators in general are not unbiased for the average treatment effect, i.e. they may not identify a convex combination of treatment effects over time and groups weighted by their relative number of observations in the sample. Further, some of the weights attached to each time- and group-specific treatment effect may be negative. This is due to so-called "forbidden comparisons" (Borusyak et al., 2021) of outcomes (i) between groups that switch treatment status between some periods $t-1$ and $t$ to groups that are treated in both of these periods, as well as (ii) groups that are exposed to different intensities of treatment in case of non-binary treatments.

Several ways to evaluate robustness of TWFE estimation to heterogeneous treatment effects have been suggested. Each of these apply to different estimation setups depending on whether dynamic effects can be ruled out or not, whether treatment adoption is staggered, and the

specific nature of the treatment variables (binary, discrete, or continuous).

In our application, heterogeneity in the impact of women's managerial representation on the gender pay gap between establishments and over time may arise for several reasons. First, the effectiveness and implementability of policies that aim to reduce the gender pay gap may depend on the current level of the gender pay gap in an establishment. Second, wages in some establishments may be stickier than in others, e.g. due to collective bargaining agreements or differing levels of employee turnover. Third, the ability of female managers to influence wages as a function of their share in management could be non-linear and vary between different levels of representation since a critical mass of supporters may be needed to change a certain policy. Since the treatment variables in our application are non-binary, both of the above-mentioned "forbidden comparisons" are relevant for our analysis.

We calculate the size of the negative weights as well as the heterogeneity-robust estimator suggested by De Chaisemartin et al. (2020) to assess the robustness of our estimates to heterogeneous treatment effects. In their framework, treatment varies at the group level and affects all units within a group. In our analysis, however, we are interested exactly in how managerial representation of women affects men and women within one group, i.e. one establishment, differently. Therefore, we cannot directly apply the suggested tools to our specification of a TWFE regression. Instead, we estimate the regression equation separately for men and women. This allows us to estimate the size of negative weights occurring in our original regression as the treatment variable varies at the establishment level, thus establishment-time specific weights attached to each treatment effect are the same in the equations estimated separately by men and women. Only for establishments where there are either only men or women employed will the size of potential negative weights differ. Thus the sum of negative weights in our baseline regression should be close to the sum of the negative weights obtained in the regressions that we run separately by gender.Moreover, we include means of employee characteristics, including tenure, experience, and education by year and establishment.
Table 11 shows that estimating the regression equations separately by gender yields a positive effect of women's managerial representation in first-level management on wages of men and women, but more so for women. These results are in line with our finding of a negative impact of women's managerial representation in first-level management on the gender pay gap from Section 5.

To assess how much negative weights (by which year- and establishment specific treatment effects are weighted in the calculation of the ATE) may affect the sign and bias our estimates, we calculate the sum of the negative weights attached to the year-establishment cells in each of

the regression models. Table 12 shows that the sum of negative weights is small in regressions both for women and for men. From this small sum of negative weights in these regressions we conclude that heterogeneity of treatment effects over time or between groups does not seem to play a major role in our application. Thus, we trust our results in the specifications of the two-way fixed effects model presented in section 5.

Table 11: TWFE regressions of log wages on women's representation in first-level management separate by gender

|  | (1) | (2) |
|---|---|---|
| Men - Women's share in first-level management | 0.013 | 0.012 |
| Men - > 0 women's share in first-level management | 0.002 | 0.003 |
| Men - >33% women's share in first-level management | 0.004 | 0.003 |
| Men - ≥50% women's share in first-level management | 0.007 | 0.006 |
| N | 2892416 | 2892272 |
| Women - Women's share in first-level management | 0.02** | 0.018** |
| Women - >0 women's share in first-level management | 0.008** | 0.009** |
| Women - >33% women's share in first-level management | 0.008** | 0.008** |
| Women - ≥50% women's share in first-level management | 0.009* | 0.008* |
| N | 1334109 | 1334045 |
| Control for firm covariates | Yes | Yes |
| Establishment fixed effects | Yes | Yes |
| Industry-specific time dummies | Yes | Yes |
| Added firm-mean of individual covariates | No | Yes |

$^{*}$ $p < 0.05$, $^{**}$ $p < 0.01$

Table 12: Sum and count of positive and negative weights in regressions by gender

|  | Positive | Negative |
|---|---|---|
| Men - Women's share in first-level management | 1.11 | -.11 |
| Men - > 0 women's share in first-level management | 1.03 | -.03 |
| Men - >33% women's share in first-level management | 1.01 | -.01 |
| Men - ≥50% women's share in first-level management | 1.01 | -.01 |
| Women - Women's share in first-level management | 1.14 | -.14 |
| Women - >0 women's share in first-level management | 1.05 | -.05 |
| Women - >33% women's share in first-level management | 1.04 | -.04 |
| Women - ≥50% women's share in first-level management | 1.03 | -.03 |

specification including firm-means of individual covariates

# 7    Conclusion

Gender inequalities in the labor market are still prevalent in all countries of the world. While some convergence has been achieved in dimensions such as educational attainment and labor force participation in many industrialized countries, other gender gaps remain strikingly constant, in particular the gender gap in pay. Similarly, the gender gap in leadership positions at the workplace is decreasing only very slowly, despite several policies that have been introduced, such as gender quotas for corporate boards. While one aim of these policies is to increase women's representation on boards, policy makers hope that by increasing the share of women in powerful positions, other gender inequalities can be decreased as well.

The empirical analysis presented in this paper shows that there is a causal relationship between the share of women in management and the gender pay gap within an establishment. While we cannot pin down the exact mechanism through which women in management affect equal pay in their firm, we can document some notable (non-)variation by corporate and cultural context.

First, we find that the share of women in second-level-management has a greater effect on the gender pay gap than the share of women in first-level management. These results suggest that women particularly benefit from frequent interactions with female managers. This corroborates results from previous studies showing that daily interactions between managers and their employees are an important channel for inequalities in pay (Cullen and Perez-Truglia, 2023; Zimmermann, 2022).

Second, we find relatively similar effects of female managers on the gender pay gap within an establishment in east and west Germany. Given that gender gaps in the labor market are so much more pronounced in west than in east Germany, this is a remarkable result. It implies that, even in a context of a labor market with relatively low gender gaps in pay, lower gender gaps in leadership positions, and relatively egalitarian social norms with respect to gender roles (Rosenfeld et al., 2004, Jessen, 2022), the gender of the manager plays a significant role when it comes to gender pay inequalities within the firm. We interpret this as even stronger evidence that frequent interactions with a female manager can positively affect wages of women.

Finally, we find functional form differences in the effect of female managers on the gender pay gap for first-level and second-level management. Our results show that the share of women in first-level management affects the gender pay gap in a non-linear way. Only if the share of women in first-level management exceeds the threshold of one-third do we find significant

effects on the gender pay gap. On the other hand, we do not find these non-linearities for second-level managers. Against the background of the much higher existing representation of women in second-level than in first-level management, these results provide empirical support for the theoretical notion of a critical mass and the theory of tokenism. In contexts where the presence of women is still rather rare, such as in first-level management, a critical mass of women needs to be present in order to impact the gender pay gap within the firm. In contexts where representation of women is already higher, such as in second-level management, these critical thresholds no longer play a role.

Overall, our results show that women in management influence the size of the gender pay gap within their firms. One important channel seems to be worker-manager interactions, where women benefit from interaction with female managers. However, our results also show that increasing the share of women in management alone will not make gender differences in pay disappear. Even if the share of women in first-level and second-level management increases to levels of gender parity, substantial gender differences in pay will remain. Thus, policies aiming at increasing the share of women in management positions need to be complemented by many other policies, e.g. family policies incentivizing more gender equality in care responsibilities (Frodermann et al., 2023) or pay transparency policies (Cullen, 2023).

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# A    Additional figures and tables

Figure A1: Gap in mean and standard deviation of log wages before and after imputation



Figure A2: Gender pay gap in West vs. East Germany