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ABSTRACT

Did the Minimum Wage Reduce the Gender Wage Gap in Germany?*

In many countries, women are over-represented among low-wage employees, which is why a wage floor could benefit them particularly. Following this notion, we analyse the impact of the German minimum wage introduction in 2015 on the gender wage gap. Germany poses an interesting case study in this context, since it has a rather high gender wage gap and set the minimum wage at a relatively high level, affecting more than four million employees. Based on individual data from the Structure of Earnings Survey, containing information for over one million employees working in 60,000 firms, we use a difference-in-difference framework that exploits regional differences in the bite of the minimum wage. We find a significant negative effect of the minimum wage on the regional gender wage gap. Between 2014 and 2018, the gap at the 10th percentile of the wage distribution was reduced by 4.6 percentage points (or 32%) in regions that were strongly affected by the minimum wage compared to less affected regions. For the gap at the 25th percentile, the effect still amounted to -18%, while for the mean it was smaller (-11%) and not particularly robust. We thus find that the minimum wage can indeed reduce gender wage disparities. While the effect is highest for the low-paid, it also reaches up into higher parts of the wage distribution.

JEL Classification: J16, J31, J38, J71

Keywords: minimum wage, gender wage gap, regional bite

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1 Introduction

The differences between men's and women's earnings have been studied extensively over recent years. One of its dimensions is the fact that women are often overrepresented among the low-paid employees (Kahn, 2015; Card *et al.*, 2016). This leads to the existence of a wage gap at the bottom of the distribution, also called 'sticky floors', and one possible way to alleviate this issue is the introduction of a minimum wage. If female employees are more prevalent among the wage floor beneficiaries than their male counterparts, they should also be disproportionately affected by a minimum wage, which would reduce wage disparities and thus the gender wage gap. In their seminal paper, DiNardo *et al.* (1996) find that labour market institutions such as a minimum wage can indeed reduce inequality, especially so for women. This line of research has been continued by an ample number of studies establishing a negative relationship between the minimum wage and the gender wage gap for a variety of countries.[1]

In this context, Germany poses an interesting case study. On the one hand, it is a country with a relatively high gender wage gap, especially at the bottom of the wage distribution. In 2014, the difference between the earnings of full-time employed men and full-time employed women amounted to 17.2 percent in Germany, placing it in the upper third of countries with the highest gaps, above the OECD average (see Figure 1a).[2] At the first decile of the wage distribution, Germany even shows a wage difference of 18.2% in 2014, placing it among the eight countries with the highest gaps among low-income earners, and well above the United States and the United Kingdom (see Figure 1b). It is thus evident that Germany suffers from high gender wage discrepancies in an OECD comparison, especially among low-wage earners. On the other hand, Germany introduced a nationwide minimum wage in 2015, which was set at a comparably high level and had only few exemptions.[3] With €8.50 gross per hour, it ranked among the highest wage floors in Europe in terms of purchasing power (Caliendo *et al.*, 2019). Its level is to be re-evaluated every two years, and it was increased to €8.84

[1]See for example Bargain *et al.* (2019) and Robinson (2005) for UK and Ireland, Broadway and Wilkins (2017) for Australia, (Hallward-Driemeier *et al.*, 2017) for Indonesia, Li and Ma (2015) for China, and Majchrowska and Strawinski (2017) for Poland.

[2]In this paper, we look at the *unadjusted wage gap*, also called the raw gap. A substantial part of the raw gap can be explained by observable factors, such as differences in schooling, working hours, etc. For Germany, these factors can explain around three quarters of the gap (Destatis, 2020). The remaining unexplained part is called *adjusted gap*.

[3]The law only stipulated a few exemptions, mainly minors, trainees, specific interns, volunteers and long-term unemployed. Additionally, employees in sectors with pre-existing wage floors below €8.50 were exempted until the end of 2016 (for details, see also Caliendo *et al.*, 2019). For the Minimum Wage Act, see `https://www.gesetze-im-internet.de/englisch_milog/index.html`, last accessed on November 11, 2021.

in January 2017, being followed by additional increases in 2019 and the subsequent years (Mindestlohnkommission, 2016a, 2018, 2020a). Caused by its high initial value, the reform affected about four million employees, i.e. about ten percent of the eligible workers (Destatis, 2016). Among them, women were vastly overrepresented, since they accounted for two-thirds of affected employees (Mindestlohnkommission, 2016b; Burauel *et al.*, 2017). This has been attributed to insufficient regulations of the low-pay sector and gender segregation, which lead to an unequal coverage of collective bargaining agreements for men and women (Grimshaw and Rubery, 2013; Herzog-Stein *et al.*, 2018). Accordingly, the introduction of the wage floor could have an influence on gender inequality. In a simulation study for Germany, Boll *et al.* (2015) predict that in the absence of job losses, the minimum wage could reduce the average gender wage gap by 2.5 percentage points. However, with job losses, the effect could even be larger. This points to a potential caveat, namely that low-paid women quitting or losing their jobs would cause a decrease in the gap. However, since ex-post evaluation studies on Germany find only small employment effects and no strong evidence of gender-specific job-losses, we assume that there are no significant heterogeneous employment effects (see Caliendo *et al.*, 2019; Bonin *et al.*, 2018; Pestel *et al.*, 2020).

In our analysis, we mainly employ data from 2014 and 2018, which we obtain from the Structure of Earnings Survey (SES), a large obligatory survey that comprises detailed wage information for over one million employees working in 60,000 firms. First, we descriptively look at the wages of male and female employees who are eligible for the minimum wage and compare the wage gap in 2014 with the one in 2018. Second, following Card (1992), we make use of regional variation in the "minimum wage bite", i.e. the degree to which a region is affected by the minimum wage, and analyse the causal effects of the minimum wage introduction on regional gender wage gaps.[4] We are able to identify a significant effect on the wage gap at the regional level, especially for low-paid employees. Between 2014 and 2018, the gap at the 10^{th} percentile was reduced by 4.6 percentage points (or 32%) in regions that were strongly affected by the minimum wage compared to less affected regions. For the gap at the 25^{th} percentile, the effect still amounted to -18%, while for the mean it was smaller (-11%) and not particularly robust. Using a continuous bite measure, we can show that an increase in a region's bite by ten percentage points, reduces the wage at the 10^{th} percentile

[4] Since our post-reform data is from 2018, in our analysis we estimate the effect of both the initial introduction of the minimum wage as well the first increase from 2017. However, previous research shows that the reform had mainly significant wage effects in 2015, whereas there were no relevant effects after the first increase in 2017 (Burauel *et al.*, 2020; Fedorets *et al.*, 2019).

by 3.3 percentage points. This thus shows that the minimum wage reform led to a significant decrease in the wage gap especially at the bottom of the wage distribution.

The remainder of this paper proceeds as follows. Section 2 reviews the previous literature on gender-specific minimum wage effects on wages and presents the data that we use. Additionally, it offers a first descriptive overview of the gender-specific wages before and after the reform, as well as the regional differences in the wage gap and the bite measure. Section 3 then presents the identification strategy and displays the results of the main estimation and the robustness analyses. In section 4, we summarise our results.

2 Previous Evidence, Data and Descriptives

2.1 Previous Evidence

The previous evidence on gender-specific wage effects of the German minimum wage is scarce. In a descriptive analysis with the Socio-Economic Panel (SOEP), Herzog-Stein *et al.* (2018) find that the wage gap at the tenth percentile had reduced by seven percentage points (from 22% to 15%) two years after the reform, which the authors attribute to the minimum wage. Interestingly, the gender gap stagnated for the lowest paid five percent (at 18%), which they relate to circumvention strategies. Ohlert (2018) looks at wages below €10 in 2014 and 2015 and finds that women's wages increased more strongly (14.6%) than men's wages (11.3%) in East Germany, while in the former West German states there was no gender-specific difference.[5] Additionally, some causal studies on wage effects have included some gender-specific heterogeneity analyses. However, they do not estimate the effect on the wage gap itself and suffer from small samples sizes. Burauel *et al.* (2018) find that between 2014 and 2016 the minimum wage effect on hourly wages was significant for women and amounted to about 5.9%. While the male effect was larger, it did not satisfy the common trend assumption, challenging the results for this subgroup. Bachmann *et al.* (2020) find that female employees earning less than €8.50 in 2014 experienced a statistically significant wage growth of 5.7% directly after the reform, while the effect for men was postponed: they benefited from a wage growth of about 10.2% from 2015 to 2016 and 14.8% in the following year. There was no such effect on women's wages at this time. Overall, previous studies find indications that wages

[5]However, the results are based on the voluntary Earnings Survey (ES) and are potentially influenced by selectivity issues (see Ohlert, 2018; Dütsch *et al.*, 2017).

among the low-paid employees rose due to the minimum wage introduction.[6] Moreover, there is evidence that women's wages rose more strongly shortly after the reform and men's effects were possibly postponed. However, none of these studies have explicitly examined the effects of the minimum wage on the gender wage gap.

2.2 Data Sources and Preparation

There are only a few datasets that are suitable for evaluating the minimum wage effects in Germany. All of them have different advantages but also caveats and neither is completely ideal. The differences as well as the associated issues have been widely discussed before (see, e.g., Caliendo *et al.*, 2019; Mindestlohnkommission, 2020b). In this paper, we rely on the SES[7], provided by the Federal Statistical Office of Germany (Destatis). It is a rich earnings survey in which employers are obligated to participate. Next to firm level data, the SES entails detailed individual information taken directly from payroll accounting or personnel statistics. It has first been collected in 1951 and takes place every four years since 2006. In this paper, we mainly make use of the most direct pre- and post-reform waves that are available, namely 2014 and 2018. Additionally, we look at the data from 2010 in Section 3.3 in order to check the pre-treatment trends.

The SES 2014 and 2018 are well suited for our analysis since they are large datasets, that each contain more than 1 million employees working in over 60,000 firms. The businesses were obliged to provide information on wages, working hours, and other working conditions, allowing us to construct precise hourly wages. However, two caveats should also be noted. First of all, it does not take place yearly, forcing us to look at a rather long time-frame. Second, it is not a panel study but largely comprises repeated cross sections. The recent waves include employees from nearly all economic sectors that have at least one employee. Nonetheless, we exclude public sector employees, since for them there is no detailed regional information available beyond the federal state. However, since this sector does not typically suffer from low wages, it is not strongly affected by the minimum wage. The SES is representative at the level of the sixteen federal states. In order to exploit the regional variation of the minimum wage bite, we follow previous studies (see for example Bachmann *et al.*, 2020) and rely on the smaller 257 labour market regions (*"Arbeitsmarktregionen"*). Moreover, in a sensitivity

[6]See also Ahlfeldt *et al.* (2018), who find that wages in low-wage counties increased more rapidly than in high-wage counties, particularly so for low-paid employees.

[7]Source: FDZ der Statistischen Ämter des Bundes und der Länder, Verdienststrukturerhebung, 2010, 2014 and 2018.

analysis we also look at planning regions (*"Raumordnungsregionen"*) and districts (*"Kreise und kreisfreie Städte"*), the former being a less and the latter a more disaggregated regional classification (see Section 3.4).

Since the SES does not collect data on hourly wages, we compute them using monthly income and working hours. We employ the gross monthly earnings and subtract earnings received for premiums and overtime worked. We divide this by the number of paid working hours (excluding overtime).[8] In our analysis, we only look at employees who are eligible for the minimum wage. We thus exclude trainees, interns as well as minors without a vocational training.[9] We generate the gender wage gap at the regional level as the difference between men's and women's wages divided by men's wages. We do this for regional mean wages but also with the wages at the 10^{th} and 25^{th} percentiles of the gender-specific wage distributions. This allows us to look at wage differences not only at the mean but also specifically among low-paid employees.

2.3 Descriptive Statistics

Wage Gap and Fraction of Affected Employees As a first step in our empirical analysis, we examine different aspects of the gender wage gap descriptively.[10] As shown in Table 1, we rely on information for 755,431 individuals in 2014, 46% of them being female. In 2018, there are 742,716 individuals included, 44.9% of which are women. The mean wage of employees in our sample amounted to €16.80 in 2014. While men eligible for the minimum wage earned about €19.0 on average, their female counterparts earned only €14.4. This translates into a gender wage gap of 24.5%.[11] Four years later, wages had increased overall, but women's wages more strongly. Consistently, the wage gap at the mean decreased to 21.9% in 2018.

[Insert Table 1 here]

[8] If the number of paid working hours is not known, we divide by regular weekly working hours times 4.33, which is the average number of weeks in a month.

[9] Since we cannot identify employees working in sectors with pre-existing wage floors below €8.50, we follow previous studies and include them in our analysis (see e.g., Ohlert, 2018). This should not affect our results as these were only few sectors and regulations ran out at the end of 2016 (Mindestlohnkommission, 2016b). Nevertheless, we will address this issue in our robustness analysis.

[10] The SES provides individual weights that we use for the general descriptives and the calculation of regional wages and wage distributions. While the weights yield representative results on the level of federal states, they do not necessarily do so for a smaller regional level (see FDZ der Statistischen Ämter des Bundes und der Länder, 2019, for details). Therefore we exclude the weights as a sensitivtiy check in Section 3.4.

[11] It should be noted that the gender wage gap in our sample is larger than that for the overall population found in other studies. This is caused by different factors. First, we do not include public sector personnel, whose inclusion would lead to the gap being smaller. Second, we only look at workers who are not exempt from the minimum wage. Finally, we focus on the raw/unadjusted gender wage gap, while many studies examine the (lower) adjusted gap.

It also becomes apparent that women were overrepresented in the low-wage sector. In 2014, 9.3% of men but 16.3% of women were earning less than €8.50 per hour. Looking at the first minimum wage increase to €8.84, nearly every fifth woman (19.8%) in our sample was affected in 2014, compared with only 11.5% of men. Four years later, i.e. after the introduction and first increase of the minimum wage, less than one percent of either gender earned less than €8.50 and 2.8% of employees earned less than €8.84. However, among women the percentage was slightly larger than among men, suggesting that women were disproportionately affected by non-compliance with the wage floor.[12]

Wage Gap Over the Distribution Our sample displays a higher wage gap at the top of the wage distribution: in 2014, it amounted to 31% at the 90^{th} percentile, but to only about 10% at the first decile. However, the largest decrease in the gap is found at the bottom: at the 10^{th} percentile, the gap decreased by 3.84 percentage points. A more detailed representation of this is displayed in Figure 2. Here, we depict the wage gap at twenty quantiles. Between 2014 and 2018, the gap decreased along the whole distribution, but especially up to the 15^{th} percentile. Remembering that 16.3% (19.8%) of women earned less than €8.50 (€8.84) in 2014, this indicates a connection to the minimum wage introduction. The strongest reduction took place at the fifth percentile, where the gender wage gap in hourly wages decreased from 8.5% to 1.3% among eligible employees in our sample. There was also a strong reduction in the gap at the 10^{th} and 15^{th} percentile. However, at the 20^{th} and 25^{th} percentiles – i.e. above the share of affected women – it remained nearly constant.

[Insert Figure 2 here]

Regional Variation and Development Our findings are also underlined by Figure 3, which displays the regional variation in the gender wage gap at the first decile, i.e. one of the dependent variables in our later analysis. Figure 3a and 3b map the gap in 2014 and 2018, where red colouring indicates a positive wage gap and blue colouring a negative gap. The higher the absolute value, the higher the colour intensity. Figure 3c displays the difference in the gap between the two years.[13] It highlights the fact that the gap among the low-

[12] All evaluations of (non-)compliance find that a substantial number of eligible workers were paid less than the minimum wage even after the reform. Estimations of the magnitude of that issue differ depending on the data source. Summarising a number of studies, the minimum wage commission places non-compliance in the range of 1.3% to 6.8% for 2018 (Mindestlohnkommission, 2020b).

[13] Note that in the regional descriptives, information for Saxony is averaged over all Saxon labour market regions due to data approval issues. However, in our later analysis, we use detailed data on the ten Saxon regions.

paid decreased from 2014 to 2018 in most regions. Additionally, we see that in the East of Germany, the picture is rather homogeneous: the gap at the 10^{th} percentile was reduced in all East German regions, in many of them between five and fifteen percentage points. However, in the West, the development is more diverse. There are some regions that experienced a strong decrease in the gap, but also regions in which the gap substantially increased.

[Insert Figure 3 here]

The Minimum Wage Bite Another variable central for our analysis is the minimum wage bite, measuring the degree to which a region was affected by the minimum wage in 2014. The literature features a variety of bite measures such as the fraction of affected employees or the Kaitz index (see also Caliendo *et al.*, 2018). However, the Kaitz index indicates the ratio between the minimum wage and the regional mean wage and it is thus also affected by other determinants of the mean wage, which is why we focus on the fraction of affected employees. More precisely, we employ the regional share of eligible women earning less than the wage floor in relation to all eligible women (henceforth called 'fraction'), since we aim to identify regions in which women were especially affected by the minimum wage. Figure 4a displays the fraction for the 257 labour market regions in 2014. It can be seen that – in contrast to the wage gap – the bite is generally higher in the East of Germany. However, there are also regions in the West where women are affected above average. For the empirical analysis later on, we will use a binary "high-bite" indicator and split the sample into high- and low-bite regions at the median bite level of 17.15%. Figure 4b shows the regional distribution of this new indicator. While all regions in East Germany are high-bite regions (equal or above the median) and receive a value of 1 for this indicator, it also becomes clear that high-bite regions are found across the whole country.

[Insert Figure 4 here]

3 Methodological Approach and Results

3.1 Empirical Approach

In this paper, we aim to identify the impact of the German minimum wage on the gender wage gap. In our identification strategy, we follow Card (1992), who proposes an approach relying on regional variation (also employed by other authors, e.g. Stewart, 2002; Dolton *et al.*, 2010, 2012, 2015; Caliendo *et al.*, 2018). In contrast to other methods, it therefore does not depend on differences in legislation, which do not occur in the German case (see also Caliendo *et al.*, 2018). The approach incorporates the intuition that regional wages have to adapt to varying degrees in accordance with the introduction of a minimum wage. In regions where wages were lower prior to the introduction, the minimum wage is assumed to bite harder into the wage distribution and its effect on potential outcomes is thus expected to be stronger. The corresponding fixed effects estimation equation of the gender wage gap is defined as follows:

$$Gap_{j,t} = \alpha_r + \beta T_t^{2018} + \delta T_t^{2018} Bite_j^{2014} + \gamma X_{j,t} + \upsilon_{j,t}, \qquad with \quad t = \{2014, 2018\} \tag{1}$$

where $Gap_{j,t}$ denotes the gender wage gap in percent in region j at time t. α_r is a region-fixed effect and T_t^{2018} is a dummy taking the value of 1 in the year 2018. $X_{j,t}$ is a set of regional controls and $\upsilon_{j,t}$ is the error term. $Bite_j^{2014}$ denotes the regional bite. While we use the fraction of affected women in our main analysis, we also make use of the fraction of affected employees over both genders in our sensitivity analysis. In order to obtain a clearer picture, we employ the fraction as a binary bite measure, dividing regions at the median fraction. In the robustness checks, we also include the fraction as a continuous variable. $X_{j,t}$ entails control variables provided by the INKAR database.[14] It comprises of the regional GDP per capita, the population density, the share of women, the female employment rate as well as the uptake of childcare for children under three and children between three and five. All of those are measured in the previous year to avoid endogeneity issues.[15] To control for time persistent regional characteristics, we employ a fixed effect estimation with robust standard errors.

The identifying assumption of the difference-in-difference approach that we employ is that the treatment regions (i.e. high-bite regions) and control regions (i.e. low-bite regions) have common trends in the wage gap in the absence of the treatment. In order to test this, we estimate a placebo regression in Section 3.3, assuring us that the common trend assumption holds. However, we first turn to our main results in the following section.

[14]The "Indicators, Maps and Graphics on Spatial and Urban Monitoring" database is provided by the *Federal Institute for Research on Building, Urban Affairs and Spatial Development* (BBSR Bonn, 2021).

[15]The control variables are precisely defined as follows: gross domestic product in €1,000 per inhabitant, inhabitants per km^2, the share of women among inhabitants in percent, the share of women with contracts subject to social security contributions among all women in working age, the share of children under three years in childcare among all children under three, the share of children between three and six years in childcare among all children between three and six.

3.2 Main Results

In our main analysis we estimate equation (1) described in Section 3.1 with fixed effects. As already done in Section 2.3, we look at the wage gap at three different points of the distribution: the 10^{th} and the 25^{th} percentile as well as the mean. Accordingly, our results are divided with respect to these outcome variables, which is indicated by the three different panels in Table 2. Within each panel, we include the control variables in six steps, captured by columns (1) to (6). The table shows the coefficients and indicates their significance.

[Insert Table 2 here]

The first panel estimates the effect on the gap at the tenth percentile. Without the inclusion of further control variables (column 1), there is a strongly significant treatment effect of -5.2 percentage points. This is to say that – in comparison to regions with a low bite in 2014 – high-bite regions experience a reduction of the wage gap at the tenth percentile of 5.2 percentage points in 2018, ceteris paribus. This is accompanied by a general reduction of the gap of 3.6 percentage points between 2014 and 2018. When we include additional control variables iteratively, the magnitude of the treatment effect only slightly decreases and the significance is unchanged. In the most comprehensive specification (column 6), high-bite regions experience a reduction in the wage gap of 4.6 percentage points from 2014 to 2018 due to the minimum wage. This corresponds to a reduction of about 32% in the wage gap (compared to the level in 2014 which was 14.4% in these regions). It is interesting to note, that the significance of the dummy for 2018 vanishes after controlling for the employment rate of women, meaning that the wage gap for low-paid employees only reduced for highly affected regions, and very strongly so. When looking at the wage gap at the 25^{th} percentile (see Panel B), the treatment effect is still highly significant but not as large. It ranges from -2.8 to -3.4 percentage points depending on the specification. In our preferred specification (column 6) it corresponds to a relative effect of -18% compared to the level in 2014 (which was at 18.3%). For the wage gap at the mean (Panel C), the effects are least pronounced: in the most comprehensive specification (column 6), the significant treatment effect amounts to -2.3 percentage points, corresponding to a relative reduction of 11% (compared to the 2014 level which was 20.4%). The results suggest that there was a general reduction of the wage gap at the mean between 2014 and 2018, but regions in which women were particularly affected by the minimum wage experienced an additional decrease.

Overall, the analysis shows that there is a strong effect of the minimum wage, which is especially large at the bottom of the wage distribution. The gap at the tenth percentile is reduced by 4.6 percentage points (32%) between 2014 and 2018 in regions that were strongly affected by the minimum wage compared with less affected regions. Higher up in the distribution, the magnitude and significance of the results decrease. However, an effect can still be detected and it ranges from 18% at the 25^{th} percentile to 11% at the mean.

3.3 Common Trend

In order to analyse the common trend assumption, we make use of the 2010 wave of the SES. However, the structure of the SES significantly changed between 2010 and 2014. In 2010, there were fewer sectors included and – most important to our case – there were no firms with fewer than ten employees subject to social security contributions. Additionally, the month of data collection changed. Overall, there is information on over 1.9 million employees in about 34,000 businesses included in 2010, in comparison to about one million workers in 60,000 businesses in 2014 (Destatis, 2013; FDZ der Statistischen Ämter des Bundes und der Länder, 2019). Therefore, given that we cannot simply compare our previous results to the 2010 data, we make use of a subsample of firms, which we identify via a variable that is provided by the federal statistical office and that adapts the 2014 and 2018 data to the structure of the 2010 wave (FDZ der Statistischen Ämter des Bundes und der Länder, 2019). This leads to a slightly different subsample in comparison to our main analysis (see Table A.1): here, a smaller share of male and female employees was affected by the introduction of the wage floor. Accordingly, the wages that they display are higher. One reason for this is that the subsample does not include firms with fewer than ten employees, which usually pay less. Additionally, the gender wage gaps are slightly different between the two samples. However, the two samples are comparable overall.

In Table 3 we show the results of re-running the equation 1 with our subsample (columns 4 to 6) as well as the equation adapted to the pre-reform period (columns 1-3), which is defined as follows:

$$Gap_{j,t} = \alpha_r + \beta T_t^{2014} + \delta T_t^{2014} Bite_j^{2014} + X_{j,t} + \upsilon_{j,t}, \qquad with \quad t = \{2010, 2014\} \qquad (2)$$

The table shows that when looking at the time before the minimum wage introduction, i.e. between 2010 and 2014, the wage gap evolved similarly in high- and low-bite regions, which is indicated by a statistically insignificant interaction term. This confirms our assumption of a common trend in the gap before the reform. When turning to the replication of our main regressions for the years 2014 and 2018 with the subsample, we observe very similar results to our main specification presented in Section 3.2. Again, we find significant effects for the 10^{th} and 25^{th} percentile that are also comparable in magnitude. However, in contrast to our main results in Table 2, we do not find a significant effect for the mean gap. Nonetheless, our results give us confidence that the common trend holds and that the wage gaps would have developed similarly in high- and low-bite regions in absence of the reform, especially for the lower parts of the distribution.

[Insert Table 3 here]

3.4 Robustness Analysis

In the following, we will test the sensitivity of our results to a number of practical implementation issues. We look at different computations of the minimum wage bite, the exclusion of employees working in sectors with sector-specific minimum wages, different regional classifications, a non-weighted bite measure and weighted labour market regions.

Different Bite Measures First, we employ other variations of the bite measure. As discussed in Section 2.2, our main analysis relies on the ratio of affected female employees in 2014 to all female employees in 2014. However, we could also employ the minimum wage bite for all employees, irrespective of their gender. We thus re-run the estimation using the overall fraction (see Panel B in Table A.2, Panel A repeats the results of the main analysis for comparison). The results mirror those of the full estimation of our main analysis, although the effects are not as large in magnitude. This is caused by the fact that the fraction of affected employees calculated for women only better identifies the regions that are particularly subject to reductions in the wage gap. However, regions where men are also highly affected are not expected to experience a pronounced decrease in the wage discrepancies. A second bite variation that we employ is the continuous bite (see first Panel C in Table A.2). In our main estimation, we only distinguished between low-bite and high-bite regions, cut off at the median bite. Now we include the fraction of affected female employees as a continuous variable, allowing for more variation in the treatment. The variable ranges from 3.8% to 55.8%. Again, the structure of the results is rather similar to our main results, although the interpretation of the coefficients is slightly different. Here, a ten-percentage-point increase in the bite corresponds to a reduction of the wage gap at the tenth percentile by 3.3 percentage points in 2018. Similarly, the gap at the mean decreases by 1.8 percentage points.

Excluding Sector-Specific Minimum Wages The law stipulates that employees in sectors with pre-existing minimum wages below €8.50 were exempted from the wage floor until the end of 2016. Unfortunately, we are not able to identify these sectors in our data. Since these were only few sectors and regulations ran out at the end of 2016, this should not affect our results. Nevertheless, in order to test the robsutness of our results in that direction we can exclude all employees subject to *any* sector-specific minimum wages (most of them were above €8.50, see Mindestlohnkommission, 2016b, for more details) and re-run our estimation (see Panel D in Table A.2).[16] Again, the results are similar to the main estimation and do not challenge our results.

Regional Classifications Moreover, we check the sensitivity in terms of the regional classification. In our main estimation, we decided to make use of the 257 labour market regions since they supply more variation than the 96 planning regions and include more observations per region than the 401 districts. In order to check whether this decision influences our results, we now make use of these other regional divisions (see Panels E and F of Table A.2). The results are very similar to our main results, although the effects sizes are again slightly smaller and the treatment effect at the mean becomes insignificant. However, the effects at the 10^{th} and 25^{th} percentiles are robust and mostly highly significant.

Weights Finally, we check whether our results are sensitive with respect to weighting issues. First, we focus on the individual weights provided by the Federal Statistical Office. As discussed before, our main analysis incorporates individual weights when calculating the minimum wage bite and the regional wage distributions. However, these are designed to yield representative results on the level of federal states. Since we run estimations on a smaller regional level, we check whether the inclusion of those weights influences our results. We therefore re-run our estimation without them (see Panel G in Table A.2). Additionally, since our main analysis does not include regression weights, we now repeat the analysis using the regional employment in 2014 as estimation weights (see Panel H in Table A.2). The results of both these sensitivity analyses are in line with the previous estimations, yielding very similar

[16] We thus exclude 98,076 men and 79,654 women in 2014 and 94,602 men and 71,567 women in 2018.

results compared to our main regression.

Overall, our analyses confirm the robustness of our results for low-paid employees with respect to different implementation decisions that we made in our main estimation. We can thus conclude that there is a negative and highly significant effect of the minimum wage on the gender wage gap at the bottom of the distribution. However, for the gap at the mean, the results are not as robust.

4 Conclusion

The introduction of the minimum wage in Germany was a major intervention into the labour market, which was – among other things – expected to reduce poverty and alleviate inequality (Bosch, 2007; Mindestlohnkommission, 2016b). One of the dimensions that could be affected is gender wage differentials. Germany poses an interesting research case, since it exhibits both large wage gaps and a high minimum wage. In our paper, we have thus analysed whether the wage floor did indeed lead to a decrease of the gender wage gap and – if so – at which point(s) of the distribution. For this purpose, we employed a regional difference-in-difference approach, making use of the regional variation in the degree to which female employees were affected by the minimum wage. Using comprehensive data from the Structure of Earnings Survey, we identify regional wage gaps in 2014 and 2018 as well as the regional fraction of affected female workers. Descriptively, we observe a reduction in the wage gap between 2014 and 2018 for the whole distribution. However, we also see that it was particularly reduced among the low-paid employees.

In our difference-in-difference analysis, we find that there was a significant decrease in the gender wage gap in regions in which women were strongly affected by the minimum wage in comparison to regions where women were less affected: high-bite regions experience a reduction of the wage gap at the 10^{th} percentile of 4.6 percentage points from 2014 to 2018 due to the minimum wage, and this effect is robust across specifications. The magnitude of this effect is large, corresponding to a relative reduction of about 32% compared to the level in 2014. When looking at the bite in a continuous definition, we find that increasing a region's bite by ten percentage points leads to a reduction of the wage gap at the 10^{th} percentile by 3.3 percentage points. Our placebo estimations show that there was no such effect before the reform, i.e. that the common trend assumption is reasonable. Additionally, we find that these effects fade out higher up the distribution. For the gap at the 25^{th} percentile, the effect still amounted to -18%, while for the mean it was smaller (-11%) and not particularly robust.

Overall, our analysis suggests that the minimum wage can be an effective tool for reducing the gender wage gap, especially at the lower end of the wage distribution. However, we do not incorporate employment effects. As discussed above, strongly affected women could be driven to quit or lose their jobs, which would artificially reduce the gender wage gap. While previous studies do not find strong evidence of this effect, future research should focus on this more thoroughly. Additionally, it would be insightful to determine the long-term effects on the gender wage differentials. Thus far, we are restricted to data from 2014 and 2018, which allows us to identify a medium-term effect but neglects possible long-run adaptation processes. Moreover, while our survey period includes the first minimum wage increase, an analysis of the subsequent raises could also yield relevant information. Finally, it would be interesting to disentangle the effects on the adjusted gender wage gap, not least because the distinction between the two is often a very essential issue in the gender wage gap debate.

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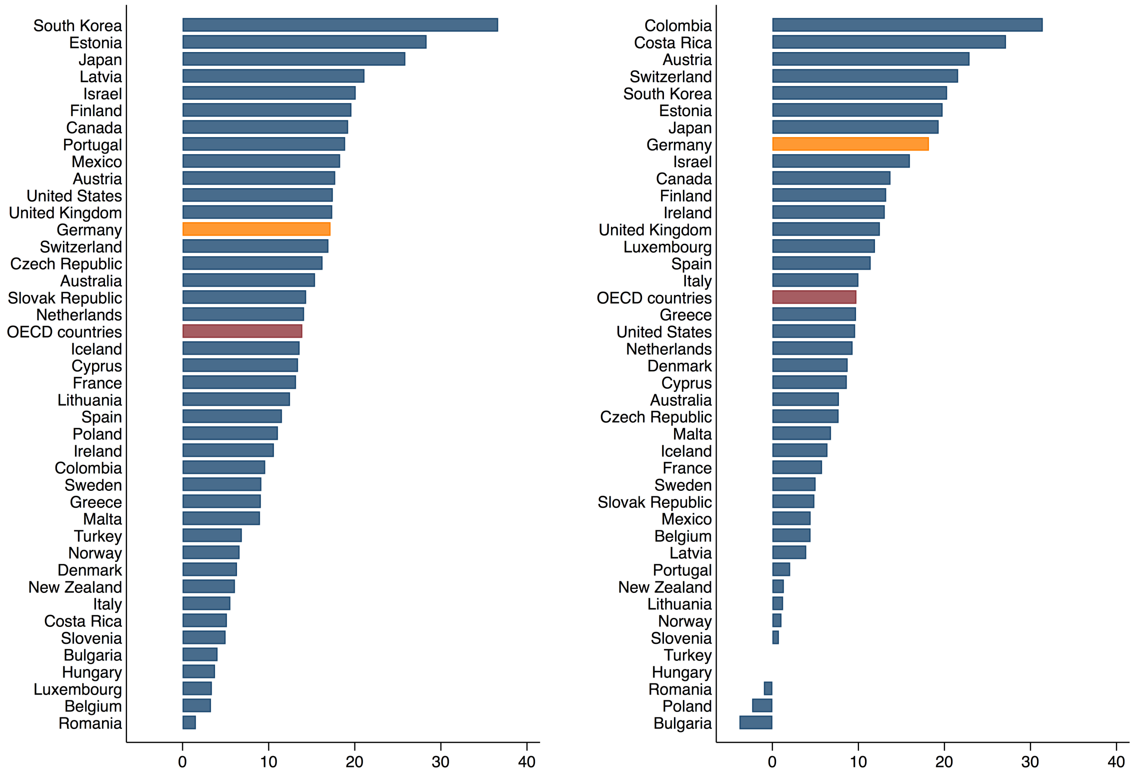
Figures

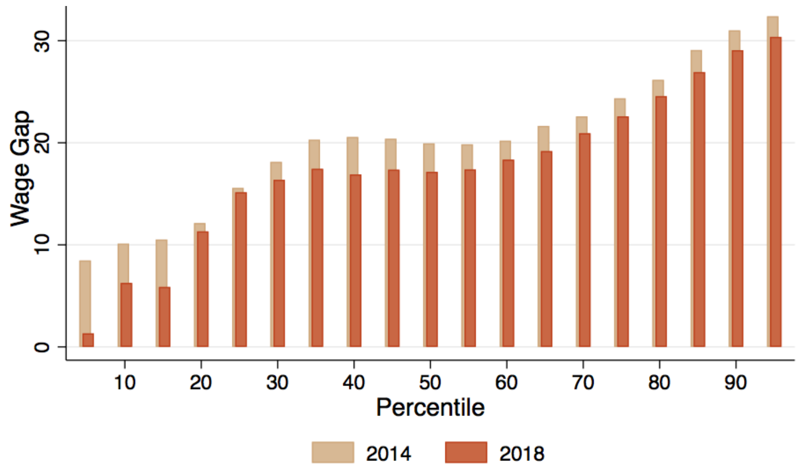
Figure 1: Unadjusted Gender Wage Gaps Across Different OECD Countries in 2014, in %

(a) Median (b) First Decile



Source: OECD (2020), Gender wage gap (indicator). doi: 10.1787/7cee77aa-en (Accessed on 22 September 2020).
Note: The gender wage gap is unadjusted and is defined as the difference between earnings of full-time employed men and full-time employed women relative to earnings of full-time employed men. Wages are measured at the median (Figure 1a) and the tenth percentile (Figure 1b).

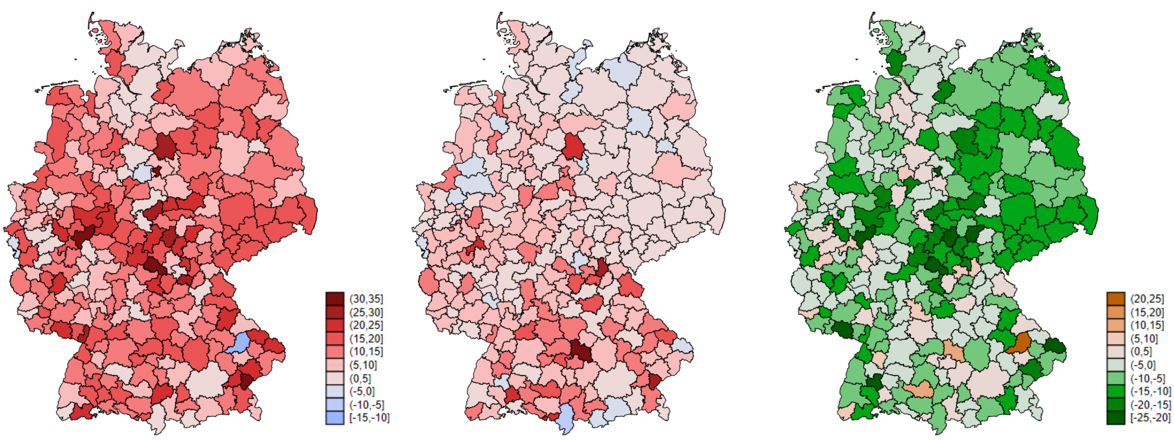
Figure 2: Wage Gaps at Percentiles of the Gender-specific Wage Distribution, in %



Source: SES 2014 and 2018, own calculation. Includes only employees eligible to the minimum wage, without public sector personnel.

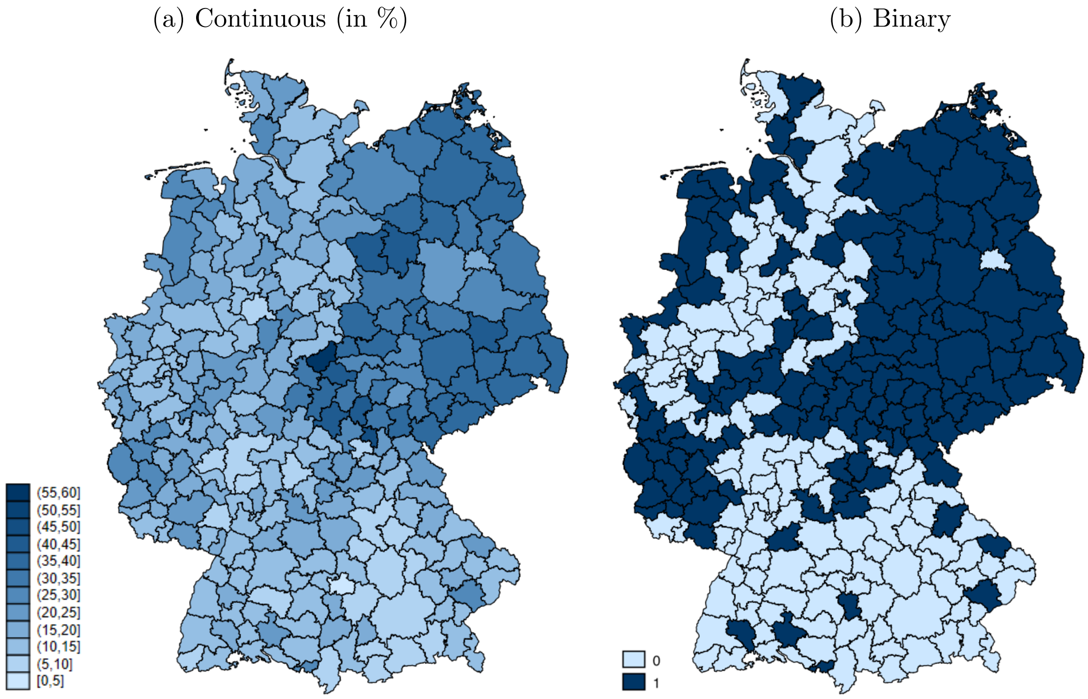
Figure 3: Regional Wage Gap at 10^{th} percentile in 2014 and 2018 and Difference in Gaps between both Years (in Labour Market Regions)

(a) Gap in 2014 (in %) (b) Gap in 2018 (in %) (c) Difference (in p.p.)



Source: SES 2014 and 2018 and BKG (2021), own calculations. Note: Due to clearing restrictions, data for Saxon regions is averaged for whole Saxony.

Figure 4: Fraction of Affected Female Employees in 2014 (in Labour Market Regions)



Source: SES 2014 and BKG (2021), own calculation. Note: Due to clearing restrictions, data for Saxon regions is averaged for whole Saxony.

Tables

Table 1: Descriptive Statistics on Wages, 2014 and 2018

	2014				2018			
	All	Men	Women	Gap (%)	All	Men	Women	Gap (%)
Share earning								
<8.50 (%)	12.66	9.34	16.28		0.69	0.62	0.76	
<8.84 (%)	15.47	11.54	19.76		2.83	2.39	3.33	
Mean	16.80	19.03	14.36	24.54	18.71	20.86	16.29	21.91
SD	11.56	13.75	7.86		12.98	15.65	8.46	
p10	8.01	8.56	7.70	10.05	9.46	9.82	9.21	6.21
p25	10.00	11.01	9.29	15.62	11.18	12.21	10.36	15.15
p50	14.11	15.67	12.54	19.97	15.58	17.10	14.17	17.13
p90	28.62	33.23	22.93	31.00	31.38	36.06	25.58	29.06
N	755,431	407,894	347,537		742,716	409,571	333,145	

Source: SES 2014 and 2018, own calculations.
Note: We only include eligible employees that are not employed in the public service. The used waves include employees from sectors A to S from the WZ 2008 classification. The SES contains workers that are employed throughout the whole month of April of the respective wave, but does not entail employees who are not paid for the full month because they were newly hired or let go.

Table 2: Fixed Effects Regressions of Wage Gaps at 10^{th} Percentile, 25^{th} Percentile and Mean (in Labour Market Regions)

	(1)	(2)	(3)	(4)	(5)	(6)
			A: Wage Gap at p10			
Bite x 2018	-5.228***	-5.085***	-4.870***	-4.735***	-4.550***	-4.550***
2018	-3.568***	-4.286***	-4.539***	-5.419***	-3.684	-3.754
GDP per capita (t-1)		0.153	0.152	0.126	0.147	0.158
Pop. Density (t-1)			0.024	0.020	0.017	0.015
Share of Women (t-1)				-2.722	-2.837	-2.610
Empl. Rate Women (t-1)					-0.412	-0.457
Childcare 0-2 (t-1)						0.044
Childcare 3-5 (t-1)						-0.061
			B: Wage Gap at p25			
Bite x 2018	-3.352***	-2.814***	-3.122***	-3.111***	-3.191***	-3.336***
2018	-1.454**	-4.154***	-3.792***	-3.865**	-4.612	-4.079
GDP per capita (t-1)		0.576**	0.578**	0.576**	0.567**	0.541**
Pop. Density (t-1)			-0.034	-0.034	-0.033	-0.027
Share of Women (t-1)				-0.225	-0.176	0.010
Empl. Rate Women (t-1)					0.178	0.280
Childcare 0-2 (t-1)						-0.239
Childcare 3-5 (t-1)						0.048
			C: Wage Gap at Mean			
Bite x 2018	-1.609*	-1.339	-1.634*	-1.684*	-2.139**	-2.297**
2018	-2.154***	-3.511***	-3.163***	-2.838*	-7.110**	-6.581**
GDP per capita (t-1)		0.289	0.292	0.301	0.249	0.229
Pop. Density (t-1)			-0.032	-0.031	-0.023	-0.018
Share of Women (t-1)				1.006	1.289	1.662
Empl. Rate Women (t-1)					1.014*	1.092*
Childcare 0-2 (t-1)						-0.228
Childcare 3-5 (t-1)						0.007
Observations	514	514	514	514	514	514
Groups	257	257	257	257	257	257

Source: SES 2014 and 2018, INKAR; own calculations.
Note: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. The table displays the results of fixed-effects estimations in a difference-in-difference framework with region-fixed effects and robust standard errors. The minimum wage bite is binary and the regions are the 257 Labour Market Regions. In Panel A the dependent variable is the unadjusted wage gap at the 10^{th} percentile of the regional gender-specific wage distribution. Accordingly, in Panel B (C) the dependent variable is the gap at the 25^{th} percentile (the mean). The reference year is 2014.

Table 3: Fixed Effects Regressions of Wage Gaps at 10^{th} Percentile, 25^{th} Percentile and Mean, with Subsample, from 2010 to 2014 and 2014 to 2018 (in Labour Market Regions)

	2010-2014			2014-2018		
	p10	p25	Mean	p10	p25	Mean
	(1)	(2)	(3)	(4)	(5)	(6)
Bite x 2014	2.277	2.031	1.075			
2014	-2.523	1.376	2.973			
Bite x 2018				-4.947***	-2.831**	-1.242
2018				-0.236	-2.608	-5.149
GDP per capita (t-1)	0.353	0.075	0.372	-0.130	0.374	0.011
Pop. Density (t-1)	0.013	0.031	-0.010	-0.006	-0.026	-0.025
Share of Women (t-1)	0.578	0.197	1.019	-1.377	4.160	2.737
Empl. Rate Women (t-1)	0.050	-0.016	-0.627	-0.171	0.352	1.027*
Childcare 0-2 (t-1)	-0.169	-0.244	-0.337	-0.074	-0.249	-0.098
Childcare 3-5 (t-1)	0.246	-0.047	0.119	-0.013	0.038	0.014
Observations	514	514	514	514	514	514
Groups	257	257	257	257	257	257

Source: SES 2014 and 2018, INKAR; own calculations.
Note: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. The table displays the results of fixed-effects estimations in a difference-in-difference framework with region-fixed effects and robust standard errors. The minimum wage bite is binary and the regions are the 257 Labour Market Regions. Columns (1)-(3) include regressions entailing the years 2010 and 2014, Columns (4)-(6) show regressions containing the years 2014 and 2018. In Columns (1) and (4) the dependent variable is the unadjusted wage gap at the 10^{th} percentile of the regional gender-specific wage distribution. Accordingly, in Columns (2) and (5) the dependent variable is the gap at the 25^{th} percentile, in Columns (3) and (6) it is the gap at the mean. The reference year is 2010 for Columns (1)-(3) and 2014 for Columns (4)-(6). The subsample is identified via the variable *GG2010*, which is provided by the federal statistical office and which adapts the 2014 and 2018 data to the structure of the 2010 wave (FDZ der Statistischen Ämter des Bundes und der Länder, 2019).

Appendix

Table A.1: Descriptive Statistics on Wages of Subsample 2010-2018

	2010			2014			2018		
	Men	Women	Gap (%)	Men	Women	Gap (%)	Men	Women	Gap (%)
Share earning									
<8.50 (%)	9.95	19.44		6.25	11.85		0.54	0.71	
<8.84 (%)	11.34	22.02		7.91	14.65		1.76	2.62	
Mean	19.16	14.43	24.67	20.54	15.64	23.88	22.35	17.55	21.50
SD	12.84	7.67		14.33	8.45		16.48	9.19	
p10	8.50	7.48	11.95	9.26	8.20	11.50	10.30	9.55	7.28
p25	11.65	9.21	20.94	12.36	9.94	19.58	13.41	11.14	16.93
p50	16.20	13.13	18.96	17.24	14.02	18.71	18.56	15.53	16.32
p90	32.65	22.75	30.32	35.17	24.82	29.44	38.29	27.68	27.70
N	892,994	612,996		345,701	265,859		328,844	244,403	

Source: SES 2010, 2014 and 2018, own calculations.
Note: We only include eligible employees that are not employed in the public service. The subsample is identified via the variable *GG2010*, which is provided by the federal statistical office and which adapts the 2014 and 2018 data to the structure of the 2010 wave (FDZ der Statistischen Ämter des Bundes und der Länder, 2019).

Table A.2: Sensitivity Analyses: Fixed Effects Regressions of Wage Gaps at 10^{th} Percentile, 25^{th} Percentile and Mean

	A: Main Results			B: Bite for All			C: Continuous Bite		
	p10	p25	Mean	p10	p25	Mean	p10	p25	Mean
Bite x 2018	-4.550***	-3.336***	-2.297**	-2.617***	-2.272**	-1.792*	-0.333***	-0.277***	-0.183***
2018	-3.754	-4.079	-6.581**	-4.000	-4.084	-6.471**	2.016	0.877	-3.336
Controls	yes	yes	yes	yes	yes	yes	yes	yes	yes
Observations	514	514	514	514	514	514	514	514	514
Groups	257	257	257	257	257	257	257	257	257
	D: No MW Sectors			E: ROR			F: Districts		
	p10	p25	Mean	p10	p25	Mean	p10	p25	Mean
Bite x 2018	-4.207***	-3.051**	-3.323***	-3.730***	-2.185*	0.133	-3.951***	-3.196***	-1.286*
2018	-3.598	-6.162*	-7.601**	-1.881	0.113	0.461	-0.739	-3.612	-3.275
Controls	yes	yes	yes	yes	yes	yes	yes	yes	yes
Observations	514	514	514	192	192	192	802	802	802
Groups	257	257	257	96	96	96	401	401	401
	G: No Individual Weights			H: Regression Weights					
	p10	p25	Mean	p10	p25	Mean			
Bite x 2018	-4.577***	-2.267**	-1.466*	-4.868***	-2.828***	-1.413*			
2018	-3.597*	-2.361	-4.486*	-0.782	-0.362	-2.578			
Controls	yes	yes	yes	yes	yes	yes			
Observations	514	514	514	514	514	514			
Groups	257	257	257	257	257	257			

Source: SES 2014 and 2018, INKAR; own calculations.
Note: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. The table displays the results of fixed-effects estimations in a difference-in-difference framework with region-fixed effects and robust standard errors. Control variables are included as in Table 2 but not reported. In the first column of each panel the dependent variable is the unadjusted wage gap at the 10^{th} percentile of the regional gender-specific wage distribution. Accordingly, in the second (third) column the dependent variable is the gap at the 25^{th} percentile (the mean). The reference year for all estimations is 2014. We adapt them main specification as follows: In Panel A we display the main results from Table 2 for comparison. In Panel B employ the minimum wage bite for all employees, irrespective of their gender. In Panel C we use a continuous fraction rather than a binary one. In Panel D we exclude individuals working in sectors with sector-specific minimum wage agreements. Panel E and F do not rely on Labour Market Regions but Planning Regions (E) and Districts (F). In Panel G we do not use individual weights for calculating the bite and the regional wage distribution. In Panel H we weight the regions in the regression using the absolute regional employment as weights.