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Minimum wage increases, wage growth and employment adjustments

Tom Noth

tom.noth@econ.lmu.de

Ludwig-Maximilians-Universität München

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Tom Noth[1*]

[1*] Department of Economics, LMU Munich, Munich, Germany .

Corresponding author(s). E-mail(s): tom.noth@econ.lmu.de;

Abstract

This study examines the effects of minimum wage increases on wages and working time by analyzing the largest single increase to date in the German minimum wage. Using data from the German Socio-Economic Panel (SOEP), the analysis applies an individual-level difference-in-difference-in-differences design comparing wage growth of affected workers before and after the October 2022 reform relative to a control group. The results show that the reform significantly increased wages at the lower end of the wage distribution. Hourly wages of directly affected workers increased by around 12 percent, while monthly wages rose by approximately 10 percent. While there is no evidence of negative short-run effects on employment retention, the findings suggest a slight reduction in working hours for part-time employees. In addition, the reform is associated with an increase in political interest among low-wage workers.

Keywords: Minimum wage, Wage inequality, Employment, Working hours, Difference-in-differences

1 Introduction

Minimum wages are among the most widely debated labor market policies. While they are intended to improve the economic well-being of low-wage workers and reduce

wage inequality, they may also affect firms' labor demand. Therefore, the effects of minimum wages have been at the center of economic research for more than three decades (Card et al. 1994; Fortin and Lemieux 1997; Neumark et al. 2004). This study contributes to this debate by examining the wage and working time effects of the largest German minimum wage reform so far. Despite high employment levels, in-work poverty remains a persistent concern in Germany. In 2025, after declining slightly in recent years, approximately 6.8 percent of workers are still estimated to be at risk of poverty (Statistisches Bundesamt (Destatis) 2026). Individuals are considered at risk of poverty if they live in a household whose equivalized disposable income falls below 60 percent of the national median. Over the past decades, income inequality in Germany increased until around 2010. Since then, inequality among full-time workers has declined. Existing evidence suggests that the introduction of the nationwide statutory minimum wage in 2015 contributed to this compression at the lower end of the wage distribution (Bossler and Schank 2023; Bachmann et al. 2025).

For Germany, the minimum wage literature has developed more recently, largely following the introduction of the nationwide statutory minimum wage in 2015. Germany introduced a statutory minimum wage of 8.50€ per hour on 1 January 2015. Since then, the minimum wage has been increased 11 times, reaching 13.90€ in 2026. The German minimum wage literature primarily focuses on two key events: the initial introduction in 2015 and the increase in October 2022. This study focuses on the year 2022, in which the largest single minimum wage increase to date took effect. In 2022, the minimum wage rose from 9.60€ to 9.82€ in January, to 10.45€ in July and to 12.00€ in October. Overall, this corresponds to an increase of around 25 percent within a single year. The October reform is the increase of interest because it raised the minimum wage by almost 15 percent and affected an even larger number of workers than the initial introduction in 2015 (Georgieva and Hohendanner 2025).

Figure 4 illustrates the evolution of the German minimum wage since 2015, highlighting the sharp increase in October 2022. Unlike previous adjustments, which were recommended by the Minimum Wage Commission, this increase was decided directly by the German parliament.

The German October 2022 reform provides a unique opportunity to evaluate the effectiveness of minimum wages as a policy tool under different economic conditions than the introduction and with a large number of affected workers. The analysis is motivated by two considerations. First, the study evaluates whether the minimum wage as a policy tool successfully improved the economic well-being of low-wage workers without harming employment. This question is central to current policy debates, particularly in periods of rising living costs and persistent in-work poverty. Second, the German 2022 reform provides an opportunity to study minimum wage effects in a highly unstable economic environment. This environment was shaped by the aftermath of the COVID-19 pandemic, supply-chain disruptions, the energy crisis, and high inflation. Therefore, this study contributes to the public debate on future minimum wage adjustments and provides evidence-based guidance for policymakers.

The central research question of this study is:

What are the wage and employment effects of large minimum wage increases?

To answer this question, this study analyzes the effects of the German October 2022 minimum wage reform on hourly wages, monthly wages, working hours, and employment retention. Focusing only on hourly wages would be insufficient, as firms may adjust through multiple channels beyond wage increases. In particular, adjustments in working hours, employment retention, and hiring may attenuate the positive effects on monthly earnings. The analysis further examines selected non-monetary outcomes, including job satisfaction and political interest. In addition, heterogeneity by gender and differences by region (East versus West Germany), employment type (part-time versus full-time), and firm size are analyzed.

The main empirical analysis relies on an individual-level difference-in-difference-in-differ- ences (DiDiD) design. This approach compares wage growth among workers whose pre-reform wages were below the new minimum wage threshold with wage growth among higher-paid workers, before and after the reform. During robustness checks, this identification strategy is complemented by a regional difference-in-differences (DiD) design that exploits variation in regional treatment intensity. The analysis leverages individual-level data from the German Socio-Economic Panel (SOEP), covering the period 2016 to 2023 and containing information on wages, actual and contractual working hours, as well as detailed socio-economic characteristics.

The results show that the largest single German minimum wage reform so far increased both hourly and monthly wages among low-wage workers. For workers with pre-reform wages below the new threshold, monthly wages rose by around 10 percent. Hourly wages increased by approximately 12 percent. There is no evidence of a decline in employment retention in the short-run. The evidence on working hours is more mixed: while contractual hours for the full sample do not fall significantly, contractual hours among part-time workers decreased. Actual working hours also decreased for the full sample. Heterogeneity analyses suggest that the treatment effect on monthly wages is slightly larger for workers in East Germany, full-time employees and workers in small- to medium-sized firms. Additionally, the findings suggest a slight decline in gender inequality, as women are more strongly affected by the wage increases than men. Non-compliance with the new minimum wage is estimated at around 6.5 percent in the year after the reform. Finally, the minimum wage reform appears to have increased political interest among low-wage workers. Taken together, these findings suggest that minimum wage increases can slightly compress wages by raising wages at the lower end of the distribution without substantial short-run employment losses. However, adjustments in working hours partly offset gains in monthly earnings.

This study makes three main contributions to the literature on minimum wage effects. First, this study contributes to the international literature on the wage and employment effects of minimum wages by providing new estimates analyzing a large nationwide minimum wage reform. The empirical literature on minimum wage effects documents mixed evidence across countries. For the United States, a large body of research finds that minimum wage increases contributed to a reduction in wage inequality (Fortin and Lemieux 1997; Autor et al. 2016). In contrast, evidence for the United Kingdom suggests more limited distributional effects (Dickens and Manning 2004). For Brazil, Engbom and Moser (2022) document substantial positive effects on hourly wages up to the median of the wage distribution following a large minimum wage increase. Evidence on employment effects is less conclusive. For example, Hirsch et al. (2015) and Cengiz et al. (2019) do not find significant employment responses to minimum wage increases in the United States, whereas Neumark et al. (2004) report negative employment effects for earlier reforms. This study reports an increase in hourly and monthly wages of directly affected workers following a 15 percent jump in the national minimum wage that compresses the wage distribution. Although the analysis finds no negative short-run effects on employment retention, working hours of part-time employees seem to decrease slightly dampening the positive effect on monthly wages.

Second, it contributes to the emerging German minimum wage literature on the 2015 introduction (Bachmann et al. 2020; Dustmann et al. 2022; Bossler and Schank 2023; Caliendo et al. 2023) and the 2022 reform (Bossler et al. 2024; Bachmann et al. 2025; Caliendo et al. 2025; Georgieva and Hohendanner 2025; Bossler et al. 2026) by providing individual-level evidence using SOEP panel data, which allows for the joint analysis of wage growth, working hours, employment adjustments, and non-monetary outcomes. The minimum wage introduction increased wages at the bottom of the distribution and reduced hourly wage inequality (Bossler and Schank 2023), while effects

on monthly wage inequality were smaller (Bachmann et al. 2020; Caliendo et al. 2023). At the same time, some studies document small reductions in working hours and employment, particularly among marginal workers (Bachmann et al. 2020; Caliendo et al. 2025; Bossler et al. 2026). While previous studies focus primarily on the introduction of the minimum wage (Bachmann et al. 2020; Dustmann et al. 2022; Bossler and Schank 2023; Caliendo et al. 2023), this study analyzes a reform that affected a larger absolute number of workers and took place during a period of heightened economic uncertainty. This period is characterized by high inflation and the energy crisis and is reflected in a considerably lower level of the ifo Business Climate Index in 2022 compared to 2015 (ifo Institute 2022), as documented by Bossler et al. (2024). This setting allows for an assessment of minimum wage effects under more adverse economic conditions. The findings show that even in this much more unstable economic environment, the minimum wage reform increased monthly wages without large employment losses.

Existing studies regarding the 2022 reform document a small reduction in wage inequality, with the decline in monthly wage inequality being smaller than that in hourly wage inequality (Bachmann et al. 2020). Bossler et al. (2026) find that short-run negative effects on working hours are more pronounced than those observed following the 2015 introduction and that this was not only driven by marginal workers. They attribute this to weaker labor demand in a more uncertain economic environment, as Link (2024) and Caliendo et al. (2025) show that firm adjustment responses are stronger during economic downturns. Unlike in 2015, the minijob earnings threshold was adjusted alongside the minimum wage (from 450€ to 520€), reducing the need for marginal workers to adjust working hours to remain below the threshold. While Bossler et al. (2024) do not find significant employment effects, other studies report negative effects on employment (Caliendo et al. 2025; Georgieva and Hohendanner 2025), arguing that employment effects are primarily driven by reduced hiring rather

than increased separations. Several studies highlight monopsonistic labor market structures as a potential explanation for the limited employment effects (Bachmann and Frings 2017; Dustmann et al. 2022; Popp 2024) or price adjustment as another mechanism (Link 2024). This study is the first study to provide individual-level evidence on the 2022 reform using SOEP panel data. In contrast to other data sources used in the 2022 minimum wage literature, SOEP data allow individuals to be followed over time to analyze wage growth in the pre- and post-reform period. Additionally, the rich set of information, such as detailed socio-economic characteristics, allows the analysis of heterogeneous effects across groups of employees and to include non-monetary outcomes into the analysis. The results suggest a compression of the wage distribution driven by an increase in wages for affected workers. While finding small reductions in working hours, no negative employment effects are found.

Third, this study contributes to the literature on non-monetary effects of minimum wage policies. Evidence on subjective outcomes suggests positive effects on pay and job satisfaction for directly affected workers following the 2015 minimum wage introduction (Bossler and Broszeit 2017; Pusch and Rehm 2017; Gülal and Ayaita 2020). These findings suggest that the minimum wage can improve the living conditions of low-wage workers. In addition, this increase in work satisfaction may also have broader economic implications, as higher job satisfaction has been shown to increase worker productivity (Böckerman and Ilmakunnas 2012). Empirical evidence on the effects of minimum wage policies on political participation remains very limited. This question has become increasingly important in light of declining electoral participation across many OECD countries (OECD 2024). Analyzing minimum wage increases in New York City, Markovich and White (2022) show a positive treatment effect on voting turnout of affected workers. While Jiménez (2023) shows an increase in the approval of the central government because of minimum wage increases in Peru no such effect can be found for Germany. Herdegen and Kalweit (2025) do not find any

increase in voter preferences for the Social Democrats Party, which favored a minimum wage, after the German minimum wage introduction. This study provides novel evidence that minimum wage increases can affect political interest among low-wage workers, highlighting an additional dimension of labor market policies that needs further investigation. Overall, this study provides new insights into the debate on future minimum wage adjustments. It focuses on the role of the minimum wage as a policy instrument to improve the economic position of low-wage workers and compress the wage distribution.

The remainder of the study is structured as follows. Section 2 describes the data. Section 3 presents the econometric framework and identification strategy. Section 4 reports the empirical results, including the main estimates, robustness checks, and additional specifications. Section 5 concludes.

2 Data and descriptive statistics

This section describes the data source used, provides an overview of the working sample and examines the extent of non-compliance with the minimum wage. In addition, it presents descriptive evidence on trends in wages, working hours, and employment across years.

2.1 Data

This study uses survey data from the German Socio-Economic Panel (SOEP). The SOEP is a representative longitudinal survey of approximately 15,000 private households and 30,000 individuals in Germany (Goebel et al. 2019). It has been conducted annually since 1984. The analysis uses SOEP version 40, including individual-level data from 2016 to 2023 (Sozio-oekonomisches Panel (SOEP) 2025). The SOEP provides detailed socio-demographic information, as well as data on monthly earnings and weekly working hours. Hourly wages are constructed using this information. The

dataset reports both contractual and actual weekly working hours. The main analysis is based on contractual hours, while actual hours are used in robustness checks.

Using survey data, measurement errors may affect the accuracy of reported wages and working hours. Addressing this concern, Caliendo et al. (2023) compare SOEP data with the Structure of Earnings Survey (SES), which is based on employer-reported payroll data covering approximately one million employees. When comparing the two data sources, Caliendo et al. (2023) do not find systematic differences in the distribution of wages and working hours. However, measurement error may still lead to misclassification of individuals into treatment and control groups. This may attenuate estimated treatment effects (Bossler and Westermeier 2020).

The SOEP offers several important advantages over other data sources commonly used in the German minimum wage literature. Its panel structure allows individuals to be followed over time, enabling the implementation of an individual-level DiDiD design that compares wage dynamics of treated and untreated workers. In addition, the dataset provides a rich set of socio-demographic characteristics and includes non-monetary outcomes such as job satisfaction and political interest. In contrast to employer-based datasets such as the SES, the SOEP covers both private and public sector employees. In contrast to employer-based datasets such as the ifo Business Survey, the worker-level data allow the computation of regional and industry-level employment rates. Moreover, unlike administrative datasets such as the Integrated Employment Biographies (IEB), the SOEP contains detailed information on working hours, which is essential for analyzing adjustments along the intensive margin. Finally, the annual frequency of the SOEP is a major advantage over the Monthly Earnings Survey (ES), which does not provide sufficient pre-treatment periods to assess parallel trends. The long time span of the SOEP, covering multiple years before the 2022 reform, allows for a detailed evaluation of pre-treatment trends.

2.2 Working sample

The final working sample includes all individuals who are eligible for the statutory minimum wage and have non-missing information on monthly gross earnings, working hours, and age. Imputed wage observations are retained in the sample. Individuals younger than 18, as well as self-employed, trainees, apprentices, interns, and employees in sheltered workshops, are excluded. The working sample is further restricted to individuals who are employed and have non-missing wage information in the reference year (2020). In addition, only observations that are part of consecutive two-year pairs are retained. The resulting sample comprises 40,472 observations from 8,772 distinct individuals, corresponding to an average of 5,781 observations per year (Table 4). Table 5 reports the composition of the working sample across years, including information on demographic characteristics, regional distribution, employment status, firm size, education, and sector. The sample used for the employment retention analysis is slightly larger, as it does not exclude unemployed individuals that were employed in $t-2$.

2.3 Non-compliance

Compliance with the minimum wage is monitored by the Customs Financial Control Unit for Illegal Employment. While penalties for violations can be substantial, with fines up to 500,000€ and the exclusion from public contracts, non-compliance remains non-negligible. This study shows that in the year after the October 2022 minimum wage reform, non-compliance with the statutory minimum wage remains substantial and is estimated at approximately 6.5 percent. Table 1 reports the share of minimum wage eligible workers with hourly wages below the new threshold of €12 per hour as well as their observable characteristics. In the reference year 2020, 16.64 percent of workers earned less than €12 per hour. This implies that a large share of workers should have been directly affected by the reform. However, in the post-reform year,

6.5 percent of workers still report wages below the new minimum wage, indicating persistent non-compliance after the reform. This estimate is in line with non-compliance estimates for the 2015 introduction also based on SOEP data (Bachmann et al. 2020). Using administrative data, Bachmann et al. (2025) report a non-compliance rate of approximately 3.5 percent following the 2022 reform. This difference is expected, as worker-level survey data tend to report higher non-compliance rates because of measurement error and reporting differences. Since the minimum wage is legally binding, firms have little incentive to report hourly wages below the official threshold.

Table 1 Non-compliance

	Oct16 - Sep17	Oct17 - Sep18	Oct18 - Sep19	Oct19 - Sep20	Oct20 - Sep21	Oct21 - Sep22	Oct22 - Sep23
Sample Size	5,004	5,407	5,809	6,120	8,772	5,034	4,326
Fraction below 2022 minimum wage	18.42	17.99	15.28	13.73	16.64	10.82	6.54
Basic Demographics							
Female	64.59	63.17	67.48	69.82	62.17	68.06	61.92
Male	35.41	36.83	32.44	30.18	37.83	31.94	38.08
Age below 25	6.88	8.06	7.27	5.17	11.62	7.70	4.99
Age between 25 and 55	77.09	71.69	67.25	66.54	58.00	57.58	49.09
Age above 55	16.03	20.25	25.48	28.29	30.38	34.72	45.93
German Nationality	88.06	85.36	84.57	85.14	81.37	83.73	84.63
Married	44.48	45.60	45.85	48.84	43.83	49.06	46.26
Region							
West Germany	69.94	71.67	73.35	71.90	78.51	78.72	81.34
East Germany	30.06	28.33	26.50	28.10	21.49	21.28	18.66
Urban	59.02	60.90	57.85	58.34	62.71	61.49	64.24
Rural	40.98	39.10	39.68	41.66	37.29	38.51	35.76
Employment							
Full-time Employment	48.48	49.17	47.36	43.39	40.33	31.35	38.61
Part-time Employment	31.39	30.98	34.34	31.22	31.95	40.05	34.10
Marginal Employment	20.13	19.86	18.27	25.39	24.68	27.50	25.17
Civil Service	12.46	12.20	12.89	11.08	15.98	14.54	15.64
Firm size (Number of Employees)							
Below 20	37.45	36.74	34.05	35.83	36.64	37.80	37.44
Between 20 and 200	26.04	26.35	29.57	29.33	32.09	36.14	26.20
Between 200 and 2000	20.30	18.94	17.82	18.15	15.37	16.16	20.19
Above 2000	16.21	17.97	18.56	16.69	15.90	9.90	16.18
Education							
Low Education	13.07	15.11	14.85	13.38	21.33	21.40	20.79
Medium Education	75.78	71.84	72.39	71.26	65.05	60.13	65.32
High Education	11.15	13.04	12.76	15.36	13.62	18.48	13.89
Sector							
Agriculture Sector	1.21	0.84	1.56	2.49	1.02	2.45	2.72
Manufacturing Sector	19.74	21.67	17.99	15.51	16.39	9.59	20.42
Service Sector	79.05	77.49	80.45	82.00	82.59	87.96	76.86

Notes: This table reports the characteristics of individuals with wages below €12 across years containing information about demographic characteristics, region, employment, firm size, education and sector. The SOEP survey weights are applied.
Data: Sozio-oekonomisches Panel (SOEP) (2025)

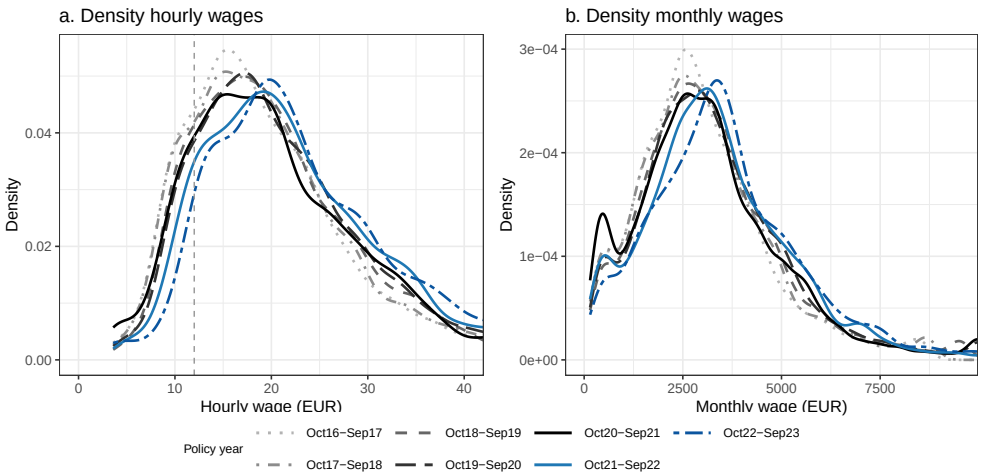
Comparing worker characteristics in Table 5 (full sample) with those in Table 1 (workers earning below €12) reveals which groups are disproportionately affected by the minimum wage reform. Women, foreign workers, workers in East Germany, marginally employed workers, employees in small firms, individuals with low education, and workers in the service sector are overrepresented among low-wage workers in the pre-reform years. Therefore, these groups are expected to benefit most from

the minimum wage increase. Examining the post-reform period indicates that non-compliance is relatively broadly distributed across affected groups rather than being concentrated in a specific segment of the low-wage labor market.

2.4 Wage and employment trends

The descriptive evidence suggests that the October 2022 reform increased wages at the lower end of the wage distribution. Figure 1 plots the distribution of hourly and monthly wages across policy years. While both distributions gradually shift to the right over time, a pronounced increase at the lower end of the distribution is visible around the €12 threshold after the October 2022 reform. A corresponding shift can also be observed for monthly wages. In addition, bunching around the marginal employment (minijob) threshold is visible before the reform and appears less pronounced afterward, consistent with the simultaneous increase in the minijob threshold from €450 to €520.

Fig. 1 Wage distribution across years

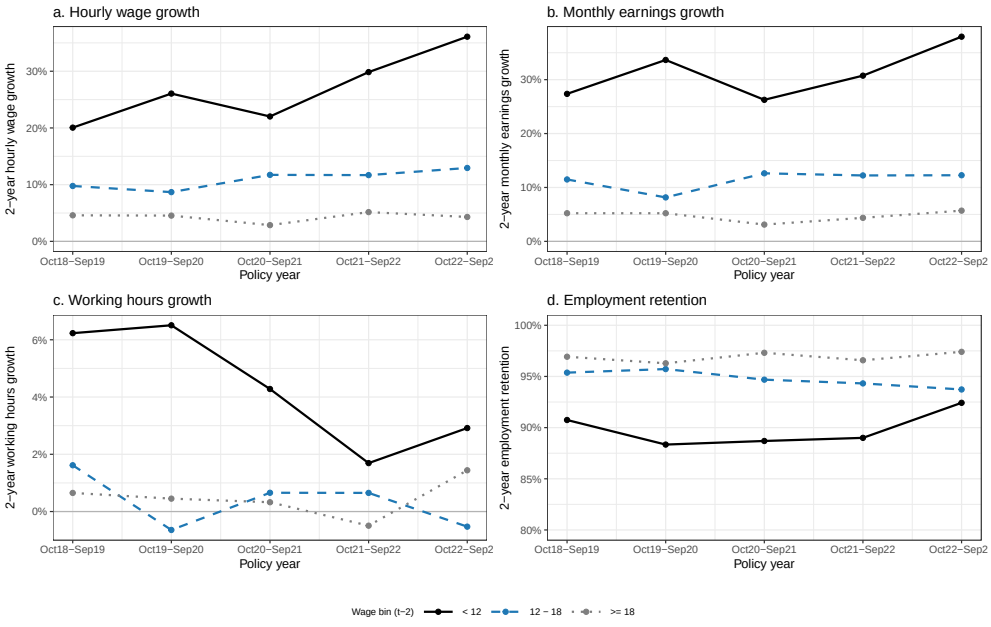


Notes: This figure plots the wage distribution across years. Panel (a) plots contractual hourly wages and Panel (b) monthly wages. SOEP survey weights are applied, and wages are winsorized at the 1st and 99th percentiles.
Source: Sozio-oekonomisches Panel (SOEP) (2025).

Figure 2 plots average two-year growth in hourly wages, monthly wages and contractual working hours as well as employment retention by wage group. Wage groups

are defined based on hourly wages in t-2. Table 6 reports the number of observations by wage group and year. Across all years, wage growth is consistently higher for the treatment group than for the control group, reflecting mean reversion. Even in the absence of the reform, wages of low-wage workers tend to grow faster than those of high-wage workers. The empirical specification accounts for these persistent differences through wage-group fixed effects, such that identification relies on changes in wage growth rather than differences in levels.

Fig. 2 Wage and employment trends



Notes: This figure plots average two-year log wage growth for the period 2018 - 2022, by lagged (t-2) wage group, separately for contractual hourly wages (a), monthly wages (b), contractual working hours (c), and employment retention (d). SOEP survey weights are applied, and wages are winsorized at the 1st and 99th percentiles.
Source: Sozio-oekonomisches Panel (SOEP) (2025).

Prior to the reform, wage growth for the treatment and control groups evolves broadly similarly, although hourly wages show some evidence of anticipation effects in 2021, possibly reflecting the announcement of the October 2022 reform and the earlier minimum wage increases in January and July 2022. Following the reform, hourly wage

growth increases sharply for the treatment group relative to the control group, with a smaller increase in monthly wage growth. The spillover group exhibits only a modest increase in hourly wage growth and little change in monthly wages.

A visual inspection of Panel (a) suggests that the parallel trends assumption is broadly satisfied, although hourly wages display some divergence between the treatment and control groups before the reform. In 2021 wage growth increases for the treatment group, indicating possible anticipation effects following the announcement of the October 2022 reform and the earlier minimum wage increases in January and July 2022. After the reform, hourly wage growth increases significantly for the treatment group relative to the control group widening the growth gap between treatment and control group. For the spillover group, the slope is only slightly positive, indicating small potential spillover effects for workers with pre-reform wages just above the threshold. A similar pattern emerges for monthly wages (Panel (b)). Prior to the reform, growth rates for the treatment and control groups evolve broadly in parallel, whereas monthly wage growth increases more strongly for the treatment group after the reform. In contrast to hourly wages, there is no visual evidence of spillover effects on monthly wages.

Panel (c) shows two-year growth in contractual monthly working hours across wage groups. Again, the treatment group exhibits consistently higher average growth compared to the control group. However, pre-treatment trends between the treatment and control groups are not always parallel, which may raise concerns about identification. In policy year 2021, the year prior to the reform, working hours decline more strongly for the treatment group and in the post-reform period, working hours growth increases less for the treatment group. This pattern suggests that treated workers may have experienced lower growth in working hours than in the absence of the reform. The spillover group also shows lower post-reform growth, although non-parallel pre-trends weaken identification. Panel (d) plots employment retention by wage group. Average

employment retention is consistently lower for the treatment group than for the other groups. However, post-reform trends provide no visual evidence of a negative employment retention effect. Moreover, employment retention seems to improve slightly for the treatment group relative to the control group after the reform.

3 Empirical approach

The main empirical strategy uses an individual-level DiDiD approach, as applied by Burauel et al. (2020), Bachmann et al. (2020), Dustmann et al. (2022), Bossler et al. (2024), and Bachmann et al. (2025). This approach exploits the panel structure of the SOEP to follow individuals over time. The identification strategy compares wage growth for workers whose pre-treatment wages were below the new minimum wage threshold (treatment group) to wage growth of workers with higher pre-reform wages (control group), before and after the reform:

$$[\Delta \ln(y^{\mathrm{t}}_{\mathrm{post}}) - \Delta \ln(y^{\mathrm{t}}_{\mathrm{pre}})] - [\Delta \ln(y^{\mathrm{c}}_{\mathrm{post}}) - \Delta \ln(y^{\mathrm{c}}_{\mathrm{pre}})] \tag{1}$$

The estimator proceeds in several steps. First, individual wage growth between two periods (t and $t-2$) is calculated. Second, changes in wage growth before and after the reform are calculated. Third, the changes are compared between treated and control groups. This difference-in-differences in wage growth identifies the causal effect of the reform.

3.1 Identification assumption

A standard difference-in-differences design relies on the parallel trends assumption. This assumption requires that wages in the treatment and control groups evolve similarly prior to the reform and would have continued to do so in the absence of the treatment. However, this assumption is likely to be violated when using wage levels. This is because wages of low-wage workers tend to grow faster than those of

higher-wage workers due to mean reversion (Bachmann et al. 2020). The DiDiD design addresses this issue by focusing on wage growth rather than levels. By differencing growth rates instead of wage levels, it differences out pre-existing differences in wage growth between the treatment and control group that are unrelated to the minimum wage reform. The identifying assumption is therefore less restrictive: it requires that differences in wage growth between groups are stable prior to the reform and would have remained unchanged in its absence.

The first component of this "parallel growth" assumption can be assessed empirically through pre-treatment trends. In particular, estimates for pre-reform periods should be statistically insignificant. The second component, that wage growth of both groups would have continued to evolve similarly in the absence of the reform, cannot be tested directly. The identification strategy assumes that no other contemporaneous shocks differentially affect wage growth across groups in a way correlated with treatment status. A threat to identification arises if, at the same time as the October 2022 minimum wage reform, another event occurs that affects the wages of treated workers differently from those of the control group. For example, shocks such as oil price increases or collective bargaining agreements may affect the same industries as the minimum wage reform. To control for industry-specific time shocks, industry-year fixed effects are included during robustness checks.

3.2 Wage groups

Workers are classified into three groups based on pre-treatment $(t-2)$ hourly wages:

- Treatment group: $w < 12\,€$
- Spillover group: $12\,€ \leq w < 18\,€$
- Control group: $18\,€ \leq w$

The treatment group includes workers directly affected by the reform with pre-reform hourly wages below the new minimum threshold of 12€. The spillover group

consists of workers whose wages may be indirectly affected through spillover effects. The control group consists of higher-wage workers who are less likely to be affected with hourly wages of at least 18€. Excluding workers just above the minimum wage threshold from the control group is important. Otherwise, spillover effects may violate the Stable Unit Treatment Value Assumption (SUTVA). Previous studies document that minimum wage reforms not only raise the wages of workers who initially earn below the new threshold, but also increase the wages of workers slightly above it through spillover effects (Dustmann et al. 2022; Bossler and Schank 2023; Caliendo et al. 2023). Including these workers in the control group would therefore bias the estimated treatment effects downward. The upper threshold of 18€ is chosen to ensure that the control group is sufficiently distant from the minimum wage and therefore unlikely to be affected by spillover effects. The threshold of 18€ is consistent with Bossler and Schank (2023) documenting wage spillovers up to the median of the wage distribution.

3.3 Estimation equation

The main specification is given by:

$$\Delta \ln(y_{it}) = \beta_0 + \sum_{k=2018, k\neq 2020}^{2022} \sum_{g=1}^{2} \beta_{g,k} \left(Y_k \times \mathrm{G}_{ig,t-2}\right) + \delta' X_{i,t-2} + \nu_t + \eta_{g,t-2} + \varepsilon_{it} \quad (2)$$

where $\Delta \ln(y_{it}) = \ln(y_{it}) - \ln(y_{it-2})$ denotes two-year growth in the outcome variable (hourly wages, monthly wages, working hours). The coefficients $\beta_{g,k}$ capture the treatment effects, which are differences in growth rates between the treatment and control groups relative to the pre-reform reference year. Because the dependent variable is specified in log differences, the coefficients $\beta_{g,k}$ can be interpreted as approximate

percentage point differences in growth rates relative to the control group and reference year. For example, a coefficient of 0.12 implies that the outcome variable grew by approximately 12 percentage points more over the two-year period compared to the control group and the reference year. Employment retention is an exception since it is a binary variable. G_{ig} is a dummy variable indicating whether individual i belongs to group g. $G_{i1,t-2}$ equals 1 if the individual belongs to the treatment group in $t-2$ and $G_{i2,t-2}$ equals 1 if the individual belongs to the spillover group in $t-2$. The control group is omitted and serves as the reference group. $\delta' X_{i,t-2}$ controls for individual characteristics. The final specification used in the main part of the analysis controls for age, gender, nationality, marital status, education, employment type, firm size, industry and job changes. ν_t captures year fixed effects to account for changes in the growth rate common to all groups in a given year. η_g controls for time-invariant differences in growth patterns between the wage groups. ε_{it} denotes the error term. Standard errors are clustered at the individual level.

Because the reform took effect in October 2022 and SOEP interviews are conducted throughout the year, calendar years do not align with policy exposure. Therefore, the analysis uses policy years defined from October to September. Policy year 2022 (October 2022 - September 2023) is treated as the post-reform period, while policy year 2020 (October 2020 - September 2021) is omitted and serves as the reference year. Policy year 2021 (October 2021 - September 2022) is not used as a reference period for two reasons. First, two smaller minimum wage increases in early 2022 already affect wage growth of treated workers (Bossler et al. 2024). Second, anticipation effects may arise, as the reform was announced far in advance. Firms may have adjusted wages prior to implementation, which could lead to an underestimation of treatment effects. Using two-year growth rates helps mitigate these concerns by comparing policy year 2022 directly to 2020. Additionally, group assignment is based on pre-treatment wages

(t-2), ensuring that treatment status is predetermined and not affected by the reform. Policy years are used consistently throughout the study.

Because all unemployed individuals are excluded from the main sample, the estimates are conditional on employment. Results should be interpreted as applying to employed individuals with valid wage observations, rather than the full population. It is therefore important to also examine employment retention to rule out the possibility that observed wage increases are upward biased and driven by sample selection if low-wage workers exit employment. A key limitation of the individual DiDiD identification strategy is that it measures only employment retention among initially employed individuals. It does not identify effects on hiring or overall employment rates, because individuals need to be assigned to a wage group in $t-2$.

4 Results

This section presents the main results on the effects of the October 2022 minimum wage increase on hourly wages, monthly wages, working hours, and employment retention. It then presents a series of robustness checks. In addition, selected non-monetary outcomes are analyzed.

4.1 Wage and employment effects

Table 2 reports the main estimation results based on equation (2) in Section 3.3. Figure 3 visualizes these results by plotting the estimates from Table 2.

Column (1) of Table 2 shows that the October 2022 reform increased hourly wages at the bottom of the wage distribution. The treatment effect on hourly wage growth of directly affected workers is estimated at 12 percentage points and is significant at the 1 percent level. This implies that, because of the minimum wage reform, hourly wages of treated workers at the bottom of the wage distribution increase by around

Table 2 Main estimation results

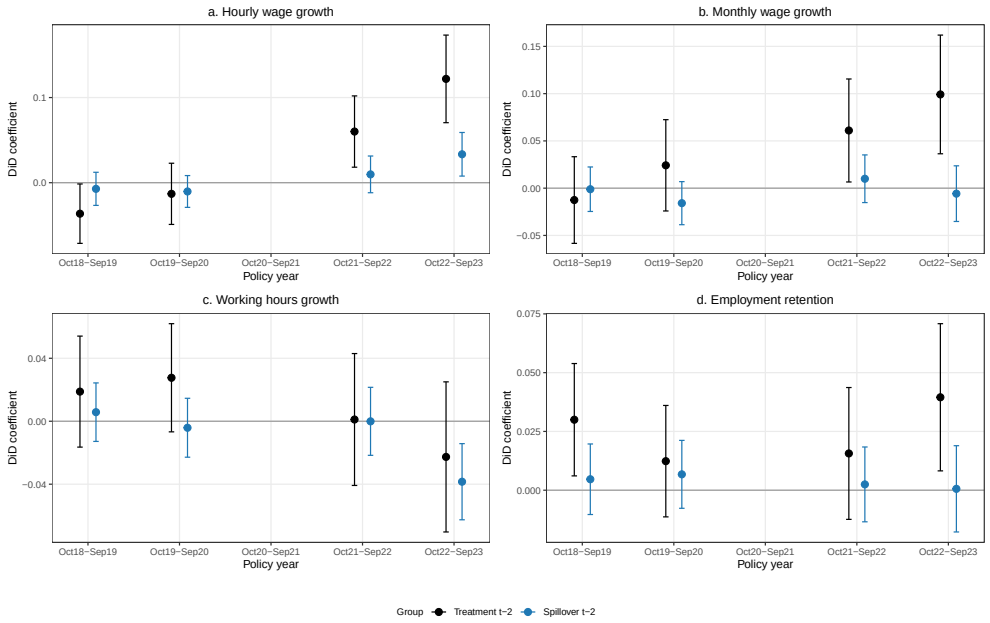
Model:	Hourly wage growth (1)	Monthly wage growth (2)	Working hours growth (3)	Employment retention (4)
Variables				
Oct18-Sep19 × Treatment Group (¡12€)	-0.0364**	-0.0126	0.0188	0.0300**
	(0.0178)	(0.0234)	(0.0180)	(0.0122)
Oct19-Sep20	-0.0131	0.0242	0.0276	0.0123
	(0.0183)	(0.0246)	(0.0175)	(0.0121)
Oct21-Sep22	0.0601***	0.0610**	0.0011	0.0156
	(0.0214)	(0.0278)	(0.0214)	(0.0143)
Oct22-Sep23	0.1219***	0.0992***	-0.0227	0.0395**
	(0.0262)	(0.0320)	(0.0243)	(0.0160)
Oct18-Sep19 × Spillover Group (12-18€)	-0.0072	-0.0011	0.0058	0.0047
	(0.0099)	(0.0120)	(0.0095)	(0.0077)
Oct19-Sep20	-0.0103	-0.0159	-0.0041	0.0067
	(0.0095)	(0.0116)	(0.0095)	(0.0074)
Oct21-Sep22	0.0098	0.0100	-6.17×10^{-5}	0.0025
	(0.0110)	(0.0129)	(0.0110)	(0.0081)
Oct22-Sep23	0.0334**	-0.0058	-0.0384***	0.0006
	(0.0131)	(0.0150)	(0.0123)	(0.0094)
Socio-demographic controls	Yes	Yes	Yes	Yes
Employment controls	Yes	Yes	Yes	Yes
Wage-group FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Fit statistics				
Observations	21,796	21,796	21,796	33,499
R^2	0.11736	0.14361	0.10198	0.04404

Clustered (individual level) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Notes: This table reports individual-level DiDiD estimates for workers with lagged (t-2) contractual hourly wages below € 12 (treatment group) and between € 12 and € 18 (spillover group), relative to a control group earning at least € 18. Reported coefficients measure changes in hourly wage growth (col. 1), monthly wage growth (col. 2), working hours growth (col. 3), and employment retention (col. 4), relative to the reference year 2020 and to the control group. The sample includes minimum-wage-eligible individuals employed in 2020 who have at least one valid wage observation pair at t and t-2. Specifications include demographic and employment controls and wage-group and year fixed effects. Wages are winsorized at the 1st and 99th percentiles.
Data: Sozio-oekonomisches Panel (SOEP) (2025)

12 percent, corresponding to an average increase of around €1.60 per hour. The magnitude should nevertheless be interpreted with caution, since the estimate for 2018 is small but significant imposing a threat to the main identifying assumption. This negative coefficient for 2018 seems to be driven mainly by full-time employees (Table 9) and becomes insignificant when applying cross-sectional weights (Table 11). The coefficient for policy year 2021 is positive and significant, indicating anticipation effects. This is consistent with the October reform being announced in advance and two smaller minimum wage increases that already took place in January and July 2022. These findings are in line with Bossler et al. (2024), who show that around one third of total wage increases in 2022 occurred already before October. A smaller positive coefficient for workers initially earning 12€ to 18€ suggests wage spillovers above the

Fig. 3 Main estimation results



Notes: This figure reports individual-level DiDiD coefficients for workers with lagged (t-2) contractual hourly wages below € 12 (treatment group) and between € 12 and € 18 (spillover group), relative to a control group earning at least € 18. Reported coefficients measure changes in hourly wage growth (a), monthly wage growth (b), working hours growth (c), and employment retention (d), relative to the reference year 2020 and to the control group. The sample includes minimum-wage-eligible individuals employed in 2020 who have at least one valid wage observation pair at t and t-2. Specifications include demographic and employment controls and wage-group and year fixed effects. Wages are winsorized at the 1st and 99th percentiles. Vertical bars indicate 95 percent confidence intervals.
Data: Sozio-oekonomisches Panel (SOEP) (2025)

new minimum-wage threshold, consistent with Bachmann et al. (2025). The positive treatment effect seems to be slightly larger for workers in East Germany (Table 8) and small to medium sized firms (Table 10). The estimated treatment effect is larger than those reported by Bachmann et al. (2025) and Bossler et al. (2024), who find hourly wage effects of around 6 percent for the 2022 reform. One potential explanation for the larger estimate is the use of two-year wage growth in this study, which captures not only the impact of the October 2022 reform but also earlier adjustments in 2022 as well as anticipation effects.

Column (2) of Table 2 shows that the reform increased monthly wages of directly affected workers by approximately 10 percent. This corresponds to an average increase

of about €160 per month. The estimate is statistically significant at the 1 percent level, while the pre-reform coefficients are insignificant. The positive 2021 coefficient again suggests anticipation effects. Unlike hourly wages, there is no evidence of spillovers to workers initially earning 12–18€. Heterogeneity analyses indicate that the effect on monthly wages is primarily driven by full-time workers (Table 9) and workers in small- to medium- sized firms (Table 10). In addition, the effect seems to be slightly larger for workers in East Germany (Table 8). Consistent with the fact that women are overrepresented among low wage workers (Table 1), female workers seem to benefit slightly more than male workers (Table 7). The effect on monthly wages is smaller than on hourly wages, indicating that higher hourly wages do not fully translate into higher monthly earnings, likely because of adjustments in working hours. The estimated treatment effect on monthly wages is again larger than the effect reported by Bossler et al. (2024). Bachmann et al. (2025) do not find any significant individual-level treatment effect for the 2022 reform. For the 2015 minimum wage introduction, Bachmann et al. (2020) find only very small positive effects on monthly wages of treated workers while Burauel et al. (2020) do not find any significant effects. Overall, the results indicate a moderate increase in monthly wages at the bottom of the distribution and a smaller degree of wage compression than for hourly wages.

Column (3) of Table 2 provides no evidence that the reform affected contractual working hours of directly affected workers on average. While the estimated treatment effect is negative, it is statistically insignificant. Workers in the spillover group experienced a small but statistically significant decline in contractual working hours of around 3.8 percent, which may partly explain why higher hourly wages did not translate into higher monthly earnings for these workers. Heterogeneity analyses shows a significant reduction in working hours by around 7 percent among part-time workers (Table 9), suggesting that working hours primarily declined for workers already

employed part-time before the reform rather than through transitions between employment types. These findings differ somewhat from Bossler et al. (2026), who report even larger reductions in working hours following the 2022 reform than after the 2015 minimum wage introduction, although they use a regional DiD measuring regional averages based on regional treatment intensity. Bachmann et al. (2025) estimate an average reduction in working hours of around 2.8 percent and likewise find larger reductions for workers in the spillover group than for directly affected workers. Overall, the results suggest that the increase in monthly wages is primarily driven by full-time workers, whereas reductions in working hours are concentrated among part-time workers. This contrasts with the 2015 minimum wage introduction, when reductions in working hours were mainly observed among marginal workers. While marginal workers cannot be analyzed separately in this study, Bossler et al. (2026) show that in contrast to 2015 after the October 2022 reform working hours of both marginal and part-time workers decreased. This difference likely reflects the institutional change in 2022, when the minijob threshold was adjusted in line with the minimum wage increase. Instead, the unstable macroeconomic environment, which may have strengthened firms' adjustment responses decreasing labor demand (Link 2024; Caliendo et al. 2025; Bossler et al. 2026), may play a role in explaining the observed reduction in working hours.

Column (4) of Table 2 provides no evidence that the October 2022 minimum wage increase reduced employment retention among directly affected workers. Post-reform coefficients for both the treatment and spillover groups are not negative. Heterogeneity analyses likewise provide no evidence of negative employment retention effects for any subgroup. It is important to note that the individual-level DiDiD design identifies effects on employment retention but not on hiring. Consequently, potential reductions in hiring or total employment cannot be assessed. In addition, there are several possible explanations for the absence of negative employment retention effects. First, firms may adjust primarily through reduced hiring rather than increased separations

(Georgieva and Hohendanner 2025). Second, adjustments along the intensive margin (working hours) may be more flexible in the short-run than adjustments in employment levels. Therefore, it is important to also analyze long-term employment effects. Third, monopsony power and labor market frictions may allow firms to increase wages without reducing employment (Bachmann and Frings 2017; Popp 2024). Additionally, reservation wages increase, reducing incentives to change employers. Finally, firms may pass on higher labor costs through price increases rather than employment reductions (Link 2024). The absence of negative employment retention effects is consistent with Bossler et al. (2024) and Bossler et al. (2026). While Caliendo et al. (2025) and Georgieva and Hohendanner (2025) report small negative effects on total employment, Georgieva and Hohendanner (2025) attribute these primarily to reduced hiring rather than increased separations. Overall, the results indicate that the October 2022 minimum wage increase did not reduce employment retention in the short-run.

Taken together, the results indicate that the October 2022 minimum wage increase raised wages at the lower end of the distribution without reducing employment retention. At the same time, part of the wage gains were offset by adjustments in working hours.

4.2 Robustness checks

The robustness checks largely confirm the main findings. Applying SOEP cross-sectional weights (Table 11), yields qualitatively similar results and removes the significant pre-reform 2018 coefficient for hourly wages. The estimated wage effects remain positive and statistically significant, although spillover effects on hourly wages are no longer observed. Additionally, the coefficients for hourly and monthly wages become slightly larger, which is why the magnitude of the wage effects need to be treated with caution.

Using the actual instead of contractual working hours measure confirms a significant positive effect on hourly and monthly wages of treated workers (Table 12). In contrast to contractual working hours there seems to be a significant reduction in actual working hours of around 7.5 percent for directly affected workers. This suggests, that overtime work of treated workers decreases because of the minimum wage reform. However, when analyzing overtime separately, no statistically significant treatment effect can be found (Table 13). Therefore, adjustments in working hours are likely to occur through channels other than overtime, such as changes in employee absences or other flexible working-time arrangements.

The results are also robust to alternative sets of control variables (Table 14) and to excluding observations with imputed wage information (Table 15). Controlling for industry-specific time shocks such as oil price increases or collective bargaining agreements that may affect similar industries as the minimum wage reform and therefore may threaten identification slightly reduces the estimated wage effects. Estimations based on a balanced panel with longitudinal SOEP weights seem not to be suitable here due to the limited sample size (Table 16).

As an additional robustness check, this study implements a regional difference-in-differences design that exploits variation in the regional minimum wage bite, as suggested by Card (1992) and following Dustmann et al. (2022), Caliendo et al. (2023), and Bossler et al. (2024). In contrast to the individual-level DiDiD approach, this specification uses a continuous treatment variable and captures differences in regional treatment intensity incorporating broader spillover and general equilibrium effects. For a detailed description of this approach see the Appendix. Overall, the regional DiD approach provides no robust evidence of positive effects on hourly or monthly wages at the regional level following the October 2022 reform (Table 21). Additionally, while no significant effects are found for the employment rate, there is some indication of a negative effect on working hours. However, these findings are not consistent across

specifications and therefore should be interpreted with caution. The limited number of regions (28) and the low variation in treatment intensity weaken identification. Additionally, the regional units used here do not align with local labor markets, unlike the planning regions typically used in the literature. Therefore the Regional DiD approach is only used as a complementary approach. Despite these limitations, the regional DiD results are broadly consistent with findings from Bachmann et al. (2025), who also report a small negative effect on working hours and also do not find any significant positive effects on hourly or monthly wages at the aggregated regional level. Bossler et al. (2024) also document negative effects on working hours using a regional DiD approach, although they find small significant positive effects on hourly and monthly wages.

Overall, the robustness checks confirm the main findings of a positive treatment effect on hourly and monthly wages and the absence of any employment retention effects. Estimates for working hours, spillover effects, and the precise magnitude of the wage effects are somewhat more sensitive to the specification and therefore should be interpreted with some caution.

4.3 Non-monetary outcomes

Table 3 reports the results for political interest, work satisfaction, life satisfaction, income satisfaction, and financial worries. The results indicate a significant increase in political interest among low-wage workers around the time of the discussion and implementation of the October 2022 minimum wage reform. To facilitate comparisons between outcomes, all variables are standardized using the mean and standard deviation of the full sample in the reference year 2020. The reform is associated with a statistically significant increase in political interest among directly affected workers of around 0.12 standard deviations (Column 1) in 2022. In addition, a significant positive effect is reported for the treatment and spillover group in 2021. During this period,

the October 2022 minimum wage reform was publicly debated and decided. Tables 18 and 17 show that the results are robust to using the original (non-standardized) variables and SOEP cross-sectional survey weights. The estimated effect becomes slightly larger when applying survey weights. The increase in political interest among low-wage workers is consistent with Markovich and White (2022), who document higher voter turnout among low-wage workers following a minimum wage increase in New York City. In contrast, the wage increases are not associated with measurable improvements in broader subjective well-being for low-wage workers in the short-run within the individual-level DiDiD analysis. One possible explanation for the absence of measurable improvements in satisfaction outcomes, particularly income satisfaction, is that adjustments in working hours or prices offset gains in hourly wages and may prevent the purchasing power of affected workers from increasing. The absence of positive effects on work and income satisfaction differs from earlier studies, such as Bossler and Broszeit (2017); Pusch and Rehm (2017); Gülal and Ayaita (2020), which document improvements in job and pay satisfaction following the German minimum wage introduction.

5 Conclusion

This study analyzes the largest single increase in the German minimum wage to date in order to assess the effects of large minimum wage adjustments on wages and employment. The German minimum wage increased by almost 15 percent in October 2022 and by around 25 percent over the course of 2022. Using an individual-level difference-in-difference-in-differences (DiDiD) approach, the analysis examines the effects of the reform on hourly wages, monthly wages, working hours, and employment retention by comparing wage growth of treated and untreated workers before and after the reform.

Do minimum wages compress wages and improve the situation of low-wage workers? Overall, the findings suggest that the German reform contributed to a compression

Table 3 Results non-monetary outcomes

Model:	Interest in politics (1)	Work satisfaction (2)	Life satisfaction (3)	Income satisfaction (4)	Financial worries (5)
Variables					
Oct18-Sep19 × Treatment Group (¡12€)	0.0370	0.0426	-0.0736	-0.0396	-0.0457
	(0.0385)	(0.0513)	(0.0496)	(0.0487)	(0.0472)
Oct19-Sep20	0.0215	0.0121	-0.0625	-0.0434	0.0201
	(0.0393)	(0.0538)	(0.0522)	(0.0511)	(0.0494)
Oct21-Sep22	0.1154**	0.0414	-0.0357	-0.0067	-0.0515
	(0.0458)	(0.0613)	(0.0562)	(0.0595)	(0.0599)
Oct22-Sep23	0.1186**	0.0761	-0.0447	0.0406	-0.0214
	(0.0505)	(0.0665)	(0.0612)	(0.0634)	(0.0599)
Oct18-Sep19 × Spillover Group (12-18€)	0.0210	0.0115	-0.0411	0.0284	-0.0475
	(0.0331)	(0.0408)	(0.0382)	(0.0357)	(0.0394)
Oct19-Sep20	0.0196	-0.0956**	-0.0086	-0.0208	-0.0072
	(0.0315)	(0.0412)	(0.0369)	(0.0349)	(0.0384)
Oct21-Sep22	0.0675**	-0.0310	-0.0320	-0.0678*	-0.0721*
	(0.0338)	(0.0436)	(0.0397)	(0.0387)	(0.0431)
Oct22-Sep23	0.0105	0.0064	-0.0681	-0.0590	-0.1033**
	(0.0381)	(0.0459)	(0.0442)	(0.0417)	(0.0434)
Socio-demographic controls	Yes	Yes	Yes	Yes	Yes
Employment controls	Yes	Yes	Yes	Yes	Yes
Wage-group FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Fit statistics					
Observations	21,275	21,275	21,275	21,275	21,275
R^2	0.16605	0.02361	0.03385	0.13296	0.10147

Clustered (pid) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Notes: This table reports individual-level DiDiD estimates for workers with lagged (t-2) contractual hourly wages below €12 (treatment group) and between €12 and €18 (spillover group), relative to a control group earning at least €18. All outcome variables are standardized (mean = 0, standard deviation = 1) using the mean and standard deviation in the reference year 2020. Reported coefficients for interest in politics, work satisfaction, life satisfaction, income satisfaction and financial worries therefore measure effects in standard deviations. Higher values indicate better outcomes in all columns (greater interest in politics, higher satisfaction, less financial concerns). The sample includes minimum-wage-eligible individuals employed in 2020 who have at least one valid wage observation pair at t and t-2. Specifications include demographic and employment controls and wage-group and year fixed effects. Wages are winsorized at the 1st and 99th percentiles.
Data: Sozio-oekonomisches Panel (SOEP) (2025)

of the wage distribution by increasing wages at the lower end of the distribution. It also improved earnings outcomes for low-wage workers without generating negative short-run effects on employment retention. However, adjustments in working hours point to potential changes in labor demand, highlighting that minimum wage policies should consider both wage and working time responses when evaluating their effectiveness.

The results show that the minimum wage reform increased hourly wages at the bottom of the wage distribution. Hourly wages of workers with pre-reform wages below the new threshold, as well as those slightly above it, increased after the reform. The estimated treatment effect on hourly wages is around 12 percent, although this magnitude should be interpreted with caution. Wage increases are already visible in the year prior to the reform, likely reflecting anticipation effects and the two smaller minimum

wage increases earlier in 2022. Both contractual and actual hourly wages increase, suggesting a compression of hourly wages driven by an increase in hourly wages at the lower end of the distribution.

Monthly wages of treated workers also increase as a result of the minimum wage reform, with an estimated treatment effect of around 10 percent. This implies a modest compression of monthly wages, driven by an increase in monthly wages at the bottom of the wage distribution. However, the smaller effect on monthly wages compared to hourly wages suggests downward adjustments in working hours for low-wage workers. The evidence on working hours is mixed. While contractual hours decline only within the spillover group, actual hours worked decrease significantly for both treated and spillover workers. The reduction in working hours for low-wage workers appears to be driven mainly by workers who were already employed part-time before the reform. Their working hours decline by around 7 percent following the reform. At the same time, the analysis finds no evidence of negative effects of the minimum wage reform on employment retention, at least in the short-run. The findings are broadly consistent with the international evidence. Similar to Autor et al. (2016), the results suggest that minimum wage increases compress the lower tail of the wage distribution, while the absence of substantial employment losses is in line with the evidence reported by Cengiz et al. (2019) for the United States and Engbom and Moser (2022) for Brazil.

Analyzing non-monetary outcomes, no significant treatment effects on work and income satisfaction are found. However, this study provides novel evidence of an increase in political interest among low-wage workers as a result of the minimum wage reform.

Additional heterogeneity analysis reveals several interesting patterns. Women are overrepresented among low-wage workers, which likely explains why the increase in monthly wages is statistically significant for women but not for men. Treatment effects on wages are stronger in East Germany than in West Germany. Moreover, the increase

in monthly wages is mainly driven by full-time workers and employees in small and medium-sized firms. Non-compliance with the new minimum wage is estimated at around 6.5 percent in the year after the reform.

Methodologically, this study demonstrates that combining the rich worker-level information of the SOEP with an individual-level DiDiD approach allows for a detailed analysis of minimum wage effects. At the same time, this study has several limitations. First, the analysis relies on survey data, which may be subject to measurement error in wages and working hours. Second, the limited regional resolution restricts the ability to exploit variation in treatment intensity and to analyze and quantify distributional effects directly using approaches such as unconditional quantile regressions. Third, results do not capture effects on hiring responses. Finally, when deciding on future minimum wage adjustments, the findings from this analysis should be treated with caution, since the institutional and macroeconomic environment seems to play an important role in shaping the effects of the minimum wage.

Future research should aim to quantify the distributional effects more directly, for example by using regional inequality measures such as the Gini coefficient or the gender wage gap as outcome variables. In addition, further work is needed to better understand firm adjustment mechanisms, including price-setting behavior, effects on firm profits, investment, hiring decisions, and long-term employment responses. For instance, if firms respond by increasing prices, part of the wage gains for low-wage workers may be offset. Given that macroeconomic conditions shape the effects of minimum wage policies, it is particularly important to examine how firm responses to minimum wage increases vary across different economic conditions. A better understanding of firm adjustment mechanisms, such as reductions in employment or increases in prices, could also help explain why this study does not find statistically significant effects on job and pay satisfaction. Finally, the observed increase in

political interest among low-wage workers highlights an additional and largely unexplored dimension of minimum wage policy that warrants further investigation. Future research could build on this by analyzing effects of labor market policies on political participation and polarization.

For policymakers, these results suggest that minimum wage increases can be an effective instrument for raising low wages and compress the lower tail of the wage distribution. At the same time, policymakers should account for firm adjustment responses, potential long-run labor demand effects, and prevailing institutional and macroeconomic conditions when deciding on future minimum wage increases.

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Declarations

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Competing interests

The author declares that there are no competing interests.

Data availability

The data used in this study are drawn from the German Socio-Economic Panel (SOEP-Core, version 40.1), covering the period 2016–2023. The data are subject to access and redistribution restrictions and therefore cannot be made publicly available by the author. Researchers affiliated with eligible research institutions can apply for access

through the SOEP Research Data Center at the German Institute for Economic Research (DIW Berlin), subject to a data distribution agreement. Further information is available at https://www.diw.de/soep.

Code availability

The R code used for data preparation, estimation, and the production of tables and figures is available in a replication package prepared by the author. The package includes documentation of the required SOEP datasets, variables, software, and dependencies. Reproduction of the results requires authorized access to SOEP-Core version 40.1. *"Additional information 1"* provides a description of the replication package.

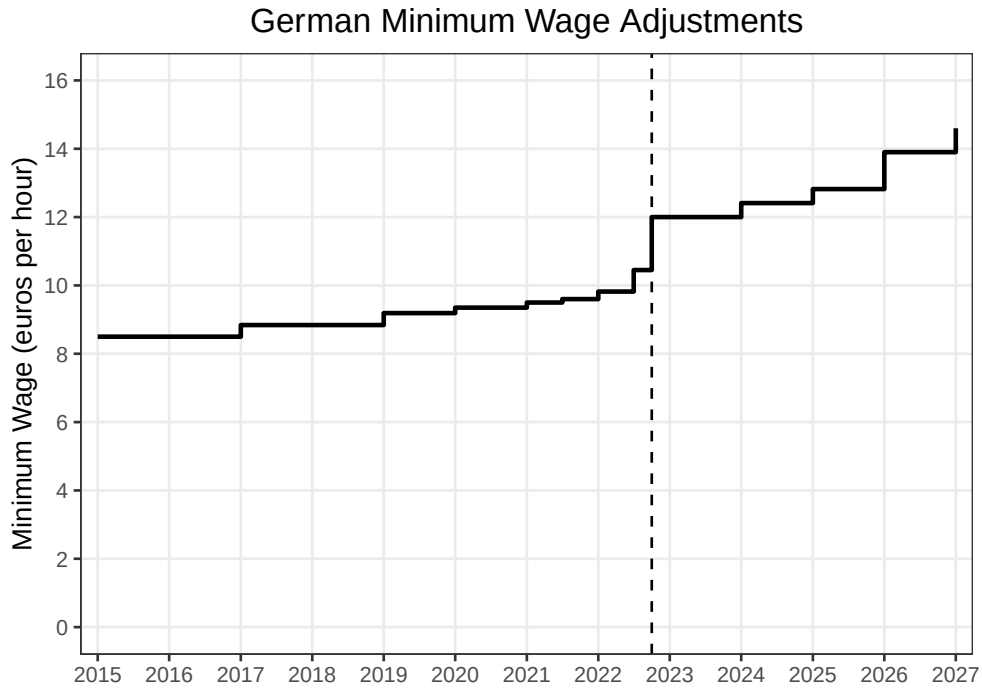
A Descriptive statistics

Table 4 Individual-level DiDiD working sample

	Oct16 - Sep17	Oct17 - Sep18	Oct18 - Sep19	Oct19 - Sep20	Oct20 - Sep21	Oct21 - Sep22	Oct22- Sep23
Observations	5,004	5,407	5,809	6,120	8,772	5,034	4,326
Average hourly wages							
Actual wages	18.17	18.51	19.44	20.04	20.90	23.47	25.17
Contractual wages	19.82	20.16	21.20	21.65	21.76	23.54	24.80
Average monthly wages	3,003.49	3,064.55	3,216.32	3,274.86	3,172.30	3,431.53	3,619.41
Average monthly working hours							
Actual Wages	161.85	162.14	162.26	159.57	156.69	155.04	156.07
Contractual Wages	148.27	148.41	148.57	147.68	144.39	144.64	145.48
Fraction below 2022 minimum wage							
Actual wages	0.23	0.22	0.19	0.17	0.20	0.14	0.09
Contractual wages	0.18	0.18	0.15	0.14	0.17	0.11	0.07

Notes: This table reports the average number of observations, average hourly and monthly wages and average monthly hours worked of the individual level DiDiD analysis working sample. Both the contractual and actual working hours measure are used. The SOEP survey weights are applied and hourly wages are winsorized at the 1st and 99th percentiles.
Data: Sozio-oekonomisches Panel (SOEP) (2025)

Fig. 4 Minimum wage over time



Notes: This figure plots the development of the German minimum wage since its introduction in 2015.

Table 5 Individual-level DiDiD sample characteristics

	Oct16 - Sep17	Oct17 - Sep18	Oct18 - Sep19	Oct19 - Sep20	Oct20 - Sep21	Oct21 - Sep22	Oct22 - Sep23
Basic Demographics							
Female	48.08	47.61	47.41	48.55	48.88	50.50	50.18
Male	51.92	52.39	52.58	51.44	51.11	49.49	49.82
Age below 25	2.95	3.27	2.87	2.74	5.39	2.91	1.94
Age between 25 and 55	83.00	79.47	77.67	75.59	71.32	70.21	68.04
Age above 55	14.05	17.26	19.46	21.67	23.29	26.88	30.02
German Nationality	92.57	91.67	90.96	91.11	88.69	90.45	89.71
Married	51.32	51.18	51.17	51.58	50.69	53.23	53.90
Region							
West Germany	82.27	82.46	82.52	82.67	83.51	84.37	84.36
East Germany	17.73	17.54	17.34	17.33	16.49	15.63	15.64
Urban	67.37	66.76	65.78	67.66	67.97	67.92	65.73
Rural	32.63	33.24	32.55	32.34	32.03	32.08	34.27
Employment							
Full-time Employment	72.02	72.37	72.03	70.72	68.09	68.42	66.64
Part-time Employment	23.45	22.88	23.98	24.86	24.31	26.56	28.98
Marginal Employment	4.53	4.65	3.98	4.42	6.15	4.86	4.21
Civil Service	28.83	28.74	28.76	28.80	27.74	28.74	29.43
Firm size (Number of Employees)							
Below 20	17.21	16.36	15.98	14.83	17.56	16.51	16.56
Between 20 and 200	23.63	24.06	24.04	23.48	25.50	25.10	22.19
Between 200 and 2000	24.50	24.25	24.19	25.43	23.55	25.31	25.05
Above 2000	34.67	35.33	35.79	36.27	33.40	33.07	36.19
Education							
Low Education	4.93	5.33	5.21	5.05	7.45	6.52	6.52
Medium Education	58.63	58.16	57.48	56.55	57.82	55.62	56.24
High Education	36.44	36.51	37.31	38.40	34.73	37.87	37.25
Sector							
Agriculture Sector	0.48	0.49	0.63	0.68	0.66	0.81	0.54
Manufacturing Sector	28.94	29.00	29.26	28.59	27.58	27.90	25.52
Service Sector	70.58	70.51	70.10	70.73	71.76	71.29	73.94

Notes: This table reports the composition of the working sample used in the individual-level DiDiD analysis across years. It includes information on demographic characteristics, region, employment type, firm size, education, and sector. Values are reported as percentage shares. SOEP survey weights are applied.
Data: Sozio-oekonomisches Panel (SOEP) (2025)

Table 6 Observations per wage group

	Treatment group (<12)	Spillover group (12 - 18)	Control group (>18)
Oct 18 - Sep 19	858	1,372	2,193
Oct 19 - Sep 20	811	1,429	2,441
Oct 20 - Sep 21	1,017	1,748	3,072
Oct 21 - Sep 22	502	1,150	2,322
Oct 22 - Sep 23	595	1,151	2,643

Notes: This table shows the number of observations per year for the treatment group (col. 1), the spillover group (col.2) and the control group (col.3).
Data: Sozio-oekonomisches Panel (SOEP) (2025)

B Heterogeneity Analyses

Table 7 Results heterogeneity analysis by gender

Model:	Male: Hourly wage growth (1)	Female: Hourly wage growth (2)	Male: Monthly wage growth (3)	Female: Monthly wage growth (4)	Male: Working hours growth (5)	Female: Working hours growth (6)	Male: Employment retention (7)	Female: Employment retention (8)
Variables								
Oct18-Sep19 × Treatment Group (¡12€)	-0.0270	-0.0416*	-0.0140	-0.0064	0.0068	0.0314	0.0269	0.0394**
	(0.0294)	(0.0229)	(0.0426)	(0.0288)	(0.0282)	(0.0235)	(0.0209)	(0.0156)
Oct19-Sep20	0.0379	-0.0427*	0.1151**	-0.0172	0.0710**	0.0147	-0.0010	0.0253*
	(0.0341)	(0.0221)	(0.0508)	(0.0274)	(0.0300)	(0.0216)	(0.0214)	(0.0152)
Oct21-Sep22	0.0298	0.0714***	0.0646	0.0631**	0.0358	-0.0078	0.0287	0.0067
	(0.0394)	(0.0258)	(0.0549)	(0.0317)	(0.0344)	(0.0270)	(0.0246)	(0.0179)
Oct22-Sep23	0.1397***	0.1031***	0.0969	0.0990***	-0.0574	0.0059	0.0660**	0.0245
	(0.0481)	(0.0307)	(0.0625)	(0.0361)	(0.0396)	(0.0307)	(0.0257)	(0.0208)
Oct18-Sep19 × Spillover Group (12-18€)	-0.0180	-0.0023	-0.0122	0.0089	0.0048	0.0117	0.0010	0.0101
	(0.0143)	(0.0142)	(0.0151)	(0.0184)	(0.0109)	(0.0152)	(0.0093)	(0.0119)
Oct19-Sep20	-0.0085	-0.0180	-0.0100	-0.0234	-0.0007	-0.0034	-0.0089	0.0217*
	(0.0144)	(0.0131)	(0.0151)	(0.0173)	(0.0123)	(0.0143)	(0.0093)	(0.0112)
Oct21-Sep22	0.0007	0.0151	0.0097	0.0106	0.0052	-0.0020	0.0025	0.0020
	(0.0152)	(0.0158)	(0.0165)	(0.0191)	(0.0137)	(0.0166)	(0.0107)	(0.0119)
Oct22-Sep23	0.0242	0.0350**	-0.0152	0.0007	-0.0446**	-0.0291*	-0.0044	0.0052
	(0.0201)	(0.0175)	(0.0224)	(0.0207)	(0.0177)	(0.0174)	(0.0122)	(0.0137)
Socio-demographic controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Employment controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Wage-group FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fit statistics								
Observations	10,129	11,665	10,129	11,665	10,129	11,665	15,558	17,939
R^2	0.12720	0.11895	0.17711	0.13351	0.13406	0.09589	0.06168	0.04320

Clustered (individual level) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Notes: This table reports individual-level DiDiD estimates for workers with lagged (t-2) contractual hourly wages below €12 (treatment group) and between €12 and €18 (spillover group), relative to a control group earning at least €18. Reported coefficients measure changes in hourly wage growth (col. 1), monthly wage growth (col. 2), working hours growth (col. 3), and employment retention (col. 4), relative to the reference year 2020 and to the control group. Female and male workers are analyzed separately. The sample includes minimum-wage-eligible individuals employed in 2020 who have at least one valid wage observation pair at t and t-2. Specifications include demographic and employment controls and wage-group and year fixed effects. Wages are winsorized at the 1st and 99th percentiles.
Data: Sozio-oekonomisches Panel (SOEP) (2025)

Table 8 Results heterogeneity analysis by region

Model:	West: Hourly wage growth (1)	East: Hourly wage growth (2)	West: Monthly wage growth (3)	East: Monthly wage growth (4)	West: Working hours growth (5)	East: Working hours growth (6)	West: Employment retention (7)	East: Employment retention (8)
Variables								
Oct18-Sep19 × Treatment Group (¡12€)	-0.0329	-0.0433	-0.0236	0.0012	0.0063	0.0365	0.0353**	0.0269
	(0.0226)	(0.0284)	(0.0302)	(0.0355)	(0.0235)	(0.0256)	(0.0147)	(0.0218)
Oct19-Sep20	0.0059	-0.0469	0.0250	0.0220	0.0144	0.0514*	0.0066	0.0333
	(0.0231)	(0.0295)	(0.0316)	(0.0382)	(0.0225)	(0.0270)	(0.0149)	(0.0211)
Oct21-Sep22	0.0753***	0.0413	0.1013***	-0.0067	0.0271	-0.0485	0.0159	0.0153
	(0.0283)	(0.0315)	(0.0375)	(0.0369)	(0.0284)	(0.0302)	(0.0177)	(0.0236)
Oct22-Sep23	0.1088***	0.1540***	0.0932**	0.1103**	-0.0151	-0.0439	0.0542***	0.0017
	(0.0328)	(0.0408)	(0.0410)	(0.0451)	(0.0310)	(0.0337)	(0.0187)	(0.0303)
Oct18-Sep19 × Spillover Group (12-18€)	-0.0075	-0.0153	-0.0040	-0.0033	0.0029	0.0138	0.0074	0.0029
	(0.0112)	(0.0214)	(0.0142)	(0.0226)	(0.0112)	(0.0179)	(0.0089)	(0.0151)
Oct19-Sep20	-0.0102	-0.0185	-0.0211	-0.0110	-0.0108	0.0137	0.0062	0.0164
	(0.0107)	(0.0205)	(0.0138)	(0.0224)	(0.0114)	(0.0168)	(0.0086)	(0.0143)
Oct21-Sep22	0.0128	0.0062	0.0106	0.0115	-0.0039	0.0105	0.0039	0.0014
	(0.0126)	(0.0231)	(0.0157)	(0.0228)	(0.0132)	(0.0208)	(0.0095)	(0.0157)
Oct22-Sep23	0.0292*	0.0552**	-0.0077	0.0073	-0.0362**	-0.0476**	0.0067	-0.0191
	(0.0155)	(0.0241)	(0.0179)	(0.0272)	(0.0148)	(0.0201)	(0.0110)	(0.0177)
Socio-demographic controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Employment controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Wages-group FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fit statistics								
Observations	17,091	4,704	17,091	4,704	17,091	4,704	26,419	7,077
R^2	0.12694	0.10935	0.15308	0.13172	0.10623	0.10606	0.04576	0.05173

Clustered (individual level) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Notes: This table reports individual-level DiDiD estimates for workers with lagged (t-2) contractual hourly wages below €12 (treatment group) and between €12 and €18 (spillover group), relative to a control group earning at least €18. Reported coefficients measure changes in hourly wage growth (col. 1), monthly wage growth (col. 2), working hours growth (col. 3), and employment retention (col. 4), relative to the reference year 2020 and to the control group. Workers in East and West Germany are analyzed separately. The sample includes minimum-wage-eligible individuals employed in 2020 who have at least one valid wage observation pair at t and t-2. Specifications include demographic and employment controls and wage-group and year fixed effects. Wages are winsorized at the 1st and 99th percentiles.
Data: Sozio-oekonomisches Panel (SOEP) (2025)

Table 9 Results heterogeneity analysis by employment type

Model:	Part: Hourly wage growth (1)	Full: Hourly wage growth (2)	Part: Monthly wage growth (3)	Full: Monthly wage growth (4)	Part: Working hours growth (5)	Full: Working hours growth (6)	Part: Employment retention (7)	Full: Employment retention (8)
Variables								
Oct18-Sep19 × Treatment Group (¡12€)	-0.0016	-0.0475**	-0.0195	-0.0021	-0.0184	0.0368**	0.0406*	0.0138
	(0.0326)	(0.0224)	(0.0392)	(0.0272)	(0.0292)	(0.0172)	(0.0208)	(0.0169)
Oct19-Sep20	-0.0028	-0.0066	0.0043	0.0350	0.0013	0.0334**	-0.0016	0.0126
	(0.0312)	(0.0242)	(0.0408)	(0.0293)	(0.0299)	(0.0169)	(0.0212)	(0.0168)
Oct21-Sep22	0.0495	0.0617**	0.0477	0.0693**	0.0045	-0.0002	-0.0137	0.0224
	(0.0378)	(0.0297)	(0.0508)	(0.0336)	(0.0341)	(0.0209)	(0.0263)	(0.0197)
Oct22-Sep23	0.1344***	0.1631***	0.0657	0.1400***	-0.0689*	-0.0414	0.0338	0.0279
	(0.0439)	(0.0394)	(0.0485)	(0.0457)	(0.0371)	(0.0272)	(0.0272)	(0.0232)
Oct18-Sep19 × Spillover Group (12-18€)	0.0125	-0.0117	0.0251	-0.0072	0.0099	0.0056	-0.0068	0.0072
	(0.0197)	(0.0113)	(0.0253)	(0.0121)	(0.0219)	(0.0086)	(0.0145)	(0.0091)
Oct19-Sep20	0.0125	-0.0213*	0.0110	-0.0216*	-0.0037	0.0024	0.0063	0.0049
	(0.0187)	(0.0109)	(0.0244)	(0.0119)	(0.0210)	(0.0090)	(0.0137)	(0.0089)
Oct21-Sep22	0.0244	0.0052	0.0258	0.0049	5.08×10^{-6}	-0.0003	-0.0082	0.0036
	(0.0211)	(0.0129)	(0.0255)	(0.0135)	(0.0227)	(0.0112)	(0.0145)	(0.0100)
Oct22-Sep23	0.0528**	0.0258*	0.0349	-0.0135	-0.0240	-0.0372***	-0.0154	0.0044
	(0.0251)	(0.0149)	(0.0300)	(0.0163)	(0.0250)	(0.0133)	(0.0172)	(0.0113)
Socio-demographic controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Employment controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Wage-group FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fit statistics								
Observations	6,527	14,388	6,527	14,388	6,527	14,388	9,783	21,960
R^2	0.11903	0.11464	0.11476	0.07494	0.05193	0.02379	0.06963	0.03308

Clustered (individual level) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Notes: This table reports individual-level DiDiD estimates for workers with lagged (t-2) contractual hourly wages below €12 (treatment group) and between €12 and €18 (spillover group), relative to a control group earning at least €18. Reported coefficients measure changes in hourly wage growth (col. 1), monthly wage growth (col. 2), working hours growth (col. 3), and employment retention (col. 4), relative to the reference year 2020 and to the control group. Full- and part-time workers are analyzed separately. Marginal workers are excluded due to too few observations. The sample includes minimum-wage-eligible individuals employed in 2020 who have at least one valid wage observation pair at t and t-2. Specifications include demographic and employment controls and wage-group and year fixed effects. Wages are winsorized at the 1st and 99th percentiles.
Data: Sozio-oekonomisches Panel (SOEP) (2025)

Table 10 Results heterogeneity analysis by firm size

Model:	Hourly: Firm ¡200 (1)	Hourly: Firm ¿=200 (2)	Monthly: Firm ¡200 (3)	Monthly: Firm ¿=200 (4)	Hours: Firm ¡200 (5)	Hours: Firm ¿=200 (6)	Emp: Firm ¡200 (7)	Emp: Firm ¿=200 (8)
Variables								
Oct18-Sep19 × Treatment Group (¡12€)	-0.0422*	-0.0626*	-0.0037	-0.0465	0.0386*	0.0020	0.0422***	0.0025
	(0.0227)	(0.0327)	(0.0297)	(0.0397)	(0.0232)	(0.0308)	(0.0163)	(0.0197)
Oct19-Sep20	-0.0006	-0.0478	0.0388	0.0056	0.0316	0.0378	0.0172	0.0097
	(0.0238)	(0.0327)	(0.0302)	(0.0449)	(0.0226)	(0.0307)	(0.0165)	(0.0193)
Oct21-Sep22	0.0777***	0.0051	0.0702**	0.0474	-0.0008	0.0279	0.0341*	-0.0166
	(0.0272)	(0.0388)	(0.0351)	(0.0486)	(0.0285)	(0.0350)	(0.0189)	(0.0245)
Oct22-Sep23	0.1676***	0.0460	0.1420***	0.0191	-0.0308	-0.0270	0.0459**	0.0440*
	(0.0349)	(0.0432)	(0.0417)	(0.0503)	(0.0331)	(0.0370)	(0.0217)	(0.0237)
Oct18-Sep19 × Spillover Group (12-18€)	-0.0151	-0.0102	0.0176	-0.0246	0.0342**	-0.0162	0.0062	0.0032
	(0.0167)	(0.0128)	(0.0186)	(0.0158)	(0.0154)	(0.0120)	(0.0121)	(0.0102)
Oct19-Sep20	-0.0116	-0.0149	0.0120	-0.0418***	0.0236	-0.0249*	0.0191	-0.0033
	(0.0165)	(0.0122)	(0.0187)	(0.0152)	(0.0151)	(0.0127)	(0.0117)	(0.0101)
Oct21-Sep22	0.0078	0.0041	0.0303	-0.0071	0.0237	-0.0135	0.0070	0.0019
	(0.0181)	(0.0146)	(0.0198)	(0.0173)	(0.0176)	(0.0143)	(0.0133)	(0.0108)
Oct22-Sep23	0.0481**	0.0275	0.0052	-0.0132	-0.0418**	-0.0422***	0.0179	-0.0105
	(0.0214)	(0.0179)	(0.0243)	(0.0199)	(0.0205)	(0.0163)	(0.0146)	(0.0129)
Socio-demographic controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Employment controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Wage-group FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fit statistics								
Observations	8,974	12,817	8,974	12,817	8,974	12,817	14,674	18,821
R^2	0.12234	0.12346	0.14062	0.15512	0.11285	0.10463	0.04925	0.03726

Clustered (individual level) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Notes: This table reports individual-level DiDiD estimates for workers with lagged (t-2) contractual hourly wages below €12 (treatment group) and between €12 and €18 (spillover group), relative to a control group earning at least €18. Reported coefficients measure changes in hourly wage growth (col. 1), monthly wage growth (col. 2), working hours growth (col. 3), and employment retention (col. 4), relative to the reference year 2020 and to the control group. Effects are analyzed by firm size. The sample includes minimum-wage-eligible individuals employed in 2020 who have at least one valid wage observation pair at t and t-2. Specifications include demographic and employment controls and wage-group and year fixed effects. Wages are winsorized at the 1st and 99th percentiles.
Data: Sozio-oekonomisches Panel (SOEP) (2025)

C Robustness checks

Table 11 Estimation results weighted

Model:	Hourly wage growth (1)	Monthly wage growth (2)	Working hours growth (3)	Employment retention (4)
Variables				
Oct18-Sep19 × Treatment Group (¡12€)	-0.0442	-0.0129	0.0180	0.0187
	(0.0274)	(0.0342)	(0.0250)	(0.0176)
Oct19-Sep20	0.0086	0.0466	0.0299	0.0129
	(0.0276)	(0.0378)	(0.0266)	(0.0163)
Oct21-Sep22	0.0618*	0.0161	-0.0442*	0.0110
	(0.0349)	(0.0428)	(0.0261)	(0.0225)
Oct22-Sep23	0.1553***	0.1135*	-0.0393	0.0339
	(0.0518)	(0.0603)	(0.0297)	(0.0216)
Oct18-Sep19 × Spillover Group (12-18€)	-0.0337*	-0.0217	0.0124	0.0140
	(0.0177)	(0.0191)	(0.0184)	(0.0122)
Oct19-Sep20	-0.0488***	-0.0626***	-0.0101	0.0236**
	(0.0177)	(0.0194)	(0.0196)	(0.0120)
Oct21-Sep22	-0.0068	0.0089	0.0124	0.0017
	(0.0206)	(0.0200)	(0.0207)	(0.0144)
Oct22-Sep23	0.0133	-0.0237	-0.0348*	-0.0026
	(0.0215)	(0.0226)	(0.0209)	(0.0162)
Socio-demographic controls	Yes	Yes	Yes	Yes
Employment controls	Yes	Yes	Yes	Yes
Wage-group FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Fit statistics				
Observations	21,523	21,523	21,523	33,499
R^2	0.14329	0.16247	0.10636	0.03764

Clustered (individual level) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Notes: This table reports individual-level DiDiD estimates for workers with lagged (t-2) contractual hourly wages below € 12 (treatment group) and between € 12 and € 18 (spillover group), relative to a control group earning at least € 18. Reported coefficients measure changes in hourly wage growth (col. 1), monthly wage growth (col. 2), working hours growth (col. 3), and employment retention (col. 4), relative to the reference year 2020 and to the control group. The sample includes minimum-wage-eligible individuals employed in 2020 who have at least one valid wage observation pair at t and t-2. Specifications include demographic and employment controls and wage-group and year fixed effects. Wages are winsorized at the 1st and 99th percentiles. SOEP cross-sectional survey weights are applied.
Data: Sozio-oekonomisches Panel (SOEP) (2025)

Table 12 Estimation results actual working hours measure

Model:	Hourly wage growth (actual) (1)	Monthly wage growth (2)	Working hours growth (actual) (3)	Employment retention (4)
Variables				
Oct18-Sep19 × Treatment Group (¡12€)	-0.0337*	-0.0131	0.0160	0.0261**
	(0.0177)	(0.0204)	(0.0179)	(0.0104)
Oct19-Sep20	-0.0092	0.0149	0.0170	0.0077
	(0.0177)	(0.0210)	(0.0175)	(0.0104)
Oct21-Sep22	0.0166	0.0410*	0.0264	0.0169
	(0.0216)	(0.0246)	(0.0218)	(0.0120)
Oct22-Sep23	0.1497***	0.0735***	-0.0745***	0.0303**
	(0.0274)	(0.0273)	(0.0261)	(0.0137)
Oct18-Sep19 × Spillover Group (12-18€)	-0.0182	-0.0053	0.0138	-0.0032
	(0.0119)	(0.0118)	(0.0118)	(0.0074)
Oct19-Sep20	-0.0142	-0.0146	0.0020	0.0051
	(0.0116)	(0.0115)	(0.0116)	(0.0071)
Oct21-Sep22	0.0111	0.0146	0.0055	0.0017
	(0.0157)	(0.0123)	(0.0155)	(0.0076)
Oct22-Sep23	0.0696***	0.0026	-0.0620***	0.0038
	(0.0180)	(0.0146)	(0.0181)	(0.0088)
Socio-demographic controls	Yes	Yes	Yes	Yes
Employment controls	Yes	Yes	Yes	Yes
Wage-group FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
State FE				
Individual FE (pid)				
Fit statistics				
Observations	21,469	21,469	21,469	35,116
R^2	0.08974	0.14376	0.07289	0.04383

Clustered (individual level) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Notes: This table reports individual-level DiDiD estimates for workers with lagged (t-2) actual hourly wages below € 12 (treatment group) and between € 12 and € 18 (spillover group), relative to a control group earning at least € 18. Reported coefficients measure changes in hourly wage growth (col. 1), monthly wage growth (col. 2), working hours growth (col. 3), and employment retention (col. 4), relative to the reference year 2020 and to the control group. The actual working hours measure is used. The sample includes minimum-wage-eligible individuals employed in 2020 who have at least one valid wage observation pair at t and t-2. Specifications include demographic and employment controls and wage-group and year fixed effects. Wages are winsorized at the 1st and 99th percentiles.
Data: Sozio-oekonomisches Panel (SOEP) (2025)

Table 13 Estimation results overtime

Model:	(1)
Variables	
Oct18-Sep19 × Treatment Group (¡12€)	-0.0153
	(0.1713)
Oct19-Sep20	0.1223
	(0.1549)
Oct21-Sep22	0.1085
	(0.1757)
Oct22-Sep23	0.1905
	(0.1844)
Oct18-Sep19 × Spillover Group (12-18€)	-0.0938
	(0.1473)
Oct19-Sep20	0.0690
	(0.1326)
Oct21-Sep22	0.0667
	(0.1331)
Oct22-Sep23	-0.0032
	(0.1530)
Fit statistics	
Observations	21,117
R^2	0.01282

Clustered (individual level) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Notes: This table reports individual-level DiDiD estimates for workers with lagged (t-2) contractual hourly wages below € 12 (treatment group) and between € 12 and € 18 (spillover group), relative to a control group earning at least € 18. Reported coefficients compare overtime hours growth of treated workers relative to the control group and relative to policy year 2020. The sample includes minimum-wage-eligible individuals employed in 2020 who have at least one valid wage observation pair at t and t-2. Specifications include demographic and employment controls and wage-group and year fixed effects. Wages are winsorized at the 1st and 99th percentiles.
Data: Sozio-oekonomisches Panel (SOEP) (2025)

Table 14 Estimation results different control variables

	Hourly wage growth				Monthly wage growth				Working hours growth				Employment retention			
Model:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
Variables																
Oct18-Sep19 × Treatment Group (<12€)	-0.0271	-0.0317*	-0.0364**	-0.0577***	-0.0161	-0.0184	-0.0126	-0.0236	0.0075	0.0092	0.0188	0.0307*	0.0428***	0.0404***	0.0300**	0.0251**
	(0.0176)	(0.0175)	(0.0178)	(0.0199)	(0.0240)	(0.0238)	(0.0234)	(0.0259)	(0.0187)	(0.0186)	(0.0180)	(0.0186)	(0.0122)	(0.0123)	(0.0122)	(0.0128)
Oct19-Sep20	0.0041	-0.0050	-0.0131	-0.0306	0.0282	0.0204	0.0242	0.0062	0.0160	0.0178	0.0276	0.0307	0.0183	0.0169	0.0123	0.0125
	(0.0181)	(0.0177)	(0.0183)	(0.0201)	(0.0249)	(0.0244)	(0.0246)	(0.0263)	(0.0179)	(0.0179)	(0.0175)	(0.0188)	(0.0121)	(0.0121)	(0.0121)	(0.0129)
Oct21-Sep22	0.0519**	0.0552***	0.0601***	0.0380	0.0580**	0.0686**	0.0610**	0.0601*	0.0083	0.0146	0.0011	0.0238	0.0192	0.0168	0.0156	0.0087
	(0.0209)	(0.0206)	(0.0214)	(0.0239)	(0.0291)	(0.0284)	(0.0278)	(0.0309)	(0.0222)	(0.0221)	(0.0214)	(0.0225)	(0.0143)	(0.0143)	(0.0143)	(0.0153)
Oct22-Sep23	0.1141***	0.1124***	0.1219***	0.0940***	0.0984***	0.0998***	0.0992***	0.0622*	-0.0112	-0.0084	-0.0227	-0.0283	0.0450***	0.0451***	0.0395**	0.0282
	(0.0239)	(0.0240)	(0.0262)	(0.0288)	(0.0310)	(0.0306)	(0.0320)	(0.0362)	(0.0242)	(0.0242)	(0.0243)	(0.0260)	(0.0154)	(0.0153)	(0.0160)	(0.0174)
Oct18-Sep19 × Spillover Group (12-18€)	-0.0068	-0.0057	-0.0072	-0.0125	-0.0109	-0.0079	-0.0011	-0.0051	-0.0032	-0.0013	0.0058	0.0077	0.0076	0.0078	0.0047	0.0042
	(0.0102)	(0.0101)	(0.0099)	(0.0107)	(0.0126)	(0.0124)	(0.0120)	(0.0131)	(0.0102)	(0.0101)	(0.0095)	(0.0102)	(0.0077)	(0.0076)	(0.0077)	(0.0083)
Oct19-Sep20	-0.0109	-0.0084	-0.0103	-0.0175	-0.0225*	-0.0207*	-0.0159	-0.0249*	-0.0090	-0.0095	-0.0041	-0.0046	0.0089	0.0091	0.0067	0.0088
	(0.0097)	(0.0096)	(0.0095)	(0.0106)	(0.0122)	(0.0121)	(0.0116)	(0.0130)	(0.0103)	(0.0102)	(0.0095)	(0.0105)	(0.0074)	(0.0074)	(0.0074)	(0.0080)
Oct21-Sep22	0.0025	0.0048	0.0098	0.0036	0.0013	0.0040	0.0100	0.0133	-9.39×10^{-5}	0.0006	-6.17×10^{-5}	0.0099	0.0062	0.0060	0.0025	0.0039
	(0.0110)	(0.0111)	(0.0110)	(0.0120)	(0.0132)	(0.0131)	(0.0129)	(0.0141)	(0.0115)	(0.0115)	(0.0110)	(0.0117)	(0.0080)	(0.0081)	(0.0081)	(0.0088)
Oct22-Sep23	0.0243*	0.0278**	0.0334**	0.0276*	-0.0107	-0.0060	-0.0058	-0.0126	-0.0336***	-0.0328***	-0.0384***	-0.0379***	-0.0009	-0.0012	0.0006	-0.0002
	(0.0128)	(0.0127)	(0.0131)	(0.0142)	(0.0151)	(0.0149)	(0.0150)	(0.0167)	(0.0126)	(0.0125)	(0.0123)	(0.0133)	(0.0093)	(0.0093)	(0.0094)	(0.0101)
Socio-demographic controls		Yes	Yes	Yes		Yes	Yes	Yes		Yes	Yes	Yes		Yes	Yes	Yes
Employment controls			Yes	Yes			Yes	Yes			Yes	Yes			Yes	Yes
Wage-group FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry-year FE				Yes				Yes				Yes				Yes
Fit statistics																
Observations	23,304	23,118	21,796	21,768	23,304	23,118	21,796	21,768	23,304	23,118	21,796	21,768	36,126	35,840	33,499	33,485
R^2	0.07889	0.09919	0.11736	0.13352	0.06558	0.09452	0.14361	0.15665	0.00249	0.01461	0.10198	0.11852	0.02324	0.03569	0.04404	0.05274

Clustered (individual level) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Notes: This table reports individual-level DiDiD estimates for workers with lagged (t-2) contractual hourly wages below €12 (treatment group) and between €12 and €18 (spillover group), relative to a control group earning at least €18. Reported coefficients measure changes in hourly wage growth, monthly wage growth , working hours growth, and employment retention, relative to the reference year 2020 and to the control group. The sample includes minimum-wage-eligible individuals employed in 2020 who have at least one valid wage observation pair at t and t-2. The first specification (col. 1,5,9,13) applies only wage group and time fixed effects without any additional controls. The second specification (col. 2,6,10,14) includes socio-demographic controls (age, gender, nationality, marital status and education). The third specification (col. 3,7,11,15), used in the main part of the analysis includes demographic and employment controls (employment type, firm size, industry, and job changes). The last specification (col. 4,8,12,16) additionally includes industry-year fixed effects. Wages are winsorized at the 1st and 99th percentiles.
Data: Sozio-oekonomisches Panel (SOEP) (2025)

Table 15 Estimation results excluding imputed wage information

Model:	Hourly wage growth (1)	Monthly wage growth (2)	Working hours growth (3)	Employment retention (4)
Variables				
Oct18-Sep19 × Treatment Group (¡12€)	-0.0272	-0.0141	0.0090	0.0295**
	(0.0175)	(0.0235)	(0.0191)	(0.0133)
Oct19-Sep20	-0.0102	0.0270	0.0254	0.0105
	(0.0180)	(0.0253)	(0.0185)	(0.0132)
Oct21-Sep22	0.0493**	0.0599**	0.0103	0.0190
	(0.0203)	(0.0279)	(0.0216)	(0.0156)
Oct22-Sep23	0.1104***	0.1036***	-0.0080	0.0387**
	(0.0253)	(0.0311)	(0.0266)	(0.0179)
Oct18-Sep19 × Spillover Group (12-18€)	-0.0042	-0.0037	-0.0017	0.0058
	(0.0095)	(0.0122)	(0.0098)	(0.0082)
Oct19-Sep20	-0.0037	-0.0154	-0.0117	0.0079
	(0.0090)	(0.0117)	(0.0098)	(0.0078)
Oct21-Sep22	0.0145	0.0072	-0.0105	0.0046
	(0.0107)	(0.0131)	(0.0116)	(0.0088)
Oct22-Sep23	0.0394***	0.0069	-0.0352***	0.0031
	(0.0124)	(0.0144)	(0.0132)	(0.0100)
Socio-demographic controls	Yes	Yes	Yes	Yes
Employment controls	Yes	Yes	Yes	Yes
Wage-group FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Fit statistics				
Observations	19,680	19,680	19,680	30,120
R^2	0.11847	0.15815	0.10029	0.04567

Clustered (individual level) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Notes: This table reports individual-level DiDiD estimates for workers with lagged (t-2) contractual hourly wages below €12 (treatment group) and between €12 and €18 (spillover group), relative to a control group earning at least €18. Reported coefficients measure changes in hourly wage growth (col. 1), monthly wage growth (col. 2), working hours growth (col. 3), and employment retention (col. 4), relative to the reference year 2020 and to the control group. The sample includes minimum-wage-eligible individuals employed in 2020 who have at least one valid wage observation pair at t and t-2. Specifications include demographic and employment controls and wage-group and year fixed effects. Wages are winsorized at the 1st and 99th percentiles. Imputed wage information is excluded.
Data: Sozio-oekonomisches Panel (SOEP) (2025)

Table 16 Estimation results balanced panel

Model:	Hourly wage growth (1)	Monthly wage growth (2)	Working hours growth (3)	Employment retention (4)
Variables				
Oct18-Sep19 x Treatment Group (¡12€)	0.0241	0.0595	0.0514	-0.0065
	(0.0434)	(0.0609)	(0.0428)	(0.0245)
Oct19-Sep20	0.0185	0.0349	0.0139	-0.0163
	(0.0478)	(0.0521)	(0.0313)	(0.0189)
Oct21-Sep22	0.0767	0.0566	0.0241	-0.0273
	(0.0544)	(0.0911)	(0.0248)	(0.0285)
Oct22-Sep23	0.1686**	0.0957	-0.0307	0.0040
	(0.0760)	(0.1062)	(0.0394)	(0.0304)
Oct18-Sep19 x Spillover Group (12-18€)	0.0157	0.0480	0.0326	0.0348
	(0.0340)	(0.0307)	(0.0319)	(0.0247)
Oct19-Sep20	-0.0163	0.0050	0.0217	0.0457**
	(0.0335)	(0.0295)	(0.0316)	(0.0196)
Oct21-Sep22	0.0041	0.0619	0.0572	0.0011
	(0.0328)	(0.0412)	(0.0502)	(0.0218)
Oct22-Sep23	0.0099	0.0013	-0.0110	0.0338
	(0.0377)	(0.0345)	(0.0286)	(0.0252)
Socio-demographic controls	Yes	Yes	Yes	Yes
Employment controls	Yes	Yes	Yes	Yes
Wage-group FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Fit statistics				
Observations	9,105	9,105	9,105	11,716
R^2	0.12185	0.13330	0.09080	0.06024

Clustered (individual level) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Notes: This table reports individual-level DiDiD estimates for workers with lagged (t-2) contractual hourly wages below €12 (treatment group) and between €12 and €18 (spillover group), relative to a control group earning at least €18. Reported coefficients measure changes in hourly wage growth (col. 1), monthly wage growth (col. 2), working hours growth (col. 3), and employment retention (col. 4), relative to the reference year 2020 and to the control group. The sample includes minimum-wage-eligible individuals employed in 2020 who have at least one valid wage observation pair at t and t-2. Specifications include demographic and employment controls and wage-group and year fixed effects. Wages are winsorized at the 1st and 99th percentiles. The working sample only contains workers observed in every year resulting in a balanced panel. Cross-sectional and longitudinal SOEP weights are combined to control for sample attrition.
Data: Sozio-oekonomisches Panel (SOEP) (2025)

Table 17 Results non-monetary outcomes (weighted)

Model:	Interest in politics (1)	Work satisfaction (2)	Life satisfaction (3)	Income satisfaction (4)	Financial worries (5)
Variables					
Oct18-Sep19 × Treatment Group (¡12€)	0.0949	0.0555	-0.1016	-0.1301*	0.0115
	(0.0686)	(0.0827)	(0.0896)	(0.0694)	(0.0844)
Oct19-Sep20	0.1048	0.0064	-0.2036**	-0.1181	0.1224
	(0.0664)	(0.0963)	(0.0964)	(0.0862)	(0.0892)
Oct21-Sep22	0.3053***	0.1295	-0.0391	-0.0319	0.0109
	(0.0783)	(0.0965)	(0.0998)	(0.0905)	(0.0905)
Oct22-Sep23	0.1700**	0.1743	0.0310	0.0854	-0.0293
	(0.0814)	(0.1120)	(0.1236)	(0.1070)	(0.1137)
Oct18-Sep19 × Spillover Group (12-18€)	-0.0342	0.0888	-0.0530	0.0525	-0.0884
	(0.0592)	(0.0690)	(0.0613)	(0.0559)	(0.0638)
Oct19-Sep20	-0.0243	-0.0311	-0.0494	0.0387	-0.0478
	(0.0566)	(0.0752)	(0.0582)	(0.0612)	(0.0638)
Oct21-Sep22	0.1388**	-0.0094	-0.0031	-0.0585	-0.1517**
	(0.0558)	(0.0766)	(0.0582)	(0.0626)	(0.0706)
Oct22-Sep23	-0.0348	0.0264	-0.1121	0.0441	-0.1425*
	(0.0651)	(0.0825)	(0.0768)	(0.0655)	(0.0727)
Socio-demographic controls	Yes	Yes	Yes	Yes	Yes
Employment controls	Yes	Yes	Yes	Yes	Yes
Wage-group FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Fit statistics					
Observations	21,010	21,010	21,010	21,010	21,010
R^2	0.19100	0.03650	0.04894	0.15188	0.11045

Clustered (pid) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Notes: This table reports individual-level DiDiD estimates for workers with lagged (t-2) contractual hourly wages below €12 (treatment group) and between €12 and €18 (spillover group), relative to a control group earning at least €18. All outcome variables are standardized (mean = 0, standard deviation = 1) using the mean and standard deviation in the reference year 2020. Reported coefficients for interest in politics, work satisfaction, life satisfaction, income satisfaction and financial worries therefore measure effects in standard deviations. Higher values indicate better outcomes in all columns (greater interest in politics, higher satisfaction, less financial concerns). The sample includes minimum-wage-eligible individuals employed in 2020 who have at least one valid wage observation pair at t and t-2. Specifications include demographic and employment controls and wage-group and year fixed effects. Wages are winsorized at the 1st and 99th percentiles. The SOEP cross-sectional survey weights are applied.
Data: Sozio-oekonomisches Panel (SOEP) (2025)

Table 18 Results non-monetary outcomes (without standardization)

Model:	Interest in politics (1)	Work satisfaction (2)	Life satisfaction (3)	Income satisfaction (4)	Financial worries (5)
Variables					
Oct18-Sep19 × Treatment Group (¡12€)	-0.0320	0.0765	-0.1101	-0.0774	-0.0302
	(0.0333)	(0.0921)	(0.0741)	(0.0953)	(0.0312)
Oct19-Sep20	-0.0186	0.0217	-0.0935	-0.0849	0.0133
	(0.0340)	(0.0966)	(0.0781)	(0.1000)	(0.0326)
Oct21-Sep22	-0.1000**	0.0743	-0.0535	-0.0131	-0.0340
	(0.0397)	(0.1102)	(0.0841)	(0.1165)	(0.0395)
Oct22-Sep23	-0.1028**	0.1368	-0.0669	0.0794	-0.0141
	(0.0437)	(0.1195)	(0.0915)	(0.1240)	(0.0395)
Oct18-Sep19 × Spillover Group (12-18€)	-0.0182	0.0206	-0.0615	0.0556	-0.0313
	(0.0287)	(0.0733)	(0.0571)	(0.0698)	(0.0260)
Oct19-Sep20	-0.0170	-0.1716**	-0.0128	-0.0407	-0.0048
	(0.0272)	(0.0740)	(0.0552)	(0.0683)	(0.0253)
Oct21-Sep22	-0.0585**	-0.0556	-0.0478	-0.1325*	-0.0476*
	(0.0293)	(0.0782)	(0.0594)	(0.0757)	(0.0284)
Oct22-Sep23	-0.0091	0.0114	-0.1019	-0.1154	-0.0682**
	(0.0330)	(0.0823)	(0.0660)	(0.0816)	(0.0286)
Socio-demographic controls	Yes	Yes	Yes	Yes	Yes
Employment controls	Yes	Yes	Yes	Yes	Yes
Wage-group FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Fit statistics					
Observations	21,275	21,275	21,275	21,275	21,275
R^2	0.16605	0.02361	0.03385	0.13296	0.10147

Clustered (individual level) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Notes: This table reports individual-level DiDiD estimates for workers with lagged (t-2) contractual hourly wages below € 12 (treatment group) and between € 12 and € 18 (spillover group), relative to a control group earning at least € 18. This analysis uses the original SOEP survey scales without standardization. Reported coefficients measure the effect on interest into politics (scale: 1 very much - 4 not interested at all), work satisfaction (scale: 0 completely dissatisfied - 10 completely satisfied), life satisfaction (scale: 0-10), income satisfaction (scale: 0-10) and financial worries (scale: 1 very concerned - 3 not concerned at all). The sample includes minimum-wage-eligible individuals employed in 2020 who have at least one valid wage observation pair at t and t-2. Specifications include demographic and employment controls and wage-group and year fixed effects. Wages are winsorized at the 1st and 99th percentiles.
Data: Sozio-oekonomisches Panel (SOEP) (2025)

D Regional DiD

As an additional robustness check and complementary approach, this study implements a difference-in-differences design exploiting variation in regional treatment intensity. This identification strategy using a continuous treatment variable is suggested by Card (1992) and is used, for example, by Dustmann et al. (2022), Bossler and Schank (2023) and Caliendo et al. (2023). Regional treatment intensity is measured by the regional minimum wage bite, which is the share of employees in each region who earned less than the new minimum wage prior to the reform in policy year 2020. The coefficients capture how changes in outcomes differ across regions with higher versus lower pre-reform exposure to the minimum wage. The effect is expected to be stronger in regions with a higher share of workers initially earning below the new minimum wage threshold. The regional minimum wage bite is calculated at the level of federal states, distinguishing between urban and rural areas. This approach results in 32 regions, corresponding to one urban and one rural region for each of the 16 federal states. Four rural regions are dropped because of missing observation resulting in 28 regions.

The main estimation equation is specified as:

$$\log(y_{irt}) = \sum_{k=2017, k \neq 2020}^{2022} \beta_k \left(Y_k \times \mathrm{B}_r\right) + \delta' X_{ir,t-1} + \nu_t + \eta_r + \varepsilon_{irt} \tag{3}$$

where $log(y_{irt})$ represents the dependent variables of interest such as the hourly wage of individual i at time t in region r. The dependent variable is measured at the individual level and not on the aggregated regional level. The *log* specification allows coefficients to be interpreted as percentage changes. β_k captures the treatment effect by interacting the year dummies Y_k with the regional bite measures B_r. While the individual-level DiDiD approach identifies treatment effects for directly affected workers, the regional DiD strategy captures variation in regional exposure to the reform and incorporates spillover and general equilibrium effects within local labor

markets. For example, wage increases for some workers may be offset by adjustments for others within the same region, which would be captured by the regional approach. $\delta X_{ir,t-1}$ includes a set of control variables. ν_t includes time fixed effects to account for common time shocks across regions in a given year and η_r region fixed effects to account for pre-existing differences across regions. ε_{irt} denotes the remaining error term. The year 2020 is omitted as the reference year, so that estimated coefficients capture changes relative to the pre-reform period. Standard errors are clustered at the level of treatment variation, which is at the state-urban/rural level.

The implementation of the regional DiD approach is constrained by the limited regional resolution of the SOEP data. The SOEP Core dataset includes identifiers at the federal state level and distinguishes between urban and rural areas, but does not provide more granular regional identifiers such as planning regions (Raumordnungsregionen) (Bundesinstitut für Bau-, Stadt- und Raumforschung (BBSR) 2016). Ideally, a regional DiD design would exploit variation in minimum wage exposure across the 96 German planning regions. These regions are constructed based on economic structure and commuting patterns and exhibit substantial heterogeneity in wage distributions as shown by Caliendo et al. (2023). In the absence of such detailed regional identifiers, variation in treatment intensity is limited. Moreover, federal state boundaries do not necessarily align with local labor markets and may aggregate heterogeneous regions with different levels of minimum wage exposure. As a result, identification based on regional variation is likely to be weaker compared to designs using finer regional units and estimated effects may be downward biased and less precisely estimated. If more detailed regional identifiers were available, a complementary unconditional quantile regression approach could be implemented to analyze distributional effects in greater detail. Following Firpo et al. (2009), this approach is based on recentered influence function (RIF) regressions and has been applied by for example Bossler and Schank (2023) and Caliendo et al. (2023). It allows the estimation of treatment effects at

different points of the wage distribution and enables the direct analysis of inequality measures such as the wage variance or the Gini coefficient. Another limitation of the SOEP data is, that the relatively small sample size limits the scope for detailed analyses, particularly at the regional level and across the wage distribution. Caliendo et al. (2018) show that regional measures of minimum wage exposure are broadly comparable between SOEP and SES data. However, the limited number of observations restricts the feasibility of aggregated DiD approaches at the regional level.

The identification strategy relies on the parallel trends assumption. This assumption requires that regions with different levels of treatment intensity followed similar trends prior to the 2022 reform and would have continued to do so in the absence of the minimum wage increase. This assumption can be partially assessed by examining pre-treatment coefficients. Estimates for the years 2017 to 2019 should not be statistically different from zero. In addition, graphical evidence can be used to assess pre-trends. It is important that no other contemporaneous shocks systematically correlate with regional treatment intensity. For example, sector-specific shocks such as energy price increases or collective bargaining agreements could disproportionately affect regions with a high minimum wage bite. To address this concern, including industry-specific time trends is tested (Georgieva and Hohendanner 2025).

Three alternative measures of treatment intensity are tested. The baseline specification uses the minimum wage bite, defined as the share of workers earning below the new minimum wage in 2020 (Bossler and Schank 2023). In addition, the average wage gap, defined as the difference between the new minimum wage and the wages of workers with pre-treatment wages below the new threshold, is computed at the regional level (Dustmann et al. 2022). Finally, the Kaitz index, defined as the ratio of the minimum wage to the regional median wage, is used as an alternative measure (Bachmann et al. 2020). Table 19 summarizes the variation in treatment intensity across these dimensions.

The regional DiD approach has the following advantages compared to the individual-level DiDiD design if more detailed regional data were available: first, it would allow for a more direct analysis of inequality by using aggregate measures such as the wage variance, the Gini coefficient, or the gender wage gap directly as outcome variables. Second, it would better capture spillover effects across the entire wage distribution when combined with the unconditional quantile regression approach. Third, it would enable the analysis of employment effects at the regional level, including both employment retention and hiring rates.

For the regional DiD analysis, all observations with missing regional identifiers (state and urban/rural classification) are excluded. The resulting working sample consists of 85,649 observations, with an average of 12,235 observations per year (Table 20). The sample covers 28 regions, as Berlin, Hamburg, Bremen, and Saarland do not have rural observations. The small sample size also prevents the implementation of DiD specifications based on aggregated regional wage and working hours information, as used in studies relying on administrative datasets. Accordingly, the analysis is conducted at the individual level, measuring wages, working hours, and control variables at the worker level as for example done by Dustmann et al. (2022), Bossler and Schank (2023), and Caliendo et al. (2023). While the main specification uses the regional minimum wage bite as the treatment variable (Table 21), an alternative specification uses the Kaitz Index as the treatment variable (Table 24). Additionally cross-sectional SOEP weights are included (Table 22) and actual instead of contractual working hours are used (Table 23).

Table 19 Treatment intensity measures

	Bite	**Wage Gap**	**Kaitz Index**
Treatment intensity SD	0.07	0.011	0.0.72

Notes: The table reports the standard deviation of three alternative treatment intensity measures: a) the fraction of employees earning less than the new minimum wage, b) the average wage gap between the new minimum wage and the wages of employees paid below that threshold and c) the Kaitz index, defined as the ration of the new minimum wage to the regional median wage. All measures are constructed using contractual hours worked.
Data: Sozio-oekonomisches Panel (SOEP) (2025).

Table 20 Regional DiD working sample

	Oct16 - Sep17	Oct17 - Sep18	Oct18 - Sep19	Oct19 - Sep20	Oct20 - Sep21	Oct21 - Sep22	Oct22 - Sep23
Observations	13,546	13,324	12,638	12,910	8,772	10,862	13,597
Average hourly wages							
Actual wages	17.12	17.62	18.28	19.06	20.90	23.45	24.83
Contractual wages	18.62	19.15	19.94	20.56	21.76	23.44	24.24
Average monthly wages	2,787.74	2,865.00	2,996.58	3,069.97	3,172.30	3,343.91	3,505.46
Average monthly working hours							
Actual Wages	158.49	157.91	159.84	157.39	156.69	152.55	153.50
Contractual Wages	145.67	145.10	146.59	145.89	144.39	142.05	143.39
Fraction below 2022 minimum wage							
Actual wages	0.30	0.27	0.24	0.21	0.20	0.16	0.12
Contractual wages	0.25	0.23	0.20	0.18	0.17	0.13	0.09

Notes: This table reports the average number of observations, average hourly and monthly wages and average monthly hours worked of the regional-level DiD analysis working sample. Both the contractual and actual working hours measure are used. The SOEP survey weights are applied and wages are winsorized at the 1st and 99th percentiles.
Data: Sozio-oekonomisches Panel (SOEP) (2025)

Table 21 Main estimation results regional DiD approach

Model:	Log contractual hourly wage (1)	Log monthly wage (2)	Log monthly contractual hours (3)	Employment rate (4)
Variables				
Oct17–Sep18	0.0072	-0.0242	-0.0280	-0.0849
	(0.1529)	(0.1455)	(0.0640)	(0.1541)
Oct18–Sep19	0.0700	0.0693	0.0141	0.1020
	(0.1155)	(0.1297)	(0.0734)	(0.0843)
Oct19–Sep20	0.0700	0.1531	0.0904	-0.0537
	(0.0934)	(0.1141)	(0.0894)	(0.1372)
Oct21–Sep22	0.1613	-0.0509	-0.2185***	0.0329
	(0.0966)	(0.1275)	(0.0655)	(0.1163)
Oct22–Sep23	-0.1078	-0.2611*	-0.1454**	0.0955
	(0.1113)	(0.1311)	(0.0700)	(0.1018)
Socio-demographic controls	Yes	Yes	Yes	Yes
Employment controls	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes
Policy-year FE	Yes	Yes	Yes	Yes
Fit statistics				
Observations	45,006	45,006	45,006	168
R^2	0.42993	0.60519	0.58442	0.82483

Clustered (region) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Notes: This table reports regional DiD estimates based on the regional minimum wage bite, defined as the 2020 share of workers earning less than 12€ per hour in each region (28 regions). Reported coefficients measure how log hourly wages (col.1), log monthly wages (col.2), log monthly working hours (col.3) and the employment rate (col.4) change in each year relative to 2020 as the regional bite increases. The sample includes minimum-wage-eligible individuals. Specifications include demographic and employment controls, region and year fixed effects, and regional-level clustered standard errors. Wages are winsorized at the 1st and 99th percentiles.
Data: Sozio-oekonomisches Panel (SOEP) (2025)

Table 22 Estimation results regional DiD approach weighted

Model:	Log hourly contractual wage (1)	Log monthly wage (2)	Log monthly contractual hours (3)	Employment rate (4)
Variables				
Oct17–Sep18	0.1207	0.1299	-0.0064	-0.1667
	(0.1889)	(0.2249)	(0.0875)	(0.1196)
Oct18–Sep19	0.1955*	0.1972	-0.0082	-0.0524
	(0.1134)	(0.1837)	(0.0976)	(0.1088)
Oct19–Sep20	0.1623	0.2557	0.0910	-0.0675
	(0.1552)	(0.1916)	(0.1292)	(0.1023)
Oct21–Sep22	0.1811	0.0294	-0.1907	-0.0283
	(0.1298)	(0.1617)	(0.1151)	(0.1182)
Oct22–Sep23	0.1940	0.0741	-0.1432	-0.2068
	(0.1868)	(0.2250)	(0.1069)	(0.1286)
Socio-demographic controls	Yes	Yes	Yes	Yes
Employment controls	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes
Policy-year FE	Yes	Yes	Yes	Yes
Fit statistics				
Observations	44,790	44,790	44,790	168
R^2	0.40739	0.60621	0.61050	0.55217

Clustered (region) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Notes: This table reports regional DiD estimates based on the regional minimum wage bite, defined as the 2020 share of workers earning less than 12€ per hour in each region (28 regions). Reported coefficients measure how log hourly wages (col.1), log monthly wages (col.2), log monthly working hours (col.3) and the employment rate (col.4) change in each year relative to 2020 as the regional bite increases. The sample includes minimum-wage- eligible individuals. Specifications include demographic and employment controls, region and year fixed effects, and regional-level clustered standard errors. Wages are winsorized at the 1st and 99th percentiles. The SOEP cross-sectional surveyweights areapplied.
Data: Sozio-oekonomisches Panel (SOEP) (2025)

Table 23 Estimation results regional DiD approach actual working hours

Model:	Log hourly actual wage (1)	Log monthly wage (2)	Log actual working hours (3)	Employment rate (4)
Variables				
Oct17-Sep18	0.0472	-0.0740	-0.0988	-0.0681
	(0.1109)	(0.1124)	(0.0701)	(0.1622)
Oct18-Sep19	0.1333	0.0492	-0.0642	0.1004
	(0.1000)	(0.1048)	(0.0649)	(0.0822)
Oct19-Sep20	0.0945	0.0936	0.0197	-0.0650
	(0.0759)	(0.1055)	(0.0677)	(0.1356)
Oct21-Sep22	0.1378	-0.0652	-0.1948***	-0.0762
	(0.1022)	(0.1137)	(0.0605)	(0.1186)
Oct22-Sep23	-0.1220	-0.2619**	-0.0956	0.0583
	(0.0883)	(0.1113)	(0.0941)	(0.1059)
Socio-demographic controls	Yes	Yes	Yes	Yes
Employment controls	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes
Policy-year FE	Yes	Yes	Yes	Yes
Fit statistics				
Observations	44,585	45,006	44,585	168
R^2	0.39203	0.60519	0.50586	0.82602

Clustered (region) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Notes: This table reports regional DiD estimates based on the regional minimum wage bite, defined as the 2020 share of workers earning less than 12€ per hour in each region (28 regions). Reported coefficients measure how log hourly wages (col.1), log monthly wages (col.2), log monthly working hours (col.3) and the employment rate (col.4) change in each year relative to 2020 as the regional bite increases. The sample includes minimum-wage-eligible individuals. Specifications include demographic and employment controls, region and year fixed effects, and regional-level clustered standard errors. The actual working hours measure is used. Wages are winsorized at the 1st and 99th percentiles.
Data: Sozio-oekonomisches Panel (SOEP) (2025)

Table 24 Estimation results regional DiD approach Kaitz Index

Model:	Log hourly contractual wage (1)	Log monthly wage (2)	Log monthly contractual hours (3)	Employment rate (4)
Variables				
Oct17–Sep18	0.0262	-0.0393	-0.0711	0.0271
	(0.1206)	(0.1104)	(0.0673)	(0.1191)
Oct18–Sep19	0.0959	0.0212	-0.0789	0.0736
	(0.1071)	(0.1048)	(0.0697)	(0.0889)
Oct19–Sep20	0.1287	0.1261	-0.0138	-0.0152
	(0.0952)	(0.0898)	(0.0779)	(0.0955)
Oct21–Sep22	0.1966**	-0.0338	-0.2282***	-0.0182
	(0.0882)	(0.0952)	(0.0543)	(0.1146)
Oct22–Sep23	-0.0652	-0.2061	-0.1397**	0.0661
	(0.1306)	(0.1391)	(0.0672)	(0.1144)
Socio-demographic controls	Yes	Yes	Yes	Yes
Employment controls	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes
Policy-year FE	Yes	Yes	Yes	Yes
Fit statistics				
Observations	45,006	45,006	45,006	168
R^2	0.42997	0.60518	0.58438	0.82249

Clustered (region) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Notes: This table reports regional DiD estimates. Regional treatment intensity is measured by the Kaitz index, defined as the ration of the new minimum wage to the regional median wage. Reported coefficients measure how log hourly wages (col.1), log monthly wages (col.2), log monthly working hours (col.3) and the employment rate (col.4) change in each year relative to 2020 as the regional bite increases. The sample includes minimum-wage-eligible individuals. Specifications include demographic and employment controls, region and year fixed effects, and regional-level clustered standard errors. Wages are winsorized at the 1st and 99th percentiles.
Data: Sozio-oekonomisches Panel (SOEP) (2025)

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