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Abstract

In this paper, we investigate the wage, employment and reallocation effects of the introduction of a nation-wide minimum wage in Germany that affected 15% of all employees. Based on identification designs that exploit variation in exposure across individuals and regions, we find that the minimum wage raised wages, but did not lower employment. At the same time, the minimum wage lead to reallocation effects. At the individual level, the minimum wage induced low wage workers (but not high wage workers) to move from small, low paying firms to larger, higher paying firms. This worker upgrading to better firms can account for up to 25% of the wage increase induced by the minimum wage. Moreover, at the regional level, average firm quality (measured as firm size or fixed firm wage effect) increased in more affected regions in the years following the introduction of the minimum wage.

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1 Introduction

Despite being one of the most controversial labor market policies, the popularity of the minimum wage is rising. Many U.S. states have recently increased the minimum wage, and some have passed legislation that foresees increases of up to $15/hour.[1] Similarly, European countries have enacted substantial increases in the minimum wage.[2] Germany is a prime example of these trends. Against the backdrop of falling wages at the bottom of the wage distribution (wages at the 10th percentile of the wage distribution have declined in real terms by 13% between 1995 and 2015, see Kügler, Schönberg, and Schreiner 2018), the German government introduced for the first time in its history a national minimum wage in January 2015. Set at 8.50 EUR per hour, it cut deep into the wage distribution, with 15% of workers earning a wage below 8.50 EUR six months before the minimum wage came into effect. Moreover, despite the large variation in wage levels across regions, the minimum wage is set at a uniform national level. As a result, it was much more binding in some regions than in others, with more than one in three workers being affected in the most exposed regions.

In this paper, we examine the labor market effects of this first time introduction of the minimum wage, drawing on high quality register data and exploiting variation in the exposure to the minimum wage across workers and regions. The key contribution of our paper is to analyze, for the first time in the literature, whether the minimum wage induced low-wage workers to reallocate from small, low-paying firms to larger, higher paying firms.

As a first step, we investigate the wage and employment effects of the policy by comparing workers who earned less (treated group) and considerably more (control group) than the minimum wage (and should hence be largely unaffected) before and after its introduction. While being similar to empirical strategies

[1] California, Illinois, Massachusetts, New Jersey, and New York have all passed legislation to eventually increase minimum wages to $15/hour; see Cengiz et al. (2019) for details.

[2] The Italy's new coalition government plans to introduce a nation-wide minimum wage. The Polish government recently announced its plans to increase the minimum wage by *73%* by 2023. The current chancellor of the United Kingdom seeks to raise the minimum wage to two-thirds of median earnings within five years, which would make it the highest wage floor in the developed world.

used by Currie and Fallick (1996) and Clemens and Wither (2019), we introduce two important extensions. First, whereas previous studies relied on survey data, we leverage rich and high quality administrative data on hourly wages, which addresses measurement issues and improves the precision of our estimates. Second, our research design deals with potential biases, such as mean reversion, in a convincing and transparent way. We find that the minimum wage significantly increased wages of low-wage workers, relative to wages of high-wage workers located further up the wage distribution. At the same time, there is no indication that it lowered the employment prospects of low-wage workers. Findings from an analysis that exploits variation in the exposure to the minimum wage across regions (see Card 1992) corroborate our findings from the individual-level analysis: the minimum wage boosted wages, but did not reduce employment in regions heavily affected by it. Thus, it helped reducing wage inequality, both across individuals and across regions.

In the second part of the paper, we address the question how the labor market absorbs wage increases induced by the minimum wage. The hypothesis that we put forward and directly test is that the minimum wage improves the quality of firms that operate in the market, by reallocating workers from smaller, lower paying firms to larger, higher paying ones.[3] Such reallocation can arise in models with search frictions (e.g., Acemolgu 2001; Flinn 2010; Burdett and Mortensen 1998), monopsonistic competition (e.g. Bhaskar, Manning, and To 2002) or product market frictions where firms raise prices in response to the minimum wage, inducing consumers to switch toward cheaper products produced by more efficient firms (such an idea is explored in Luca and Luca 2018 and in Mayneris, Poncet, and Zhang 2018). We present evidence consistent with reallocation at both the individual and regional level. Most importantly, at the individual level, we show that low-wage workers, but not high-wage workers, are more likely to upgrade to "better" firms after the introduction of the minimum wage. This "upgrading" takes different forms. First, the minimum wage induces low wage workers to move to firms that pay a higher daily wage on average.

[3] The idea that minimum wage affects allocation of resources between firms is not new. The introduction of the very first minimum wage in modern times in the 1890s in New Zealand was motived by helping worthwhile companies against "sweatshops" in manufacturing industries (Nordlund 1997). Many efficient and worthwhile companies employing working class breadwinners lost market shares as they were undercut by these sweatshops. The minimum wage, according to the advocates of the policy, sought to reverse these trends.

This effect is quantitatively important, and can account for about 25% of the overall increase in daily wages that low wage workers experience following introduction of the minimum wage. The improvement in average daily wages reflects a movement to both firms that offer more full-time jobs and employ a more skilled workforce, and firms that pay a higher wage premium to the same type of worker. Second, we find that the minimum wage induces low wage workers to move to larger and more stable firms with a lower churning rate. Low wage workers further reallocate toward firms that are able to poach a larger share of workers from other firms—that is, firms that workers consider as superior based on their revealed preferences—in response to the minimum wage (Sorkin 2018; Bagger and Lentz 2018). Overall, these results suggest that minimum wages allocated low wage workers to more productive establishments.[4] Given that the policy did not lower employment, these findings suggest that minimum wages increased production efficiency of labor.

We provide further evidence in support of worker reallocation based on our regional approach. Specifically, we show that in the years following the introduction of the minimum wage, the number and the share of micro firms with less than three employees declined, whereas firm size and the share of larger firms increased, in regions more exposed to the minimum wage compared to less exposed regions. Moreover, we also find that the minimum wage increased the average firm wage premium, measured as a fixed firm effect in an AKM-style regression estimated using only pre-policy data, suggesting a compositional shift toward higher paying firms.

We provide several pieces of evidence that the findings highlighted above reflect the causal impact of the minimum wage, rather than macroeconomic shifts in the economy. First, the effects of the minimum wage emerge exactly when the policy was introduced. Second, they are concentrated among low wage workers at the bottom of the wage distribution who are most affected by the minimum wage. Trajectories of high wage workers, in contrast, do not change in response to the minimum wage, underscoring that the overall macroeconomic environment was stable around its introduction. Third, our results are robust to

[4] We do not measure directly productivity in the data. Nevertheless, productivity is strongly correlated with the firm's wage premium, size, churning rate, and poaching index; see e.g. Lochner et al. (2019) in the context of Germany.

controlling for individual and regional characteristics, such as the local unemployment rate, in a flexible manner.

In the final step of the empirical analysis, we provide suggestive evidence on three potential mechanisms underlying these reallocation effects: search frictions, monopsonistic competition, and product market frictions. Our analysis suggests that the reallocation effects that we uncover are unlikely to be driven by one single channel; rather, all three channels are likely to be at play. In particular, our findings that the minimum wage induces low wage workers to switch to more stable firms with lower churning rates, and to firms with a more skilled workforce that pay a higher wage premium, is in line with search and matching models such as Acemoglu (2001) and Cahuc, Postel-Vinay and Robin (2006). Our result that the reallocation toward higher paying firms comes at the expense of increased commuting time naturally emerges from models of monopsonistic or oligopolistic competition where idiosyncratic, non-pecuniary preferences toward a workplace—such as distance from home—give firms the power to set wages (see e.g., Card, Cardoso, Heining, and Kline 2018; Bergen, Herkenhoff, and Mongey 2019). Our finding that the reallocation effect is more pronounced in the non-tradable sector, where firms have more power to set product prices, than in the tradable sector, is most consistent with models of product market frictions where the minimum wage induces consumers to switch to cheaper products produced by more efficient firms (e.g., Luca and Luca 2018 and in Mayneris, Poncet, and Zhang 2018).

Our paper relates to several strands of literature. First, we contribute to the large empirical literature that examines the effects of minimum wage increases on employment and wages (see e.g. Card and Krueger 1995; Neumark and Wascher 2010), by exploiting a first-time introduction of a minimum wage that cuts deep into the wage distribution and that was persistent as the minimum wage has been increased twice above the inflation rate since its introduction (similarly to Harasztosi and Lindner 2019). Both the sharp bite and the high persistence of the minimum wage, combined with exceptionally high-quality administrative data on the universe of workers and firms, allow us to investigate reallocation responses, something that is not possible in the context of minor, temporary minimum wage shocks.

Second, our paper is related to the large theoretical literature on how low wage labor markets react to minimum wage shocks. Economists have long argued whether low wage labor markets are best characterized as highly competitive, implying that the minimum wage will cause displacement of workers (e.g., Stigler 1946), or whether firms behavior is inconsistent with competitive labor markets, implying limited employment effects of the minimum wage (e.g., Lester 1960). Williamson (1968) was the first to formalize the idea that a minimum wage may drive small firms that use more labor-intensive technologies out of the market. More recently, Acemoglu (2001), Bhaskar, Manning, To (2002), Flinn (2006), and Berger, Herkenhoff, and Mongey (2019), among others, show that in the presence of search frictions or monopsonistic competition, minimum wage policies may have limited employment effects and improve firm quality and ultimately aggregate total factor productivity, by shifting workers from the least efficient to more efficient firms.[5] Our paper provides, for the first time in the literature, direct empirical support of this prediction.

Third, our paper contributes to the macroeconomic literature on re- and misallocation of resources across firms. One strand of this literature has documented large shifts in reallocation over the business cycle (e.g., Davis and Haltiwanger 1992; Moscarini and Postel-Vinay 2012). Reallocation also plays a key role in understanding productivity growth (e.g., Foster, Haltiwanger and Syverson 2008). Another strand of this literature highlights that the misallocation of resources (such as labor) can be induced by policies such as state ownership and size restrictions (Hsieh and Klenow 2009), firm-level taxes or subsidies (Restuccia and Rogerson 2008), or state taxes (Fajgelbaum, Morales, Suarez Serrato and Zidar, 2018). Our paper is one of the few papers that exploits an exogenous shock or policy (in our case, the introduction of a minimum wage) to directly investigate the reallocation of workers across firms, without relying on the structure of a model.

Fourth, our paper is also related to the literature on centralized bargaining. Specifically, our paper provides direct empirical support for the core idea behind the "Swedish model" of centralized bargaining

[5] Aaronson, French, Sorkin and To (2018) make a related point and argue that a minimum wage policy induces less efficient and more labor intensive firms to exit the market and more efficient and more capital intensive firms to enter.

that pushing up wages will drive low performing firms out of the market, reallocate workers to better firms, and thereby improve the quality of firms in the economy (e.g., Agell and Lommerud 1993; Edin and Topel 1997; Erixon 2018).

Finally, our paper complements very recent papers that evaluate the labor market effects of Germany's minimum wage policy. By exploiting variation in the exposure to the minimum wage both across individuals and regions, combined with high quality register data, we provide the cleanest evidence to date that the minimum wage raised wages, but did not reduce employment.[6] While other studies have investigated the impact of Germany's minimum wage policy on outcomes such as product prices (Link 2019) welfare dependency (Schmitz 2019) and within-plant productivity increases (Bossler, Gürtzgen, Lochner, Betzl and Feist 2019), our paper is the first that highlights the reallocative effects of minimum wage policies.

2 Background and Data

2.1 The Minimum Wage Policy and Macroeconomic Environment

Germany experienced a dramatic increase in wage inequality over the past two decades (see e.g., Dustmann, Ludsteck and Schönberg 2009; Antonczyk, Fitzenberger and Sommerfeld 2010; Card, Heining and Kline 2013), with real wages increasing between 1995 and 2015 by nearly 20% at the 90th percentile, rising by only 8% at the median, and declining by 13% between at the 10th percentile (Kügler, Schönberg and Schreiner 2018). While up to the mid-1990's union wages, negotiated between trade unions and employer federations at the sectoral level and varying by worker skill and experience, acted as wage floors, the share of workers covered and protected by union agreements (either at the sectoral or firm level) decreased steadily, from nearly 80% in 1995 to about 55% in 2015 (Kügler, Schönberg and Schreiner 2018). Against

[6] Exploiting variation in the exposure to the minimum wage solely across regions, Caliendo, Fedorets, Preuss, Schröder, Wittbrodt (2018) and Ahlfeldt, Roth, and Seidel (2019) conclude that the minimum wage policy led to spatial wage convergence, without reducing employment in low-wage regions relative to high-wage regions.

this backdrop of rising wage inequality and dwindling importance of trade unions, the German government introduced for the first time in its history a nationwide minimum wage of 8.50 Euro per hour.[7]

The Minimum Wage Law was passed by the German parliament on July 3rd 2014, and the minimum wage came into effect on January 1st 2015. The minimum wage was raised to 8.84 EUR per hour in October 2017, and to 9.19 EUR per hour in January 2019. At the time of the initial introduction of the minimum wage, almost 15 percent of workers in Germany earned an hourly wage of less than 8.50 EUR, implying that around 4 million jobs were directly affected (Destatis 2016). With a ratio of 0.48 between the minimum and median wage in 2015, the German minimum wage did not cut as deep into the wage distribution as the French minimum wage (with minimum wage-to-median ratio of 0.61), but was considerably more binding than the US federal minimum wage (minimum wage-to-median ratio of 0.36; OECD Economic Indicators 2016).

Workers younger than 18 years old, apprentices, interns and voluntary workers, as well as the long-term unemployed are exempted from the minimum wage. Temporary exemptions also existed in the hairdressing and meat industry, agriculture and forestry where, up until December 31 2016, firms were allowed to pay the lower union wages agreed between trade unions and employer federations. These industries comprise only a relatively small fraction of total employment (5%).

Our empirical findings have to be interpreted within the particular macroeconomic context during which of the minimum wage policy was introduced. The German economy was characterized by robust economic growth in the years surrounding the implementation of the minimum wage policy. Over the period between 2010 and 2016, nominal GDP grew by 20% (see panel (a) of Figure 1), while unemployment fell from 5.5% in June 2011 to 3.9% in June 2016 (panel b), a record-low level not seen since the early 1980s. The stock of employed workers steadily increased from 41.58 million in 2011 to 43.64 million in 2016 (panel c).

[7] Minimum wages specific to certain industries, including construction, painting and varnishing, waste management and nursing care, have been in place since 1997.

2.2 Data and Sample Selection

We base our analysis on individual-level German administrative records taken from source data of the Federal Employment Agency's Statistics Department and processed for research purposes (vom Berge et al. 2016a; vom Berge et al. 2016b). These data comprise not only all workers covered by the social security system, but also "marginal workers" who earn no more than 450 EUR per month and are therefore exempt from social security contributions. Even though the data are in principle available for the years 2007 to 2016, we use information from 2011 only, due to a sharp break in how several key variables are coded between 2010 and 2011 (for example, the worker's full- vs part-time status and their education). The data include information on a monthly basis on the worker's employment status (i.e., employment vs un- and non-employment), her full-time status (i.e., full- vs part-time and marginal employment), the establishment the worker works for (throughout the paper, we use the term "establishments" and "firms" interchangeably), and a number of socio-demographic characteristics such as age, gender, nationality, education, place of residence and work, and the industry of employment.

To this first data source, we merge information on earnings and hours worked to the Labor Market Mirror from the Employee Histories of the Institute for Employment Research in Nuremberg (*Beschäftigtenhistorik BeH*). The Employee Histories contain information on both earnings and working hours for each job at least once per year, along with its start and end date. Top-coding of roughly 6% of observations at the upper earnings limits for compulsory social insurance does not affect our analysis, as the minimum wage does not affect wages this high up in the wage distribution.[8] The information on working hours allows us to calculate precise hourly wages for four years prior to the introduction of the minimum wage, and therefore to obtain reliable measures for how a single worker or a region are affected by its introduction. This is an advantage over existing studies on the minimum wage in Germany that lacked this information.[9] Whereas earnings information is available throughout our study period, information on

[8] When we calculate firm fixed effects from an AKM-type regression, we stochastically impute the censored part of the wage distribution similarly to Card, Kline, Heining (2013).

[9] Both vom Berge et al. (2014) and Doerr and Fitzenberger (2016) emphasize that lack of information on working hours may lead to a downward bias in the impact of the introduction of the minimum wage on employment and wages

working hours is available only from 2011 to 2014, which means that we do not have exact information on hours worked *after* the introduction of the minimum wage in 2015. To study the impact of the minimum wage on hourly wages, we therefore proxy hourly wages as the daily wage divided by the average number of working hours in each employment category (i.e., full-time, part-time, and marginal employment).[10] This approximation assumes that actual hours worked within employment status are unaffected by the minimum wage, an assumption that is in line with the empirical evidence.[11]

A drawback of the data on working hours is that some employers report actual working hours while others report contractual working time instead. We compute a harmonized measure for working hours following an imputation procedure described in detail in Appendix A1. After the imputation, weekly working hours in the Employee Histories closely follows that from the Structure of Earnings Survey of the German Statistical Office and the German Socio-Economic Panel, the two main survey data sets available in Germany. We further impute missing values in the worker's full- vs part-time status using the procedure described in Appendix A2. Missing values in the education variable are imputed using the imputation procedure suggested by Fitzenberger, Osikominu and Völter (2005).

From this database, we first create a yearly panel and select all job spells referring to June 30th. In case an individual holds more than one job, we keep her main job, defined as the full-time job or, in case of multiple full-time jobs, the job with the highest daily wage. We drop workers in apprenticeship training and workers younger than 18 from our sample, as these workers were exempt from the minimum wage. We further focus on prime-age workers and exclude workers close to retirement (i.e., workers aged 60 and older). We finally remove industries that were temporarily exempt from the minimum wage from our sample. Based on this full data set, we compute various measures of firm quality, such as the firm's

and could therefore be one reason why some existing studies have failed to detect perceptible employment and wage effects of the minimum wage.

[10] Average daily (including weekends) working hours per employment status are computed for the year 2013 (5.28 for full-time workers, 3.30 for part-time workers, and 1.18 for marginal workers).

[11] Caliendo et al (2017) estimate that actual hours dropped by 3.1% (p-value: 0.06) in the year after the minimum wage (2015 vs 2014), an effect that is not statistically different from the placebo estimates for the 2013 vs 2014 pre-policy period which suggest a 1.8% (p-value: 0.22) drop.

employment size, the firm's average wage, or the firm fixed effect obtained from a regression that also includes worker fixed effects.

Our first and main empirical approach compares the career trajectories of workers who earned less than the minimum wage prior to the introduction of the minimum wage with the career trajectories of workers who earned a wage higher than the minimum wage, similar to Currie and Fallick (1996) and Clemens and Wither (2019). To implement this approach, we draw a 50% random sample of individuals who are observed at least once in the full data set earning an hourly wage between 4.50 and 20.50 EUR. For these individuals, we observe all job spells (as of June 30th) over the 2011 to 2016 period (even if they earn more than 20.50 EUR per hour). Our second approach compares regions that, due to their lower wage levels prior to the introduction of the minimum wage, were heavily affected by the minimum wage with regions that were largely unaffected by the minimum wage. To implement this approach, we collapse the full data set at the county (*Kreis*) and year level.

3 Labor Market Effects of the Minimum Wage: Individual Approach

3.1 Method

Our data allows us to follow workers over time. The key idea of the individual approach is then to compare individuals' wage growth over two-year windows (between $t-2$ and t) along the distribution of wages in the baseline period $t-2$. We assign workers to small (typically 1 EUR) wage bins *w* ([4.5,6.5), [6.5,7.5), …, [19.5,20.5)) based on their hourly wages in $(t-2)$.[12] We then regress wage growth $\Delta y_{i_{w(t-2)}t}$ (or other outcomes like change in employment status or change in firm quality) of worker *i* between periods *t-2* and *t* on indicator variables $D_{i_{w(t-2)}t}$ equal to 1 if worker *i* falls into wage bin *w* in *t-2:*

$$\Delta y_{i_{w(t-2)}t} = \gamma_{w_{(t-2)}t} D_{i_{w(t-2)}t} + \beta X_{i,t-2} + e_{it}\,, \qquad (1)$$

[12] We group bins (4.5, 5.5] and (5.5,6.5] together since few workers fall into this group.

In this equation, the coefficients $\gamma_{w_{(t-2)}t}$ simply measure average wage growth between *t-2* and *t* of workers in wage bin *w* in the baseline period, conditional on a vector of individual baseline characteristics $X_{i,t-2}$ measured at *t-2*. We estimate regression equation (1) for two pre-policy years (2011 vs 2013; 2012 vs 2014) and two post-policy years (2013 vs 2015; 2014 vs 2016). In the two post-policy years, the coefficients $\gamma_{w_{(t-2)}t}$ capture the effect of the minimum wage along the wage (bin) distribution *w* on two-year wage growth, subject to two potential confounding factors: mean reversion and macroeconomic time effects. We would typically expect workers who earn a low wage in *t-2* to experience a higher wage growth than workers who earn a high wage in *t-2* because of mean reversion. At the same time, wages are likely to grow over a two-year period simply because the economy is growing. We can eliminate the mean reversion and macroeconomic time effects under the assumption that they affect wages (and other outcomes) of workers in the same wage bins in the same way in the post-reform periods as in the 2011 vs 2013 pre-policy period. In a second step, we therefore estimate a re-parameterized version of equation (1):

$$\Delta y_{i_{w(t-2)}t} = \gamma_{w_{(11)}13} + \delta_{w_{(t-2)}t} D_{i_{w(t-2)}t} + \beta X_{i,t-2} + e_{it}\,, \qquad (2)$$

where the coefficients $\delta_{w_{(t-2)}t} = \gamma_{w_{(t-2)}t} - \gamma_{w_{(11)}13}$ now trace out, for each initial (pre-policy) wage bin *w*, workers' two-year wage growth in the post-policy years *relative* to two-year wage growth in the 2011 vs 2013 pre-policy period, given by coefficient $\gamma_{w13_{(11)}}$. The coefficients $\delta_{w_{(t-2)}t}$ identify the causal impact of the minimum wage on wage growth (or other outcomes) under the assumption that the mean reversion and macroeconomic time effects are stable over time. Since the minimum wage should have no impact on wage growth (and other outcomes) for workers located high up in the initial wage distribution,[13] we can

[13] Since the cost share of minimum wage workers in aggregate production is small, the aggregate impact of minimum wage policies will be limited. Even in the presence of substantial substitution between low-skilled and high-skilled workers, the effects of the minimum wage on high-skilled workers (located higher up in the wage distribution) will be small, as can be seen using the Hicks-Marshall rule of derived demand (see Appendix B in Cengiz, Dube, Lindner, Zipperer, 2019).

assess the plausibility of the assumption of stable macroeconomic time effects by investigating whether estimates for $\delta_{w_{(t-2)}t}$ are close to zero for wage bins considerably higher than the minimum wage of 8.50 EUR (e.g., 12.50 EUR and up). We find this to be the case for most outcomes.

To nevertheless account for the possibility that macroeconomic time effects in the post-policy periods are different from those in the 2011 vs 2013 pre-policy period, we construct difference-in-difference estimates where we subtract $\delta_{w_{(t-2)}t}$ coefficients averaged over wage bins high up in the wage distribution—which are unaffected by the minimum wage and hence capture changes in the macroeconomic environment—from $\delta_{w_{(t-2)}t}$ coefficients averaged over wage bins below the minimum wages. These difference-in-difference estimates eliminate any possible changes in the macroeconomic environment between the post- and pre-policy periods under the assumption that these changes affect all wage bins in the same way.

In practice, we divide workers into three groups based on their location in the wage distribution at baseline. The first group are workers who earn a wage below the minimum wage prior to its introduction (i.e., workers in wage bins [4.5,6.5), [6.5,7.5) and [7.5,8.5)). These are the workers who should be primarily affected by the minimum wage policy and we refer to this group as the "treated group" accordingly. The minimum wage may also spill over to workers who earn more than, but close to the minimum wage before its introduction (i.e., workers in wage bins ([8.5,9.5), [9.5,10.5), and [10.5,11.5), [11.5,12.5)) — "the partially treated group". The third group comprises all workers higher up in the initial wage distribution (i.e., workers in wage bins [12.5,13.5) and higher), which we refer to as "control group". We then average $\delta_{w_{(t-2)}t}$ coefficients over the eight highest wage bins in the control group and subtract them from the $\delta_{wt_{(t-2)}}$ coefficients averaged over the three lowest wage bins in the treated group. These corrected estimates are for most outcomes very similar to the non-corrected estimates for $\delta_{w_{(t-2)}t}$, suggesting that macroeconomic conditions were stable during the period under consideration, in line with the evidence presented in Section 2.1.

To summarize, the key identification assumptions behind the difference-in-difference estimates are that (i) the mean reversion effect for each wage bin remains constant over time, (ii) macroeconomic time effects do not vary across wage bins, and (iii) the effect of the minimum wage on workers high up in the wage distribution is close to zero. While we cannot test these assumptions directly, there are three pieces of evidence that support these assumptions. First, as highlighted above, coefficient estimates of $\delta_{w_{(t-2)}t}$ are close to zero for wage bins beyond 12.50 EUR (see for example Figures 2 and 3). Second, controlling for the local unemployment rate interacted with wage bins in equation (2)—thus allowing for local macroeconomic conditions to differentially impact wage bins over time—barely changes our estimates (see Table 6). Third, coefficient estimates for the 2012 vs 2014 time period ($\delta_{w_{(12)}14}$), before the minimum wage was implemented, are substantially smaller than 2013 vs 2015 and 2014 vs 2016 post-policy periods for wage bins below the minimum wage for all outcomes. Hence, the effects of the minimum wage on wage bins below the minimum merge emerge exactly when the minimum wage is introduced, supporting a causal interpretation of our findings.[14]

3.2 Wage and Employment Effects of the Minimum Wage

Wage Effects. Panel (a) of Figure 2 provides a first indication that the minimum wage increased wages for low-wage workers. In the figure, we plot two-year "proxied hourly wage" growth separately for the years 2011 vs 2013 to 2014 vs 2016, obtained from regression equation (2). In the absence of exact information on hours worked after the introduction of the minimum wage, we proxy the post-policy hourly wage as the daily wage divided by the average number of working hours in each employment category (i.e., full-time, part-time, and marginal employment, see Section 2.2). As expected, workers with very low wages at

[14] Individual-level results focus on workers who had a job prior to the introduction of the minimum wage. We address the concern that firms primarily respond to the minimum wage by hiring fewer unemployed workers, rather than by displacing more employed workers, by studying local-level responses to the minimum wage in Section 4.

baseline (in *t-2*), below the minimum wage of 8.50 EUR, experience substantially higher hourly wage growth than workers earning wages above the minimum wage at baseline even in the pre-policy periods (18-30% vs 5-10%). This unusually high wage growth for low wage workers may in part reflect either mean reversion or differential probabilities in remaining employed over the two-year period. That the minimum wage did indeed raise hourly wages for low-wage workers is highlighted by the excess hourly wage growth in wage bins below the minimum wage relative to wage bins higher up in the distribution, which is considerably larger in the 2013 vs 2015 and 2014 vs 2016 post-policy periods than in the 2011 vs 2013 pre-policy period.

We investigate this in more detail in Panel (b) of Figure 2, where we plot two-year hourly wage growth by wage bin separately for the 2012 vs 2014 pre-policy period and two post-policy periods (2013 vs 2015, 2014 vs 2016) *relative to* the 2011 vs 2013 period, obtained from regression equation (3). In line with the figure in panel (a), the figure in panel (b) highlights that hourly wage growth in the post-policy periods considerably surpasses hourly wage growth over the 2011 to 2013 period for wage bins below the hourly minimum wage of 8.50 EUR, by about 10-12% for workers in the lowest wage bin. Post-policy hourly wage growth also exceeds pre-policy (2011 vs 2013) hourly wage growth for wage bins slightly above the minimum wage, up to 12.50 EUR, in line with spillover effects of the minimum wage to higher wage bins. In contrast, for wage bins higher than 12.50 EUR, hourly wage growth in the 2013-2015 and 2014-2016 periods is not higher than over the 2011-2013 period (i.e., coefficient estimates are close to zero), suggesting that the macroeconomic conditions were largely stable during our study period. This pattern suggests that the minimum wage indeed causally raised wages for workers who earned a wage below the minimum wage at baseline, with some possible spillover effects to workers who earned a wage just above the minimum wage. This causal interpretation of our findings is further corroborated by the "placebo" estimates for the years 2012 vs 2014 which are close to zero, indicating that wage growth in those years was similar to that between 2011 and 2013 for all wage bins.

We summarize our key findings in panel (a) of Table 2, where we report in the first three columns estimates based on regression equation (3), but for more aggregated wage bins: [4.50, 8.50), [8.50, 12.50),

and [12.50, 20.50). The table shows that workers directly exposed to the minimum wage—that is, workers who earned a wage of less than 8.50 EUR at baseline—experience a 6.7% higher hourly wage growth over the 2014 to 2016 post-policy period than over the 2011 to 2013 pre-policy period (26.6% vs 19.9%). Hourly wage growth of workers earning slightly above the minimum wage at baseline—between 8.50 and 12.50 EUR—is 2.3% higher in the post-policy than in the pre-policy period (13.1% vs 11.8%), whereas post-policy wage growth is very close to pre-policy wage growth for workers earning more than 12.50 EUR at baseline. To net out possible macroeconomic time effects, columns (4) and (5) of Table 2 then report difference-in-difference estimates that compare the excess wage growth in the post-policy period relative to the 2011 vs 2013 pre-policy period for the two lower wage bins ([4.50, 8.50) and [8.50, 12.50)) to the excess wage growth for the highest wage bin ([12.50, 20.50)), corresponding to the differences in estimates in columns (1) and (2), and column (3). Since hourly wage growth in the upper parts of the wage distribution was very similar between 2011 and 2013 and 2014 and 2016, the difference-in-difference estimates are close to the estimates based on regression equation (2), reported in the first two columns. Reassuringly, in line with our findings in Figure 3, estimates are close to zero in the placebo period 2012 to 2014, supporting the view that the estimates in Table 2 reflect the causal impact of the minimum wage on wages, rather than changes in macroeconomic conditions.

It should be noted that the excess hourly wage growth of 6.7% for minimum-wage workers in the 2014 vs 2016 post-policy period relative to the 2011 vs 2013 pre-policy period (column (1) in panel (a) of Table 2) is roughly in line with what we would expect under full compliance of the minimum wage policy. On average, minimum-wage workers earned an hourly wage of 6.80 EUR in 2014. Their hourly wage increases by 26.6% following the introduction of the minimum wage (as opposed to 19.9% in the absence of the minimum wage policy), bringing them to an hourly wage of 8.60 EUR, slightly above the hourly minimum wage of 8.50 EUR.

In Panel (b), we use the change in daily wages, unadjusted for the worker's full- or part-time status in period *t*, as the dependent variable. The findings suggest that the minimum wage had a slightly stronger impact on daily wages than on hourly wages of minimum-wage workers (10.7% vs 6.1% according to the

difference-in-difference estimates in column (4)). This suggests that the minimum wage induced some minimum-wage workers to move from marginal or part-time employment to full-time employment, a finding that we confirm below.

Employment Effects. Our findings in Figure 2 and Table 2 indicate that the introduction of the minimum wage in 2015 pushed up wages for workers at the lower end of the wage distribution. We now investigate how the minimum wage affected their employment prospects. We first compare the probability of being employed (regardless of the worker's full- or part-time status) in period *t* along workers' wage distribution in *t-2*, separately for two pre-policy and two post-policy periods (Panel (a) in Figure 3). Reported estimates refer to coefficients γ_{wt} in regression equation (1). The graph highlights that workers at the bottom of the wage distribution have a lower probability of remaining employed than workers higher up the wage distribution even in the pre-policy periods, in line with less stable employment relationships for low-wage workers. At the same time, the relationship between the probability of being employed and the worker's baseline wage appears to be similar in the pre- and post-policy periods, suggesting that the minimum wage had no discernable negative impact on the employment prospects of low wage workers.

Panel (b) of Figure 3 provides a more detailed investigation. The figure shows the probability of being employed in year *t* by worker's wage bin in *t-2* for one pre-policy period and two post-policy periods *relative to* the 2011 to 2013 period, where estimates are obtained from regression equation (2). The figure suggests that workers directly exposed to the minimum wage—that is, workers who earn less than 8.50 EUR at baseline—are slightly more likely to be employed after (i.e., in 2015 and 2016), relative to before the introduction of the minimum wage (i.e., in 2013). In contrast, employment prospects of workers earning more than 12.50 EUR at baseline are similar in the post-policy periods and the 2011 to 2013 pre-policy period. Coefficient estimates for the placebo period 2012 to 2014 are also close to zero, confirming once more that macroeconomic conditions have been largely stable over our study period.

We report the corresponding estimates based on regression equation (2) averaged over three aggregated wage bins and difference-in-difference estimates in panel (c) of Table 2. Both sets of estimates

suggest that the minimum wage increased the probability that a worker who earned less than the minimum wage in period *t-2* remains employed in period *t* by about 1 percentage point. Point estimates are slightly larger in magnitude (about 3 percentage points) when we use changes in full-time equivalents, where we assign 1 to full-time employment, 0.5 to part-time employment, 0.2 to marginal employment, and 0 to non-employment, as the dependent variable (panel (d)). This is in line with our finding that the minimum wage raised daily wages by more than hourly wages (panels (a) and (b)), and suggests that some minimum-wage workers in marginal employment or part-time work switched to full-time work.

The employment estimates in panels (c) and (d) rule out the possibility that the minimum wage reduced employment prospects of workers who were employed at baseline. The absence of a displacement effect of the minimum wage implies that the positive wage effects of the minimum wage policy for low-wage workers are not driven by a policy-induced change in the selection of workers into work. The small positive employment effects are consistent with the idea that, because of higher wages due to the minimum wage, employment has become a more attractive option for low-wage workers. Our findings based on the individual approach therefore show that the minimum wage raised wages for minimum-wage workers, without lowering their employment prospects. In consequence, the minimum wage policy helped to reduce wage inequality, as intended.

3.3 Reallocation Effects of the Minimum Wage

We now turn to investigating the potential role of worker reallocation in explaining these findings. Specifically, we investigate whether the minimum wage increased upward mobility from small, low-wage firms to larger, higher paying firms among workers directly affected by it. We measure the change in firm quality over a two-year period as $q^{k=t-2}_{j(i,t)i} - q^{k=t-2}_{j(i,t-2)i}$, where $q^{k}_{j(i,t)i}$ denote the time *k* characteristics of firm *j* at which worker *i* is employed in year *t*. That is, the "quality" of the firm refers to the baseline period $(t-2)$ in both periods. This way, any changes in firm quality induced by the minimum wage reflect compositional changes only, rather than improvements in quality over time (possibly caused by the

minimum wage itself) within the same firm. By construction, this measure of firm quality is zero for workers who remain employed at their baseline firm. A drawback of this measure is that it is defined only for firms that existed in both *t-2* and *t*. In the subsequent analysis, we drop workers who move to firms that entered the market after *t-2* from our sample. Panel (d) in Table 5 illustrates that the minimum wage did not have a clear-cut impact on the probability that a worker moves to a newly founded firm, so that this sample restriction is unlikely to affect our findings.

Firms' Average Daily Wage. In panel (a) of Figure 4, we use the firm's average daily wage (in logs) as a measure for firm quality, and plot the change in the firm's average daily wage along the worker's wage distribution at baseline (in *t-2*) relative to changes over the 2011 vs 2013 pre-policy period. Estimates refer to the coefficients δ_{wt} in the regression equation (2), and account for possible effects of mean reversion. The figure clearly illustrates that minimum-wage workers experience an improvement in firm quality, measured as the change in the firm's average daily wage, in the post-policy periods (2013 vs 2015 and 2014 vs 2016) relative to the 2011 vs 2013 pre-policy years. This effect slowly fades out for workers higher up the wage distribution and turns to nearly zero for workers earning more than 12.50 EUR at baseline. A similar improvement in firm quality for low-wage workers (relative to the 2011 vs 2013 period) is not observed in the 2012 vs 2014 pre-policy period, which supports the hypothesis that the improvement in firm quality is caused by the minimum wage. The corresponding difference-in-difference estimates in Table 3 (panel (b)) confirm these findings: for workers who earn less than the minimum wage in 2014, average daily wages of the firm in which they work increase by 2.5% relative to the 2011 vs 2013 pre-policy period, but remain constant in the 2012 vs 2014 pre-policy period.

To put this estimate into perspective, recall that minimum wage workers experienced an excess daily wage growth of 10.7% in the 2014 vs 2016 post-policy period (panels (b) of Tables 2 and panel (a) of Table 3). Thus, about 25% (0.025/0.107) of the overall daily wage increase can be attributed to workers moving to firms that paid higher daily wages even before the policy change, while about 75% of the individual daily wage growth induced by the minimum wage occurs within firms.

Better Jobs versus Higher Wage Premium. The reallocation of minimum wage workers to firms that pay higher daily wages could reflect either a switch to firms that offer better jobs—that is, firms that employ a more skilled workforce, more full-time and fewer part-time or marginally employed workers—or a switch to firms that pay higher hourly wages to the same worker type. We investigate this in the remaining panels of Figure 4. The findings in panel (b) suggest that the improvement in the firm's average daily wage is in part driven by workers moving to firms that employ a more skilled workforce. The figure shows that low-wage workers, but not workers located higher up the wage distribution, are more likely to reallocate to firms with a higher share of high-skilled workers (i.e., workers with a university degree) in the post-policy period relative to the pre-policy period. Reassuringly, a similar relationship is not observed for the "placebo" 2012 vs 2014 period. The difference-in-difference estimates presented in panel (a) of Table 4 indicate that the minimum wage induced an improvement in the employment share of high-skilled workers by 0.3 percentage points or, as the average share of high-skilled workers in the firm is 6.9%, by 4.3 percent.

The findings in panels (c) and (d) of Figure 4 further highlight that the improvement in the firm's average daily wage is partially driven by workers moving to firms that generally employ more full-time workers and fewer marginally employed workers. The corresponding difference-in-difference estimates presented in panels (b) and (c) of Table 4 reveal that minimum wage workers experienced an increase in the firm's full-time employment share of 1 percentage point (3 percent), and a decline in the firm's marginal employment share of 0.8 percentage points (2 percent) in response to the minimum wage.

While the reallocation of minimum wage workers to firms with more high-skilled and more full-time jobs plays an important role in accounting for the improvement in the firm's average daily wage following the introduction of the minimum wage, panels (a) and (b) of Figure 5 illustrate that the minimum wage also induced some upgrading of minimum-wage workers to firms that pay higher hourly wages to the same worker type. In panel (a), we use the firm's wage premium, calculated as the average daily wage residual in the firm obtained from an individual wage regression that controls for workers' demographic characteristics (age, sex, education, and German citizenship) as well as their full-time, part-time and

marginal employment status as a measure for firm quality. The pattern is the same as when we use the firm's average daily wage as an outcome variable: low-wage workers, but not workers higher up the wage distribution, are more likely to move to firms that pay a higher wage premium before the introduction of the minimum wage. This relationship is considerably more pronounced in the post-policy periods than in the pre-policy (placebo) 2012 vs 2014 period, corroborating our hypothesis that this upgrading is caused by the introduction of the minimum wage. The magnitude of this effect is, however, smaller than for the firm's average daily wage (0.5% vs 2.5%; panels (a) and (c) of Table 4). Using the firm's fixed effect as a measure for firm quality, estimated over a seven -year period prior to the introduction of the minimum wage on a sample of full-time workers[15], produces coefficient estimates that are very similar in magnitude to those when the firm wage premium is used as a measure of firm quality (compare panels (a) and (b) of Figure 5 and panels (d) and (e) of Table 3).

To put these estimates into perspective, recall that minimum wage workers experienced an excess hourly wage growth of 6.1% in the 2014 vs 2016 post-policy period (see column (4) in Table 2). Thus, 8.2% (0.5/6.1) of the overall hourly wage increase induced by the minimum wage can be attributed to workers relocating to firms that pay a higher wage premium to their workers. Put differently, 80% ((1-0.5/2.5) ×100) of the increase in the firm's average daily wage caused by the minimum wage is accounted for by workers moving to firms that offer better jobs and employ more skilled and more full-time workers. The remaining 20% reflect an increase in the firm wage premium that firms pay to the same worker type.

Alternative measures of firm quality. The remaining panels in Figure 5 and Table 4 show results for alternative measures of firm quality. The findings further corroborate our finding that the minimum wage induced low-wage workers to reallocate to firms of higher quality. Motivated by models of heterogeneous firms such as Melitz (2003) that predict that more productive firms employ more workers, we use firm size as a measure for firm quality in panel (c) of Figure 5 (panel (d) of Table 4). The results suggest that the

[15] In the regression, we control for worker fixed effects, year fixed effects and age effects (a polynomial of order three) in addition to firm fixed effects.

minimum wage induces low-wage workers to reallocate to larger firms. The difference-in-difference estimate indicates that relative to the pre-policy period, firm size (measured prior to the introduction of the minimum wage) increases by 4.3% for minimum-wage workers (relative to workers higher up the wage distribution) in the post-policy period.

The findings in panel (d) of Figure 5 (panel (e) of Table 4) further show that following the introduction of the minimum wage, low-wage workers move to firms characterized by generally more stable employment relationships, where (the inverse of) stability is measured by the firm's churning rate (the combined number of workers who leave and join the firm, divided by the number of employees at baseline) prior to the introduction of the minimum wage. The churning rate as a measure of firm quality is motivated by equilibrium models with search frictions (e.g., Burdett and Mortensen, 1998; Cahuc, Postel-Vinay and Robin, 2006). These models predict that more productive, larger firms set higher wages and have both a lower separation rate and a lower hiring rate in equilibrium. These results highlight that the increase in job stability following a minimum wage hike documented in the previous literature (e.g., Cardoso and Portugal 2006; Brochu and Green 2013; Dube, Lester, Reich 2016) is in part driven by reallocation of workers towards more stable firms.

In panel (f) of Table 4, we use the firm's poaching index as a final measure for firm quality, as suggested by Bagger and Lentz (2018). The poaching index captures the share of new hires whom the firm recruits directly from other firms, as opposed to new hires who join the firm from unemployment. A higher poaching index indicates a higher firm quality, as firms are able to "steal" workers from other firms only if they offer a superior job. Our findings for the poaching index further corroborates our previous findings that the minimum wage induced an upgrading of low-wage workers to higher quality firms.

Worker Reallocation Within versus Between Regions and Industries. The upgrading of low-wage workers to firms that pay higher average daily wages may occur within or between regions (401 districts). We investigate this in panel (a) of Table 5, where we display difference-in-difference and placebo estimates using the worker's change in the average daily wage in the region where the firm is located as the dependent

variable. Estimates are close to zero, indicating that the minimum wage-induced reallocation of workers to firms that pay higher daily wage is not driven by workers relocating to regions where daily wages are higher. Instead, the upgrading takes place almost entirely within regions.

In panel (b) of the table, we repeat the analysis using the worker's change in the average daily wage in the three-digit industry as the dependent variable. The coefficient estimate is positive, but relatively small in magnitude: minimum wage workers experience an increase in the average daily wage in the industry of 0.8% following the introduction of the minimum wage, compared to an increase in the average daily wage in the firm of 2.5% (panel (a) of Table 4). Thus, the upgrading of low-wage workers to firms that pay higher daily wages occurs primarily within, rather than between industries.

The findings in panel (c) of Table 5 further show that the minimum wage had little impact on the probability that minimum wage workers switch firms. Therefore, the upgrading of minimum wage workers to better firms following the introduction of the minimum wage arises chiefly because of movements to better firms conditional on switching firms, rather than because of a higher firm switching probability. Finally, the findings in panel (d) of Table 5 highlight that the minimum wage had no impact on the probability that low-wage workers reallocate to newly founded firms.

Robustness. In Table 6, we probe the robustness of our results to the inclusion of various control variables, focusing on employment, (proxied) hourly wage growth, and three measures of firm quality (firms' average daily wage, firms' size and firms' poaching index). In column (1), we report difference-in-difference estimates based on equation (2) without any control variables. In columns (2) to (4), we successively add individual-level demographic control variables and industry and location fixed effects, respectively. Estimates in column (5) correspond to our baseline specification that controls for those three sets of control variables jointly. In column (6), we include the local unemployment rate interacted with wage bins as additional controls, to account for the possibility that the (local) business cycle differentially affects workers along the wage distribution. In all specifications, estimated effects are very similar to those in our baseline

specification, providing additional reassurance that they are driven by the minimum wage, rather than business cycle effects that vary across workers located in different wage bins.

4 Labor Market Effects of the Minimum Wage: Regional Approach

Our findings from the individual approach show that the minimum wage increased wages of low-wage workers without reducing their employment prospects. At the same time, the minimum wage induced low-wage workers to reallocate to firms of higher quality. The minimum wage thereby helped to lower wage inequality, as intended, not only directly, but also indirectly, through reducing the degree of assortative matching between workers and firms. The latter has been emphasized as an important driver of the increase in wage inequality (Card, Heinig, and Kline 2016; Song, Price, Guvenen, Bloom, and von Wachter 2019).[16]

We now provide complementary evidence on the wage, employment and reallocation effects of the minimum wage by exploiting variation in exposure across regions. An advantage of this regional approach over the individual approach is that any wage, employment and reallocation effects of the minimum wage will not be driven only by workers who were employed when the minimum wage was introduced and who were possibly partially shielded from potentially harmful effects of the policy, but also by workers who were not in employment prior to the introduction of the minimum wage. For example, if firms primarily respond to the introduction of the minimum wage by reducing hiring of unemployed workers, without displacing their incumbent workforce, the regional approach will uncover negative employment effects that would be missed by the individual approach.

[16] The reduction in the degree of assortative matching between workers and firms also suggest that minimum wage reverse some of the negative trends caused by outsourcing in Germany (see Goldschmidt and Schmieder, 2017).

4.1 Method

The Gap Measure. In our regional approach, we compute for each of the 401 regions (districts) a continuous measure for its exposure to the minimum wage that has been often used in the minimum wage literature (e.g., Card and Krueger 1994 and Draca, Machin and Van Reenen 2011):

$$\mathrm{GAP_{rt}} = \frac{\sum_{i \in r} h_{it} \min\{0, MW - w_{it}\}}{\sum_{i \in r} h_{it} w_{it}}.$$

where h_{it} denotes the weekly hours worked of worker i (employed in region r), MW is the minimum wage, and w_{it} refers to the worker's hourly wage. This measure does not only depend on the share of individuals in the region who earn less than the minimum wage, but also on how much a worker's wage is below the minimum wage. The measure (if multiplied by 100) reflects the percentage wage increase necessary to bring all workers in the region up to the minimum wage.

We average the yearly gap measure over three pre-policy years (2011 to 2014) to obtain a time-constant gap measure for each region:

$$\overline{GAP_r} = \sum_{t=2011}^{2014} GAP_{\mathrm{rt}} \quad (3)$$

The gap measure, averaged across regions, equals 0.017, with standard deviation of 0.01, implying that hourly wages would have to increase by 1.7% on average to ensure that all workers earn at least the minimum wage. The gap measure is lowest in the district of Wolfsburg, the home town of Volkswagen (0.002), and highest in the district of Mansfeld-Südharz, a rural district in East Germany (0.039). Figure 6 shows a map of the 401 regions where darker colors indicate a stronger exposure to the minimum wage according to the average gap measure. The figure highlights that regions in East and North Germany are more heavily affected by the minimum wage than regions in South Germany.

We then relate our continuous measure for the exposure of region *r* to the minimum wage given by equation (3) to outcomes in the region, such as the local (log) wage, local (log) employment or local firm quality. Specifically, in a first step, we estimate event-study regressions of the following type:

$$Y_{rt} = \alpha_r + \zeta_t + \sum_{\tau=2011, \tau \neq 2014}^{2016} \gamma_\tau \overline{GAP}_r + \epsilon_{rt} \quad (4)$$

where Y_{rt} denotes the outcome of interest (e.g., log wages in the region), α_r are region fixed effects and ζ_t are year fixed effects. The coefficients γ_τ trace out how outcomes in regions more affected by the minimum wage evolve in comparison to regions less affected by the minimum wage, relative to the pre-policy year 2014. We present coefficient estimates for γ_τ in a figure, to best visualize the possible labor market effects of the minimum wage policy.

Equation (4) yields causal estimates of the minimum wage policy under the assumption that outcomes in more and less affected regions would have developed at the same rate in the absence of the minimum wage policy. This assumption can be partially assessed by investigating whether more and less exposed regions exhibit similar trends in outcome variables prior to the introduction of the minimum wage. This corresponds to the coefficient estimates γ_τ to be statistically and economically indistinguishable from zero for the pre-policy years (i.e., for $\tau < 2013$). To deal with the possibility that highly and barely exposed regions differentially evolved already prior to the introduction of the minimum wage, we first use our estimates of γ_τ for the pre-policy years 2011 to 2014 to fit a linear time trend. We then plot the deviations between the estimates of γ_τ and the predicted linear time trend updated for the post-policy years, thereby visualizing any trend breaks in outcomes at the time of the introduction of the minimum wage. We additionally report results from a continuous difference-in-difference regression that accounts for region-specific linear time trends:

$$Y_{rt} = \alpha_r + \zeta_t + \delta_{post} \overline{GAP}_r \times Post_t + \beta_r time_t + \epsilon_{rt}. \quad (5)$$

Here, $Post_t$ is an indicator variable equal to 1 for the post policy years (t = 2015, 2016), and $time_t$ is a linear time trend that is allowed to vary across regions. Both approaches rely on the assumption that any pre-existing trends in outcomes between heavily and barely exposed regions are linear and would have continued at the same rate in the absence of the introduction of the minimum wage. We further probe the

robustness of our estimates by estimating regressions based on equation (5) that include fully flexible time effects interacted with local characteristics at baseline as additional regressors.

We weight our regressions by average local employment over the 2011 to 2013 period, and cluster standard errors at the regional level to allow for an arbitrary correlation of error terms within regions over time.

4.2 Wage and Employment Effects of the Minimum Wage

Wage Effects. A first visual impression of how wages in regions heavily affected by the minimum wage evolve relative to wages in regions less exposed to the minimum wage is given in panel (a) of Figure 7, where we plot the coefficient estimates for γ_τ from regression equation (4), using the (log) average wage in the region as the dependent variable. The figure suggests that regions more exposed to the minimum wage experienced similar wage growth compared to less exposed regions already prior to the introduction of the minimum wage, over the 2011 to 2014 period. However, after the introduction of the minimum wage in 2015, wage growth in highly affected areas strongly picks up relative to wage growth in less affected areas. Thus, in line with results from the individual approach, these findings strongly suggest that the minimum wage pushed up wages. By year 2016, the coefficient estimate approaches 1, as we would expect under full compliance with the minimum wage law. In panel (a), we further display a linear time trend, calculated based on the 2011 to 2014 pre-policy years (the black solid line in the figure). Panel (b) then depicts the deviations between the coefficient estimates for γ_τ (the dashed blue line) and the linear trend (the solid black line). Since the trend line is basically a horizontal line at zero, deviations from the trend line evolve very similarly to the coefficient estimates for γ_τ. In sum, the figures in panels (a) and (b) show a very clear trend break in local wage growth starting in 2015, exactly the year in which the minimum wage was first introduced.

We provide additional estimates of the wage effects of the minimum wage in panel (a) of Table 7. In the first column, we display simple difference-in-difference estimates based on regression equation (4),

excluding linear region-specific time trends. In column (2), we include region-specific linear time trends in the regression, as in regression equation (5). In columns (3) and (4), we add controls for regional baseline characteristics interacted with a linear time trend or with fully flexible year effects, rather than a region-specific linear time trend. All specifications clearly indicate that the minimum wage raised wages. A one percentage point increase in the gap measure leads to an increase in local wages by between 0.68% to 0.80%.

Employment Effects. Panels (c) and (d) of Figure 7 and panel (b) in Table 7 provide a corresponding analysis for the employment effects of the minimum wage. Panel (c) of Figure 7 illustrates that local employment, measured as the number of workers employed in the region (in logs), fell at a nearly linear rate in more exposed relative to less exposed areas throughout the entire 2011 to 2016 period.[17] Panel (d) depicts the deviations from the coefficient estimates γ_τ (the blue dashed line in panel (c)) and the linear trend (the black solid line in panel (c)), estimated for the pre-policy period 2011 to 2013 and updated for the post-policy period. These deviations are all close to zero, suggesting that the minimum wage had no discernable impact on local employment, in line with our findings from the individual analysis.

We report corresponding difference-in-difference estimates based on variants of regression equation (5) in panel (b) of Table 7. In line with the evidence presented in the figure, the difference-in-difference estimates indicate that the minimum wage did not reduce local employment, once we account in various ways for differential pre-trends (columns (2) to (4)). The estimate from our preferred specification in the second column implies that that we can reject the hypothesis that employment in the 10% regions most exposed to the minimum wage (with a gap measure of 0.033) declined, relative to the 10% least exposed regions (with a gap measure of 0.009), by more than 1.5% ((0.018-1.96×0.059)×(0.033-0.009)) at a 5% confidence level. Putting it differently, the estimates for the local wage and employment responses to the minimum wage presented in panels (a) and (b) rule out an employment elasticity with respect to the

[17] The slope implies that regions at the 10th percentile of the exposure measure experienced a 4% higher employment growth between 2011 and 2014 than regions at the 90th percentile.

wage that is larger (in absolute magnitude) than -0.14 at a 5% confidence level.[18] The absence of a negative employment effect not only at the individual level, but also at the regional level further suggests that employment prospects of unemployed workers are not substantially harmed by the introduction of the minimum wage.

4.3 Reallocation Effects of the Minimum Wage

The wage and employment effects from the regional approach confirm the findings from the individual approach: the introduction of the minimum wage raised wages, but did not lower employment. The minimum wage thus did not only help to reduce wage inequality across individuals, but also across regions, without causing job losses among disadvantaged individuals or in disadvantaged regions. In a next step, we provide evidence that the upgrading of low-wage workers to better firms induced by the minimum wage translated into an improvement in firm quality in more relative to less exposed areas to the minimum wage.

We first investigate whether the minimum wage decreased the number of firms that are operating in the region. We find evidence in line with this hypothesis in panel (a) of Figure 8. In the figure, we display the de-trended estimates for the impact of the local gap measure on various measures in the number of firms in the region. Specifically, we plot the deviations between the coefficient estimates γ_τ obtained from regression equation (4) and a linear time trend estimated for the pre-policy years 2011 to 2013 and updated for the post-policy years in the figure, as in panels (b) and (d) of Figure 7. The figure is suggestive of a trend break around the introduction of the minimum wage, and supports the view that a greater exposure to the minimum wage led to a decline in the number of firms in the region. The corresponding regression estimate, presented in panel (c) of Table 7 (column (2)), indicates that the number of firms declined by 0.45% ((0.033-0.009) ×0.188) in the 10% regions most hit by the minimum wage relative to the 10% regions least hit by the minimum wage in response to the minimum wage. The decline in the number of very small

[18] Dividing estimates in panel (b) by estimates in panel (a) provides us with an estimate of the employment elasticity with respect to the wage. We compute standard errors of this ratio by bootstrapping.

firms with no more than two employees is even more pronounced (0.65% ((0.033-0.009) ×0.271; panel (d) of Table 7 and panel (b) of Figure 8), in line with the hypothesis that the minimum wage drives the least productive firms out of the market. We investigate firm exit directly in panel (e) of Figure 8. The figure provides clear evidence of increased exit of small businesses after the introduction of the minimum wage in regions heavily exposed to relative to regions barely hit by the minimum wage.

Since the minimum wage has little impact on overall local employment, the decline in the number of firms induced by the minimum wage implies an increase in average firm size in the region, by 0.36% in the 10% regions most exposed relative to the 10% regions least exposed to the minimum wage (panel (e) of Table 7 and panel (c) of Figure 8). Panel (d) of Figure 8 further highlights that the minimum wage increased the average firm wage premium, measured as a fixed firm effect in an AKM-style regression estimated using only pre-policy data, in heavily exposed relative to barely exposed regions. The coefficient estimates, reported in panels (a) and (f) in Table 7 (column (2)), imply that 18.2% (0.125/0.685) of the overall increase in the local wage due to the introduction of the minimum wage can be attributed to the reallocation of workers to firms that pay a higher wage premium.

To summarize, our findings from both the individual and regional approach highlight that the minimum wage pushed up wages, but did not reduce employment. Both approaches further suggest that the minimum wage led to reallocation effects: the minimum wage induced low-wage workers to move up to better and larger firms; it further led to a shift away from micro firms toward larger firms, and toward firms paying a higher wage premium, in regions where the minimum wage was more binding.

5 Discussion

Various economic models can account for the reallocation of low wage workers to larger, higher paying firms following the introduction of the minimum wage. For example, Acemoglu (2001) provides an explanation for why in the presence of search frictions, a minimum wage may induce a shift toward more productive, capital-intensive firms. Whereas wages are equalized across firms with low and high capital intensity and the composition of jobs is socially optimal in a perfectly competitive labor market, search

frictions force firms to agree to a higher wage in jobs with a high capital intensity. In consequence, firms create too many "bad" jobs (i.e., jobs with a low capital intensity) and too few "good" jobs. A minimum wage induces firms to destroy some jobs with low capital intensity, and set up additional jobs with high capital intensity. While we cannot directly measure capital intensity in the firm, we can proxy it with the firm wage fixed effect and the share of high-skilled workers in the firm.[19] Our findings that low wage workers reallocated toward firms with a higher firm fixed effect (panel (b) of Figure 4) and to skill-intensive firms (panel (b) in Figure 5) in response to the minimum wage is compatible with the mechanism described in Acemolgu (2001).[20]

Models of monopsonistic or oligopolistic competition provide an alternative explanation for the minimum-wage induced reallocation of low-wage workers toward firms of higher quality (e.g., Manning 2003 and Bhaskar, Manning, To 2002, Berger, Herkenhoff, Mongey 2019). In these types of models, monopsony power allows firms to set wages below the marginal product of labor and more productive firms find it optimal to set higher wages and employ more workers. Ae minimum wage drives the smallest and most inefficient firms out of the market. Medium sized and larger firms (partially) absorb the workers previously employed in the smallest firms that shut down. Card, Cardoso, Heinig and Kline (2018) argue that monopsony power of firms naturally emerges when workers have idiosyncratic, non-pecuniary preferences to work at a particular firm. Possibly the most important non-pecuniary characteristic of a particular job is the commuting time from home to the workplace: workers are willing to accept lower wages if the workplace is closer to their home. As a result, low paying firms are able to survive in equilibrium, by mostly attracting workers from their close neighborhood. The introduction of the minimum wage may force these firms to close down, and workers may have to find jobs that are farther from their home.

[19] Lochner et al. (2019) show a strong positive correlation between the firm wage fixed effect and the capital intensity of the firm. Numerous papers provide evidence for the complementarity between capital and high-skilled workers (e.g., Goldin and Katz 1998).

[20] The shift from less capital intensive toward more capital intensive firms is also consistent with the putty-clay model proposed by Aaronson et al. (2018). However, this model predicts a disemployment effect even in the short run, which is contrary to what we find in the data.

We explore the possibility that the reallocation of low-wage workers to higher paying firms comes at the expense of increased commuting distance (computed as the distance between the centroids of the municipalities of residence and work) in Table 8. We report difference-in-difference estimates. The estimates suggest that commuting distance increased by 1.5km (or 8%) for low-wage workers relative to high-wage workers after the introduction of the minimum wage. The increase in commuting time induced by the minimum wage is considerably larger for men than for women, in line with the hypothesis that women have a particularly strong preference to work close to home (e.g. Hanson and Johnston 1985; Caldwell and Danieli 2019). Interestingly, the reallocation effects of low-wage workers towards higher paying firms are also stronger for men than women (see Figure 9), as men are more willing to trade off wages and commuting time. These findings are consistent with a model where worker reallocation emerges due to the monopsony power of firms.

Reallocation effects toward firms of higher quality can also be explained by frictions in the consumer market, as explored in Luca and Luca (2018) and in Mayneris, Poncet, and Zhang (2018). Consider a model where firms produce differentiated goods, differ in their productivity, and face fixed costs of production, as in for example Melitz (2003). In this type of model, a minimum wage, by pushing up labor costs, causes the least productive firms to exit the market. Consumers who had previously purchased goods from these firms will switch to products produced by more efficient firms, which increases the demand for labor in these firms. In this case, we would expect the reallocation to take place predominantly within, rather than between industries. Our findings in panel (b) of Table 5 are roughly in line with this implication, as about 68% of the overall reallocation occurs within 3-digit industries. We would further expect customer switching to happen primarily among locally traded goods (that is, in retail- and restaurant-related industries), rather than among goods traded in the national or world market where consumers would more likely to switch to non-German producers. Figure 9 provides support for this prediction: the

reallocation effect of low wage workers to higher paying firms is considerably more pronounced in the non-tradable sector than in the tradable sector.[21]

6 Conclusion

This paper investigates the labor market responses to Germany's first-time introduction of a nation-wide minimum wage. We find that the minimum wage policy pushed up wages without lowering employment. The lack of employment responses, however, masks some important structural shifts in the economy: the minimum wage led to a reallocation of workers from smaller, lower paying firms to larger, higher paying firms, and thereby helped to improve the quality of firms in the economy.

These findings are hard to reconcile with perfectly competitive labor and product markets where a minimum wage unambiguously reduces efficiency and welfare. The reallocation of labor toward higher paying, potentially more capital intensive and more productive firms, and the lack of disemployment effects, suggest that the minimum wage improved production efficiency in the economy. While this result is surprising from the perspective of perfectly competitive labor markets, it can emerge in the presence of search frictions, monopsony power, or product market frictions. In these type of models, a minimum wage could potentially reduce the detrimental effects of the market imperfections or distortions, and may thus improve efficiency and welfare in the economy.

Yet, our results do not imply that there are no firms, workers or customers who lost out as a result of the introduction of the minimum wage. We find that the minimum wage caused some small businesses to exit the market. As Williamson (1968) has highlighted, increased exits may lead to increased market concentration and reduced competition among firms. Exiting firms may have produced specific goods that were particularly liked by certain customers, who may now be forced to switch to, according to their taste, an inferior alternative. Furthermore, the reallocation of low-wage workers to higher paying firms came at

[21] When classifying industries into non-tradable and tradable, we follow Mian and Sufi (2014) and classify retail- and restaurant-related industries as non-tradable, and industries listed in global trade data as tradable, as in their method 1. Our findings are similar when we classify industries as non-tradable and tradable using their method 2.

the expense of increased commuting time (and possibly other dis-amenities), which might have left some workers worse off despite earning a higher wage.

Establishing the existence of reallocation effects and quantifying its size, as we have done in this paper, is an important first step to understand the welfare implications of minimum wages.

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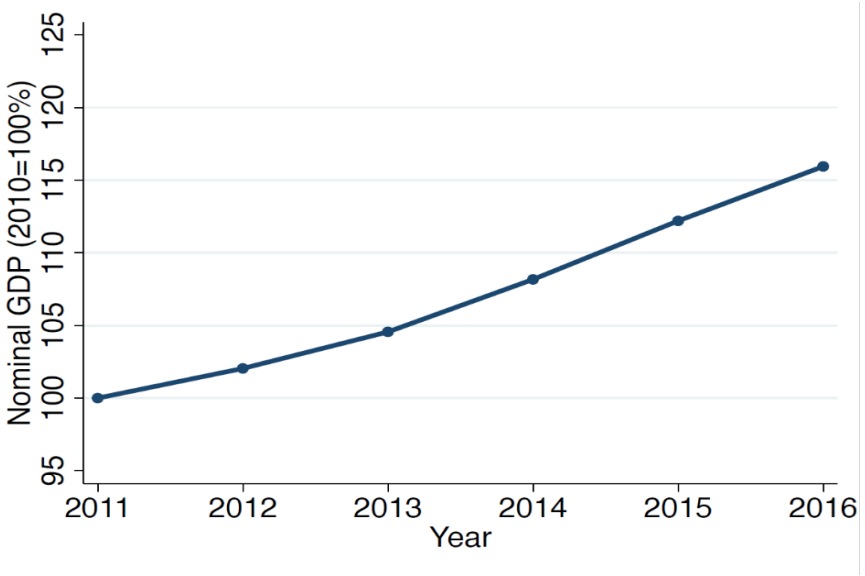
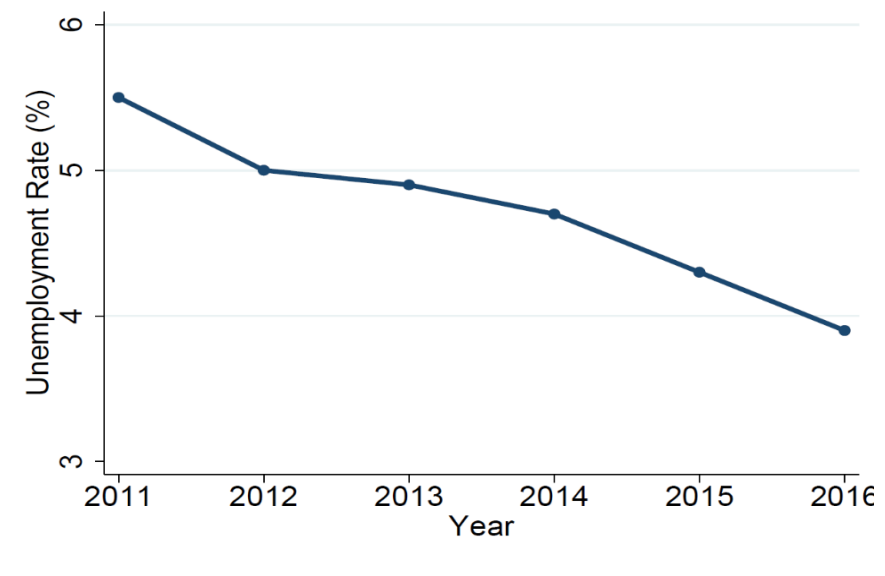
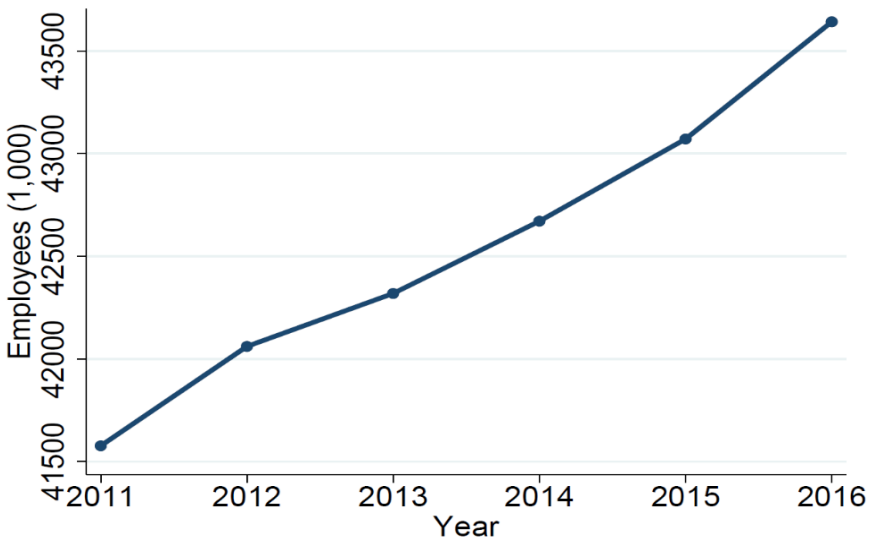
Figure 1: Macroeconomic Conditions, 2011 to 2016



Panel (a) Noimnal GDP



Panel (b): Unemployment Rate

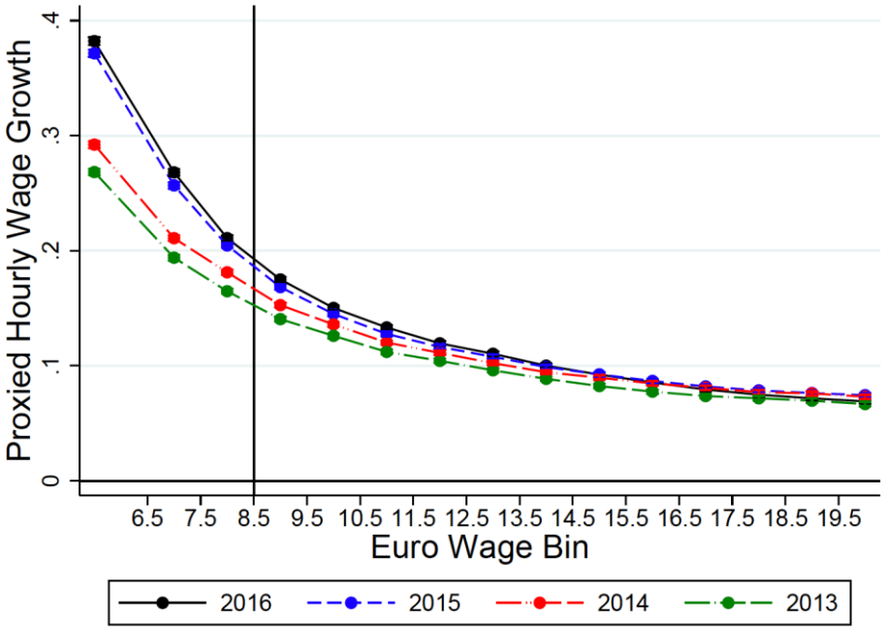


Panel (c): Employment

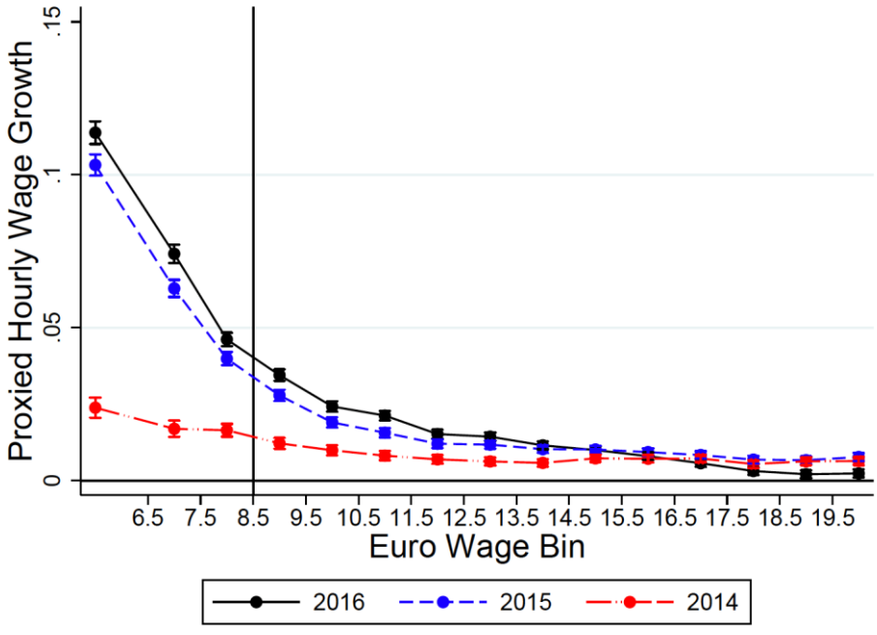
Notes: The figure provides an overview of the macroeconomic conditions at the time of the introduction of the minimum wage in January 2015. Panel (a) shows nominal GDP growth; panel (b) shows the unemployment rate, and panel (c) shows total employment between 2011 and 2016.

Source: : DeStatis, 2011-2016.

Figure 2: Wage Effects of the Minimum Wage: Individual Approach



(a) Two-Year Hourly Wage Growth by Initial Wage Bin

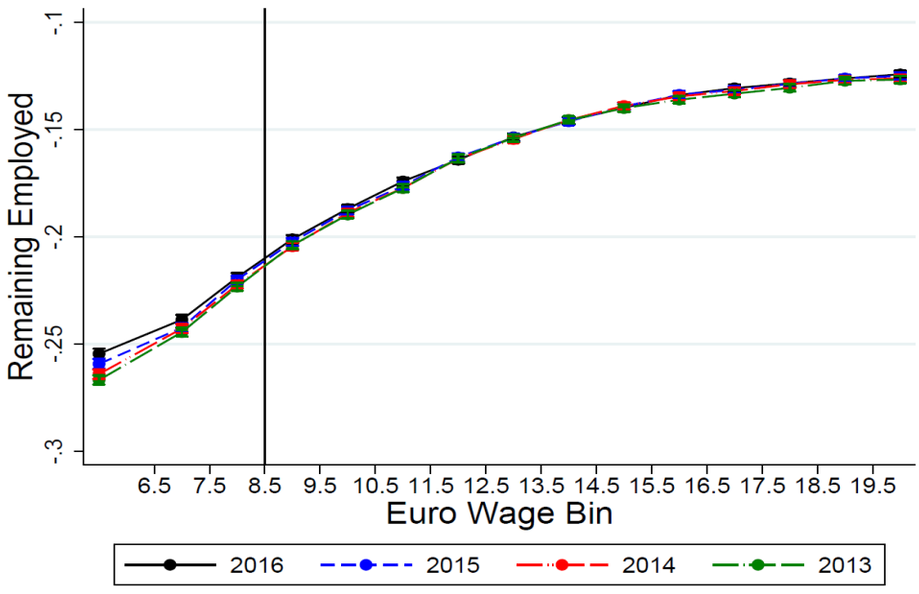


(b) Two-Year Hourly Wage Growth by Initial Wage Bin, relative to 2011 vs 2013

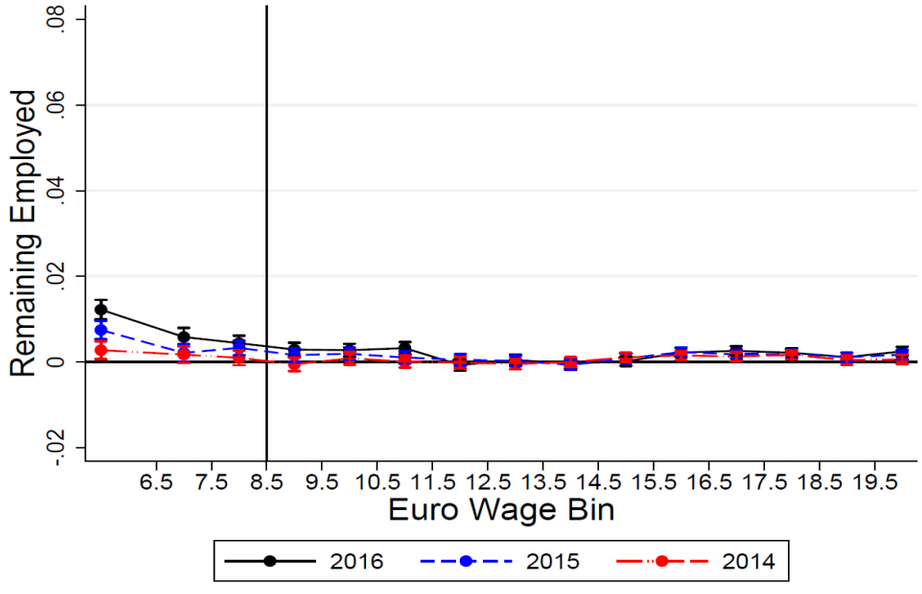
Notes: In panel (a), we plot two-year hourly wage growth of individuals who were employed in t-2 and t against their initial wage bin, separately for the periods 2011 vs 2013 (green line) to 2014 vs 2016 (black line), while controlling for individual characteristics at baseline (age, education, sex, county and industry fixed effects). Estimates refer to coefficients γwt in regression equation (1) in the text. In panel (b), we plot two-year wage growth by initial wage bin in the periods 2012 vs 2014 to 2014 vs 2016 relative to the 2011 vs 2013 pre-policy period, once again controlling for individual characteristics at baseline. Estimates refer to coefficients δwt in regression equation (2), and correspond to the differences between the black, blue, and red lines and the green line in panel (a). The black vertical line indicates the minimum wage of 8.50 Euro per hour.

Sources: Labor Market Mirror and Employee Histories of the Institute for Employment Research in Nuremberg (BEH), 2011-2016.

Figure 3: Employment Effects of the Minimum Wage: Individual Approach



(a) Employment Probablity in Year *t* by Initial Wage Bin

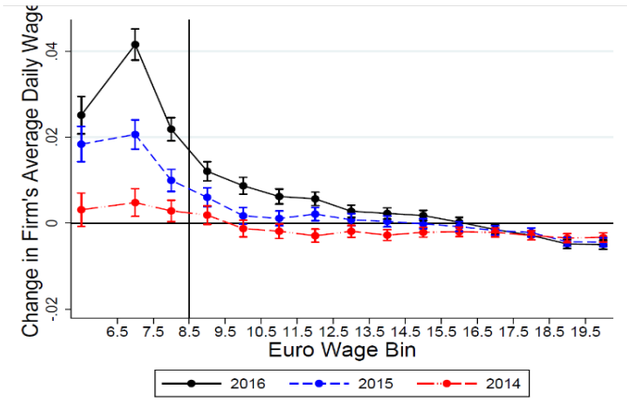


(b) Employment Probablity in Year t by Initial Wage Bin, relative to 2011 vs 2013

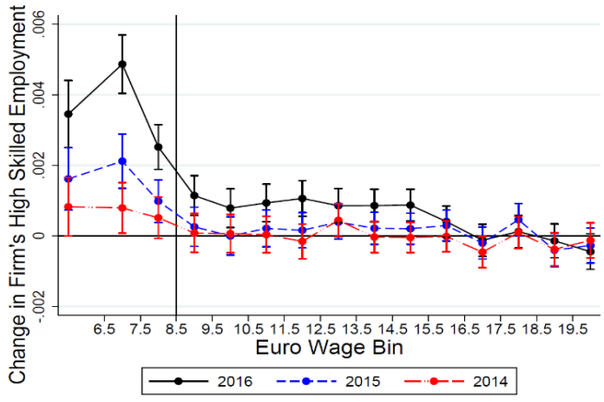
Notes: In panel (a), we plot the probability that a worker who was employed in period t-2 remains employed in period t against her initial wage bin, separately for the periods 2011 vs 2013 (green line) to 2014 vs 2016 (black line), while controlling for individual characteristics at baseline (age, education, sex, county and industry fixed effects). Estimates refer to coefficients γwt in regression equation (1). In panel (b), we plot the probability that an employed worker is employed two years later against her initial wage bin for the periods 2012 vs 2014 to 2014 vs 2016 relative to the 2011 vs 2013 pre-policy period, once again controlling for individual characteristics at baseline. Estimates refer to coefficients δwt in regression equation (2), and correspond to the differences between the black, blue, and red lines and the green line in panel (a). The black vertical line indicates the minimum wage of 8.50 Euro per hour.

Sources: Labor Market Mirror and Employee Histories of the Institute for Employment Research in Nuremberg (BEH), 2011-2016.

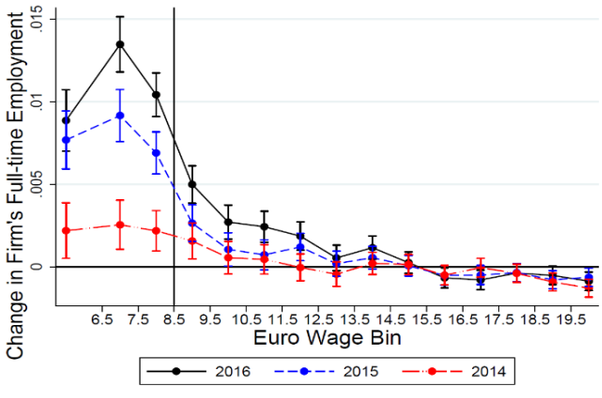
Figure 4: Reallocation Effects of the Minimum Wage: Individual Approach



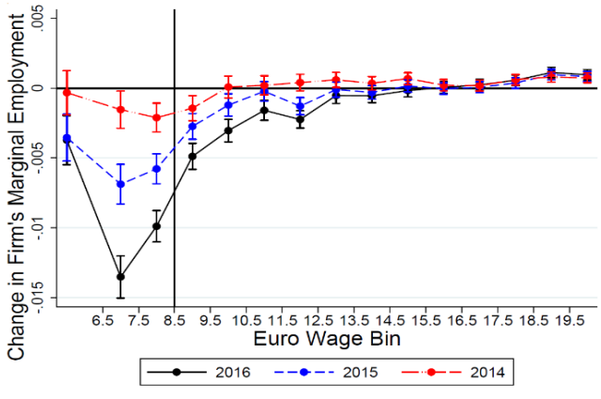
(a) Firm's Average Daily Wage



(b) Firm's High-Skilled Employment Share



(c) Firm's Full-Time Employment Share

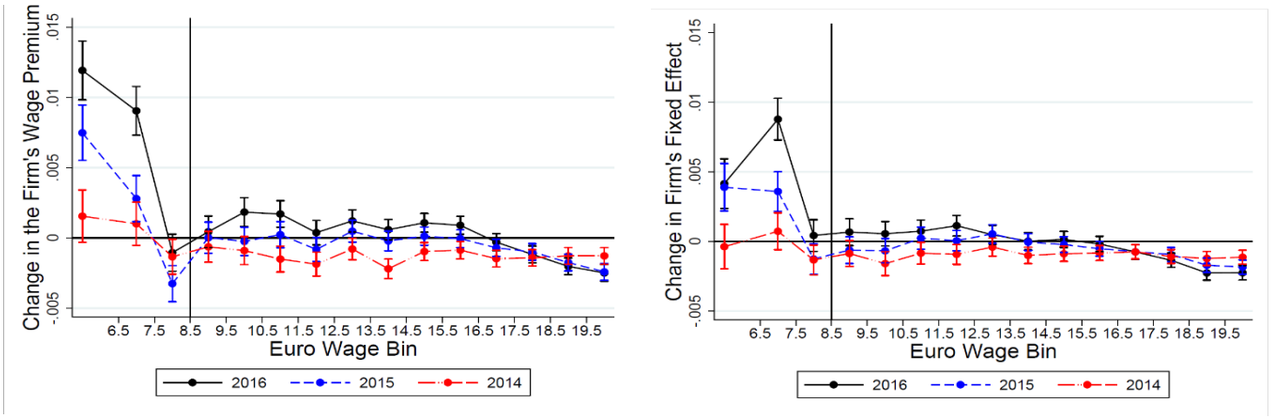


(d) Firm's Marginal Employment Share

Notes: The figure investigates the effect of the minimum wage on the reallocation of low-wage workers to firms of higher quality. Firm quality is measured before the minimum wage came into effect, and only changes for workers who switch firms. In panel (a), we plot the change in the firm's (log) average daily wage against the worker's initial wage bin for the periods 2012 vs 2014 to 2014 vs 2016, relative to 2011 vs 2013 pre-policy period, controlling for individual characteristics at baseline (age, education, sex, county and industry fixed effects). In panels (b) to (d), we repeat the analysis, using the change in the firm's employment share of high-skilled workers (i.e., workers with a university degree; panel (b)) and the change in the firm's employment share of full-time and marginally employed workers (panels (c) and (d)) as dependent variables. Estimates refer to coefficients δwt in regression equation (2). The black vertical line indicates the minimum wage of 8.50 Euro per hour.

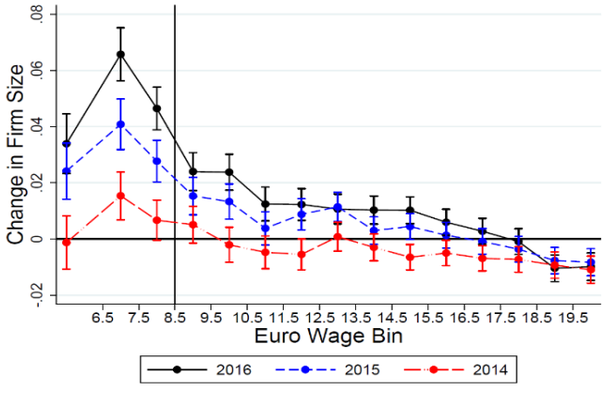
Sources: Labor Market Mirror and Employee Histories of the Institute for Employment Research in Nuremberg (BEH), 2011-2016.

Figure 5: Reallocation Effects of the Minimum Wage: Individual Approach

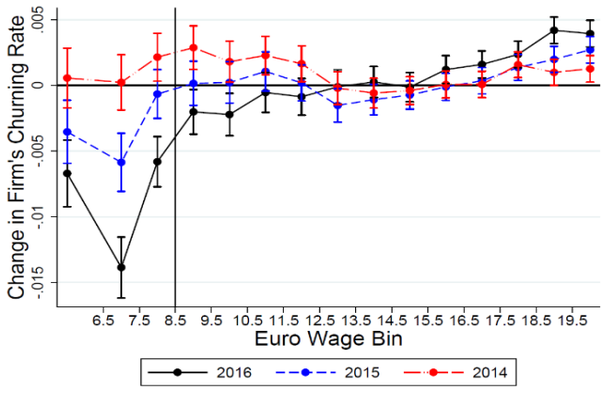


(a) Firm's Wage Premium

(b) Firm's AKM Fixed Effect



(c) Firm Size

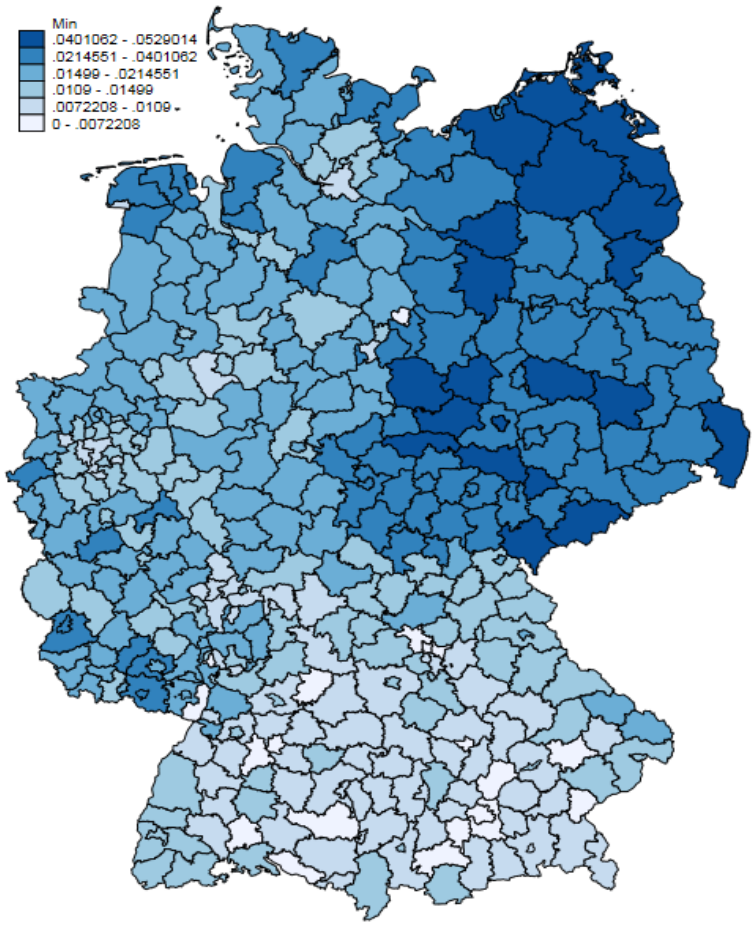


(d) Firm's Churning Rate

Notes: In the figure, we plot the change in firm quality between periods t-2 and t for workers who are employed in both periods against their initial wage bin for the periods 2012 vs 2014 to 2014 vs 2016, relative to the 2011 vs 2013 pre-policy period. Regressions control for individual characteristics at baseline (age, education, sex, county and industry fixed effects). Estimates refer to coefficients δwt in regression equation (2). Firm quality is measured before the minimum wage came into effect, and only changes for workers who switch firms. In panel (a), firm quality is measured as the firm's wage premium, calculated as the average wage residual in the firm obtained from an individual wage regression that controls for workers' demographic characteristics (age, sex, foreign status and education) and workers' employment status (full-time, part-time, marginal employment). In panel (b), firm quality is measured as the firm's fixed effect, estimated in an AKM-style wage regression that controls for worker and firm effects over a 7-year pre-basline window. In panel (c), we use firm size as a measure for firm quality. In panel (d), the dependent variable is the change in the firm's churning rate, calculated as the sum of workers who leave and join the firm, divided by the number of employees at baseline. The black vertical line indicates the minimum wage of 8.50 Euro per hour.

Sources: Labor Market Mirror and Employee Histories of the Institute for Employment Research in Nuremberg (BEH), 2011-2016.

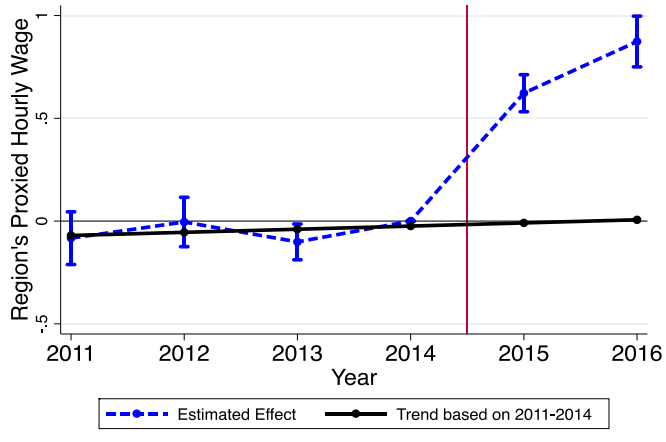
Figure 6: Exposure to the Minimum Wage across Regions



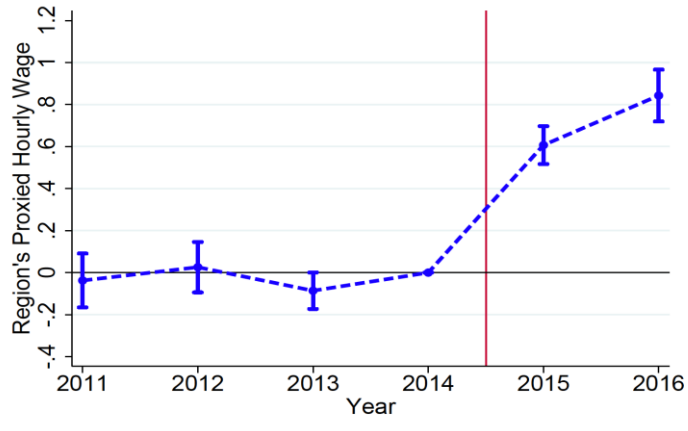
Notes: The figure shows the exposure to the minimum wage across 401 regions (districts). Regional exposure to the minimum wage is measured using the gap measure, as in equation (3).

Sources: Labor Market Mirror and Employee Histories of the Institute for Employment Research in Nuremberg (BEH), 2011-2014.

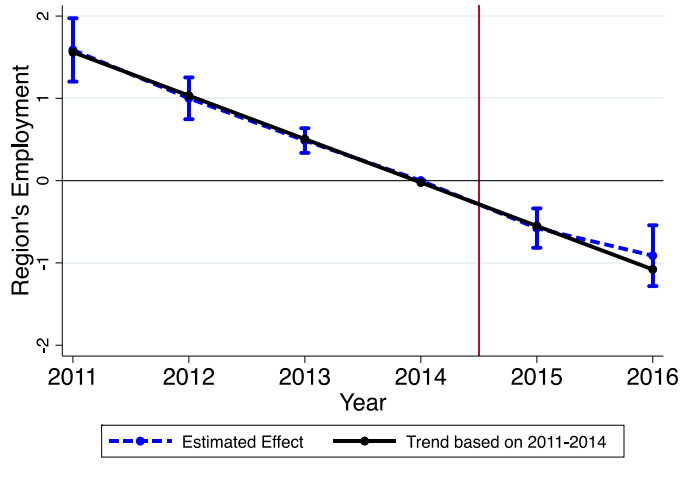
Figure 7 : Wage and Employment Effects of the Minimum Wage: Regional Approach



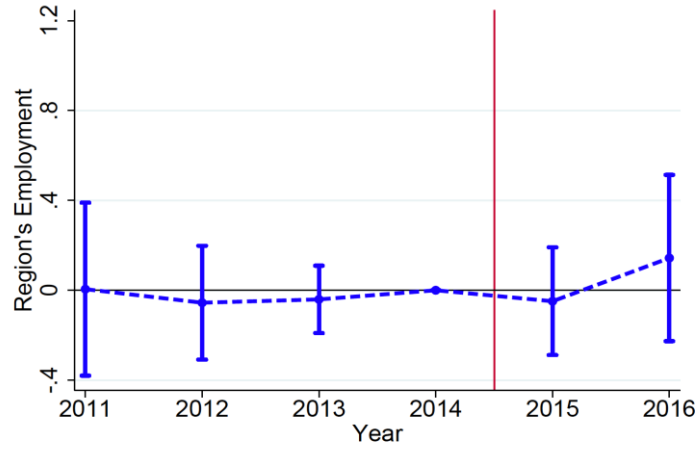
(a) Proxied Hourly Wages



(b) De-trended Proxied Hourly Wages



(c) Employment

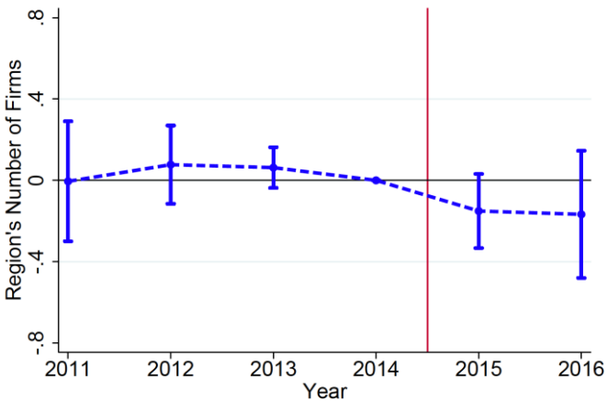


(d) De-trended Employment

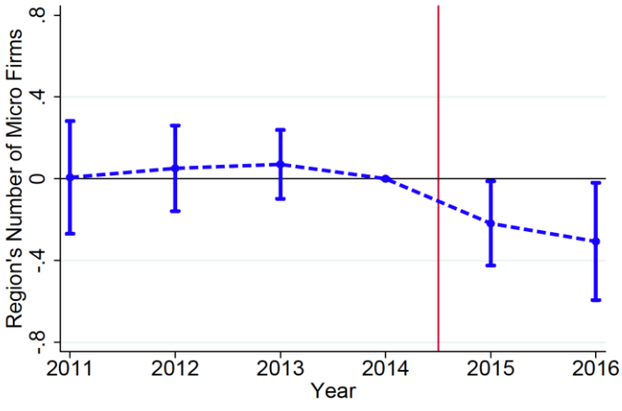
Notes: Panels (a) and (c) trace out how (log) local hourly wages (average proxied hourly wage in the the region, panel (a)) and (log) local employment (the number of employed workers in the region, panel (c)) evolve in regions differentially exposed to the minimum wage, relative to the pre-policy year 2014 (the dashed blue line). Plotted effects refer to coefficients $\gamma\tau$ in regression equation (4). The figures also plot a linear time trend estimated for the 2011-2014 pre-policy years and then updated for later years (the solid black line). Panels (b) and (d) display the deviations between the coefficient estimates and the linear time trend.

Sources: Labor Market Mirror and Employee Histories of the Institute for Employment Research in Nuremberg (BEH), 2011-2016, aggregated across regions (401 counties) and years.

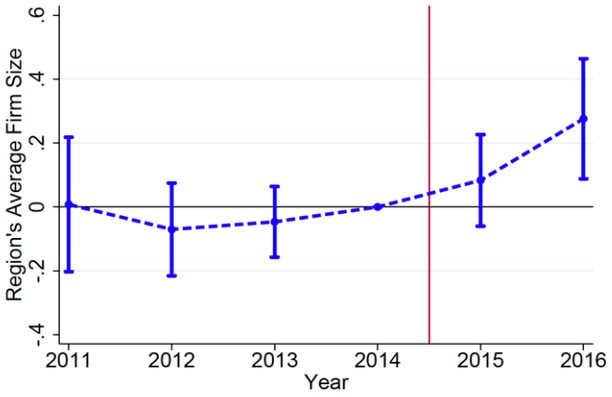
Figure 8: Evidence for Reallocation: Regional Aproach



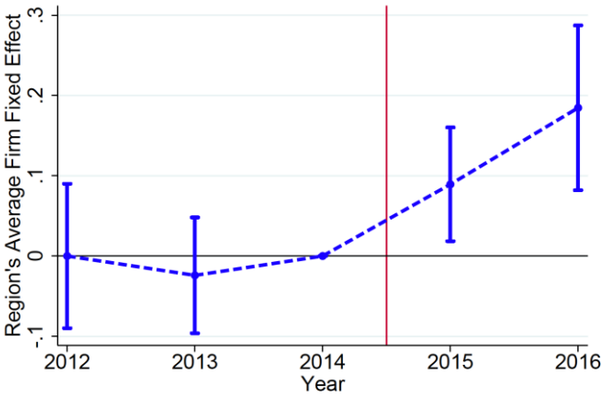
(a) Number of Firms



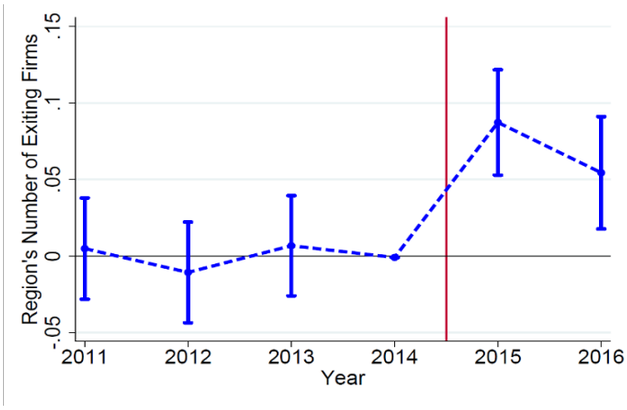
(b) Number of Micro Firms (1-2 Employees)



(c) Average Firm-Size



(d) Avreage Firm FEs

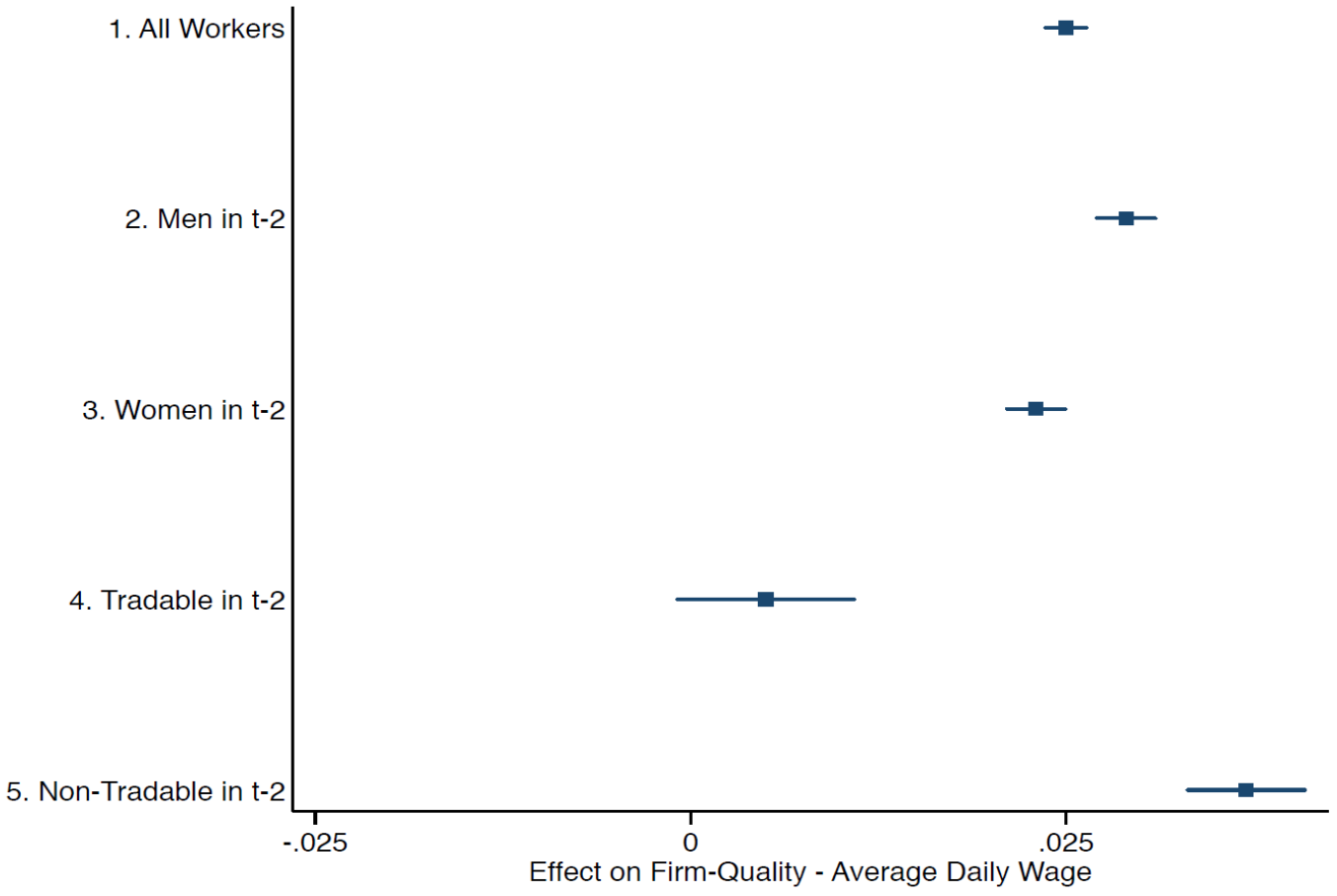


(e) Firm Exit

Notes: This figure depicts the de-trended relationship between the regional exposure to the minimum wage, measured by the gap measure as in equation (3) in the text, and the (log) number of firms in the region (panel (a)); the (log) number of micro-firms with 1 or 2 employees in the region (panel (b)); average firm size in the region (panel (c)); the average firm fixed effect in the region (estimated using AKM style wage regressions that control for worker and firm fixed effects and estimated using 7-year pre-baseline window, panel (d)); and the (log) of the number of exiting firms in the region (panel (e)). We plot the deviations between coefficients $\gamma\tau$ in regression equation (4) in the text and the linear time trend estimated for the 2011-2014 pre-policy period and updated for later years (as in panels (b) and (d) of Figure 7).

Sources: Labor Market Mirror and Employee Histories of the Institute for Employment Research in Nuremberg (BEH), 2011-2016, aggregated across regions (401 counties) and years.

Figure 9: Heterogeneity of Reallocation Responses



Notes: This figure shows the effect of the minimum wage on the reallocation of low-wage workers to firms that pay a higher average daily wages. Row (1) shows the benchmark estimate when all workers are included in the sample (as in panel (b) in Table 3). In rows (2) and (3), the sample is split into men and women, respectively. Rows (4) and Row (5) estimate the reallocation effect separately for workers who were employed in the tradable and in the non-tradable sector at baseline. We classify sectors into tradable and non-tradable using method 1 in Mian and Sufi (2014).

Sources: Labor Market Mirror and Employee Histories of the Institute for Employment Research in Nuremberg (BEH), 2011-2016.

Table 1: Which Individuals are Heavily Affected by the Minimum Wage?

	Wage bin in 2013		
	$4.5<W_{t-2}<8.5$	$8.5<W_{t-2}<12.50$	$12.50<W_{t-2}<20.50$
in East Germany	0.300	0.260	0.166
not German citizen	0.129	0.107	0.067
Education			
share low-skilled	0.219	0.138	0.075
share medium-skilled	0.712	0.798	0.827
share high-skilled	0.069	0.064	0.098
Age Structure			
share less than 24	0.175	0.136	0.076
share 24-44	0.441	0.485	0.509
share 45 -59	0.384	0.379	0.415
Employment Status			
unemployed in previous year	0.215	0.138	0.058
share full-time	0.324	0.582	0.729
share part-time	0.267	0.258	0.248
share marginally employed	0.410	0.160	0.023
Industry Structure			
Agriculture; Mining	0.002	0.002	0.003
Manufacturing; Electricity; Waste Management	0.101	0.153	0.235
Construction; Wholesale and Retail	0.234	0.265	0.284
Transportation; Accomodation and Food Services	0.216	0.137	0.082
Information and Communication; Finance and Insurance; Real Estate	0.036	0.033	0.048
Professional Services; Administrative and Support Services	0.216	0.200	0.108
Public Administration; Education; Human Health	0.114	0.169	0.209
Arts, Entertainment; Other Services	0.081	0.042	0.031
Number of observations	1,234,689	2,187,715	3,776,430

Notes: The table compares individuals located at different parts of the hourly wage distribution in terms of location, education, age, employment status, and industry affiliation in June 2013, 18 months prior to the introduction of the hourly minimum wage of 8.50 per hour in January 2015.

Sources: Labor Market Mirror and Employee Histories of the Institute for Employment Research in Nuremberg (BeH), 2011-2013.

Table 2: Effect of the Minimum Wage on Wages and Employment: Individual Approach

	(1)	(2)	(3)	(4)	(5)
	Changes relative to 2011 vs 2013			Difference-in-difference	
Wage bin in *t-2*	[4.5,8.5)	[8.5,12.5)	[12.5,20.5)	(1) minus (3)	(2) minus (3)
Panel (a): Hourly Wages					
2014 vs 2016	0.067	0.023	0.006	0.061	0.016
	(0.0006)	(0.0003)	(0.0001)	(0.0006)	(0.0003)
2012 vs 2014 (Placebo)	0.017	0.009	0.006	0.010	0.003
	(0.0005)	(0.0003)	(0.0001)	(0.0006)	(0.0003)
Baseline Change (2011 vs 2013)	0.199	0.118	0.080		
Panel (b): Daily Wages					
2014 vs 2016	0.118	0.047	0.012	0.107	0.036
	(0.0010)	(0.0005)	(0.0002)	(0.0010)	(0.0005)
2012 vs 2014 (Placebo)	0.022	0.012	0.006	0.015	0.006
	(0.0009)	(0.0005)	(0.0002)	(0.0009)	(0.0005)
Baseline Change (2011 vs 2013)	0.220	0.064	-0.002		
Panel (c): Employment (1 if employed)					
2014 vs 2016	0.009	0.003	0.002	0.007	0.001
	(0.0004)	(0.0002)	(0.0001)	(0.0004)	(0.0003)
2012 vs 2014 (Placebo)	0.003	0.000	0.001	0.002	-0.001
	(0.0004)	(0.0002)	(0.0001)	(0.0004)	(0.0003)
Baseline Change (2011 vs 2013)	-0.242	-0.184	-0.141		
Panel (d): Employment, full-time equivalents					
2014 vs 2016	0.034	0.018	0.006	0.029	0.013
	(0.0004)	(0.0002)	(0.0001)	(0.0004)	(0.0003)
2012 vs 2014 (Placebo)	0.010	0.006	0.002	0.009	0.004
	(0.0003)	(0.0002)	(0.0001)	(0.0004)	(0.0003)
Baseline Change (2011 vs 2013)	-0.180	-0.193	-0.179		

Notes: In panel (a), we report the excess hourly wage growth in the 2014 vs 2016 post-policy period and the 2012 vs 2014 "placebo" period relative to the 2011 vs 2013 pre-policy period for three groups of workers: workers who earned less than the minimum wage at baseline ([4.5, 8.5), column (1)), workers who earn more but close to the minimum wage at baseline ([8.5, 12.50), column (2)), and workers who earn more than 12.50 Euro at baseline (column (3)). Estimates refer to coefficients δwt in equation (2) in the text, where workers are grouped into three bins only. Columns (4) and (5) report generalized difference-in-difference estimates that compare the excess wage growth of workers who earn less or close to the minimum wage at baseline with the excess wage growth of workers who earn more than 12.50 Euro at baseline (i.e., estimates in columns (1) and (2) minus estimates in column (3)). In panel (b), we repeat the analysis, but now use the change in daily wages as the dependent variable. In both panels (a) and (b), the sample is restricted to individuals who are employed both in period t-2 and t. In panel (c), we report corresponding estimates using employment (1 if the individual is employed, 0 otherwise) as the dependent variable. In panel (d), we instead use the change in full-time equivalents, where we assig a value of 1 if the worker is employed full-time, 0.5 if the worker is employed part-time, 0.2 if the worker is marginally employed, and 0 if the worker is not employed, as the dependent variable. All regressions control for individual characteristics at baseline (age, education, sex, nationality, location fixed effects and industry fixed effects).

Sources: Labor Market Mirror and Employee Histories of the Institute for Employment Research in Nuremberg (BeH), 2011-2016.

Table 3: Reallocation to Higher Paying Firms: Individual Approach
(Difference-in-Difference Estimates)

	(1)	(2)	(3)	(4)
	Main Effects (2014 vs 2016)		Placebo Effects (2012 vs 2014)	
Wage bin in *t-2*	[4.5,8.5)	[8.5,12.5)	[4.5,8.5)	[8.5,12.5)
Panel (a): Daily Wages				
Estimated effect	0.107	0.036	0.015	0.006
	(0.0010)	(0.0005)	(0.0009)	(0.0005)
Panel (b): Firm's Average Daily Wage				
Estimated effect	0.025	0.008	0.004	0.001
	(0.0007)	(0.0004)	(0.0007)	(0.0003)
Fraction attributable to reallocation	**23.4%**			
Panel (c): Hourly Wages				
Estimated effect	0.061	0.016	0.010	0.003
	(0.0006)	(0.0003)	(0.0006)	(0.0003)
Panel (d): Firm's Wage Premium				
Estimated effect:	0.005	0.001	0.001	0.000
	(0.0003)	(0.0002)	(0.0003)	(0.0002)
Fraction attributable to reallocation	**8.2%**			
Panel (e): Firm's Fixed Effect				
Estimated effect	0.004	0.001	0.000	0.000
	(0.0003)	(0.0001)	(0.0003)	(0.0001)
Fraction attributable to reallocation	**6.6%**			

Notes: The table investigates the effect of the minimum wage on the reallocation of low-wage workers to firms that pay higher wages. Firm quality is measured before the minimum wage came into effect, and only changes for workers who switch firms. In panel (b), we use the change in the firm's average daily wage as the dependent variable. In panel (d), firm quality is measured as the firm's wage premium conditional on worker demographics and employment status, calculated as the residual from an individual daily wage regression that controls for workers' full-time and part-time status in addition to worker age, skill and foreign status and is aggregated to the firm level. In panel (e), the dependent variable is the firm's fixed effect, obtained from an individual daily wage regression for full-time workers that controls for worker age and worker, firm and year fixed effects and is estimated for over a 7-year period prior to the baseline year. The table reports difference-in-difference estimates for the 2014 vs 2016 post-policy period (columns (1) and (2)) and the 2012 vs 2014 "placebo" pre-policy period (columns (3) and (4)). These estimates compare the excess improvement in firm quality (relative to the 2011 vs 2013 pre-policy period) of workers who earn less than ([4.5, 8.5)), or close to ([8.5, 12.50) the minimum wage at baseline with the excess improvement in firm quality of workers who earn more than 12.50 Euro at baseline, as in columns (4) and (5) in Table 2. For comparison, we also report estimates using the change in the individual daily wage (panel (b) of Table 2) and the change in individual hourly wage (panel (a) of Table 2) as dependent variables. The table further reports the fraction of the overall improvement in daily or hourly wages that can be attributed to the reallocation of workers to better firms in bold. All regressions control for individual characteristics at baseline (age, education, sex, nationality, location fixed effects and industry fixed effects).

Sources: Labor Market Mirror and Employee Histories of the Institute for Employment Research in Nuremberg (BEH), 2011-2016.

Table 4: Reallocation to Firms of Higher Quality
(Difference-in-Difference Estimates)

	(1)	(2)	(3)	(4)
	Main Effects (2014 vs 2016)		Placebo Effects (2012 vs 2014)	
Wage bin in t-2	[4.5,8.5)	[8.5,12.5)	[4.5,8.5)	[8.5,12.5)
Panel (a): Firm's High Skilled Employment Share				
Estimated effect	0.003	0.001	0.001	0.000
	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Panel (b): Firm's Full-time Employment Share				
Estimated effect	0.010	0.003	0.002	0.001
	(0.0003)	(0.0002)	(0.0003)	(0.0002)
Panel (c): Firm's Marginal Employment Share				
Estimated effect	-0.008	-0.003	-0.001	-0.001
	(0.0003)	(0.0001)	(0.0002)	(0.0001)
Panel (d): Firm Size				
Estimated effect	0.043	0.015	0.012	0.004
	(0.0021)	(0.0013)	(0.0019)	(0.0013)
Panel (e): Firm's Churning Rate				
Estimated effect	-0.009	-0.003	0.001	0.002
	(0.0005)	(0.0003)	(0.0004)	(0.0003)
Panel (f): Firm's Poaching Index				
Estimated effect	0.005	0.003	0.001	0.000
	(0.0003)	(0.0002)	(0.0002)	(0.0002)

Notes: The table investigates the effect of the minimum wage on the reallocation of low-wage workers to firms of higher quality. Firm quality is measured before the minimum wage came into effect, and only changes for workers who switch firms. In panels (a) to (c), we use changes in the share of high-skilled workers (i.e., workers with a university education), full-time workers, and marginally employed workers as dependent variables. In panel (d), firm quality is measured as firm size (i.e., (log) number of employees in full-time equivalents). In panel (e), the dependent variable is the change in firm's churning rate, measured as the sum of workers who leave and join the firm, divided by the number of employees at baseline. The dependent variable in panel (f) is the change in the firm's poaching index, computed as share of new hires that come from employment rather than unemployment. The table reports difference-in-difference estimates for the 2014 vs 2016 post-policy period (columns (1) and (2)) and the 2012 vs 2014 "placebo" pre-policy period (columns (3) and (4)). These estimates compare the excess improvement in firm quality (relative to the 2011 vs 2013 pre-policy period) of workers who earn less than ([4.5, 8.5)), or close to ([8.5, 12.50) the minimum wage at baseline with the excess improvement in firm quality of workers who earn more than 12.50 Euro at baseline, as in columns (4) and (5) in Table 2. All regressions control for individual characteristics at baseline (age, education, sex, nationality, location fixed effects and industry fixed effects).

Sources: Labor Market Mirror and Employee Histories of the Institute for Employment Research in Nuremberg (BEH), 2011-2016.

Table 5: Reallocation to Higher Paying Regions and Industries?
(Difference-in-Difference Estimates)

	(1)	(2)	(3)	(4)
	Main Effects (2014 vs 2016)		Placebo Effects (2012 vs	
Wage bin in *t-2*	[4.5,8.5)	[8.5,12.5)	[4.5,8.5)	[8.5,12.5)
Panel (a): Average Daily Wage in the Region				
Estimated effect	-0.0002	-0.0001	-0.0001	0.0000
	(0.00005)	(0.00003)	(0.00005)	(0.00003)
Panel (b): Average Daily Wage in the Industry (3-digit)				
Estimated effect	0.0078	0.0003	0.0011	-0.0014
	(0.0004)	(0.0002)	(0.0003)	(0.0002)
Panel (c): Probability of Switching Firms				
Estimated effect	0.0019	0.0088	-0.0013	0.0020
	(0.0006)	(0.0005)	(0.0006)	(0.0005)
Panel (d): Probability of Switching to a Firm that Born after (t-2)				
Estimated effect	-0.0011	-0.0012	-0.0009	-0.0007
	(0.0003)	(0.0002)	(0.0003)	(0.0002)

Notes: The table investigates three potential channels through which the minimum wage-induced reallocation of low-wage workers to firms of higher quality may occur. In panel (a), we investigate whether low-wage workers reallocate to regions that pay higher wages following the introduction of the minimum wage. The dependent variable here is the change in the (log) average daily wage in the region, measured prior to the introduction of the minimum wage. In panel (b), we use the change in the (log) daily wage in the (3-digit) industry as the dependent variable to examine whether low-wage workers move to higher paying industries in response to the minimum wage. In panel (c), we investigate whether the minimum wage increased the probability that low-wage workers leave their baseline firm; the dependent variable here is equal to 1 if the worker is employed in the same firm in period t as in period t-2, and 0 otherwise. In panel (d) we scrutinize whether the probability of moving to a newly born firm is affected by the minimum wage. The table reports difference-in-difference estimates for the 2014 vs 2016 post-policy period (columns (1) and (2)) and the 2012 vs 2014 "placebo" pre-policy period (columns (3) and (4)). These estimates compare the excess improvement in firm quality (relative to the 2011 vs 2013 pre-policy period) of workers who earn less than ([4.5, 8.5)), or close to ([8.5, 12.50) the minimum wage at baseline with the excess improvement in firm quality of workers who earn more than 12.50 Euro at baseline, as in columns (4) and (5) in Table 2. All regressions control for individual characteristics at baseline (age, education, sex, nationality, location fixed effects and industry fixed effects).

Sources: Labor Market Mirror and Employee Histories of the Institute for Employment Research in Nuremberg (BEH), 2011-2016.

Table 6: Wage, Employment and Reallocation Effects of the Minimum Wage: Robustness Checks

(Difference-in-Difference Estimates)

	(1)	(2)	(3)	(4)	(5)	(6)
Wage bin in t-2	[4.5,8.5)	[4.5,8.5)	[4.5,8.5)	[4.5,8.5)	[4.5,8.5)	[4.5,8.5)
Panel (a): Hourly Wages						
2014 vs 2016	0.058	0.060	0.061	0.060	0.061	0.058
	(0.0006)	(0.0006)	(0.0006)	(0.0006)	(0.0006)	(0.0006)
2012 vs 2014 (Placebo)	0.009	0.010	0.010	0.010	0.010	0.009
	(0.0006)	(0.0006)	(0.0006)	(0.0006)	(0.0006)	(0.0006)
Panel (b): Employment (1 if Employed)						
2014 vs 2016	0.004	0.008	0.007	0.009	0.007	0.007
	(0.0005)	(0.0004)	(0.0004)	(0.0004)	(0.0004)	(0.0004)
2012 vs 2014 (Placebo)	0.001	0.002	0.002	0.002	0.002	0.002
	(0.0005)	(0.0004)	(0.0004)	(0.0004)	(0.0004)	(0.0004)
Panel (c): Firm's Average Daily Wage						
2014 vs 2016	0.022	0.023	0.025	0.022	0.025	0.022
	(0.0008)	(0.0007)	(0.0007)	(0.0007)	(0.0007)	(0.0007)
2012 vs 2014 (Placebo)	0.003	0.003	0.004	0.003	0.004	0.003
	(0.0007)	(0.0007)	(0.0007)	(0.0007)	(0.0007)	(0.0007)
Panel (d): Firm's Size						
2014 vs 2016	0.054	0.056	0.043	0.055	0.043	0.039
	(0.0021)	(0.0021)	(0.0021)	(0.0021)	(0.0021)	(0.0021)
2012 vs 2014 (Placebo)	0.016	0.017	0.011	0.017	0.012	0.010
	(0.0019)	(0.0019)	(0.0019)	(0.0019)	(0.0019)	(0.0019)
Panel (d): Firm's Poaching Index						
2014 vs 2016	0.005	0.005	0.005	0.005	0.005	0.005
	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)
2012 vs 2014 (Placebo)	0.001	0.000	0.001	0.001	0.001	0.001
	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)
Demographic Controls	no	yes	yes	yes	yes	yes
Industry FEs	no	no	yes	no	yes	yes
Location FEs	no	no	no	yes	yes	yes
District UR X wage bin	no	no	no	no	no	yes

Notes: The table shows the robustness of our key results with respect to the inclusion of additional control variables. The table shows, for workers earning less than the minimum wage, hourly wage growth (panel (a)), the probability of remaining employed (panel (b)), the change in the firm's (log) average daily wage (panel (c)), the change in firm size (panel (d)), and the change in poaching index (panel (d)) relative to the 2011 vs 2013 period, as in column (4) of Table 2. In column (1), we do not include any baseline controls. In column (2), we add demographic controls (education, age and foreign status). In column (3), we include industry affiliation in addition to demographic controls in the regression. In column (4), we control for location instead of industry affiliation. In column (5), we control for both demographic characteristics, industry affiliation and location as in our baseline specification. In column (6), we further add the regional unemployment rate interacted with wage bins as a control, to account for potential business cycle effects that differentially affect workers at different parts of the wage distribution.

Sources: Labor Market Mirror and Employee Histories of the Institute for Employment Research in Nuremberg (BEH), 2011-2016.

Table 7: Wage, Employment and Reallocation Effects of the Minimum Wage: Regional Approach

	No controls for differential pre-trends	Controls for differential pre-trends		
	(1)	(2)	(3)	(4)
Panel (a): Proxied Hourly Wages				
$\overline{GAP_r} \times Post_t$	0.795	0.685	0.754	0.798
	(0.0402)	(0.0527)	(0.0500)	(0.0861)
Panel (b): Employment (Number of Workers)				
$\overline{GAP_r} \times Post_t$	-1.513	0.0176	0.131	0.375
	(0.127)	(0.0594)	(0.0910)	(0.153)
Reallocation Effects: Improvement in Firm Quality in the Region				
Panel (c): Number of firms				
$\overline{GAP_r} \times Post_t$	-1.458	-0.188	-0.216	-0.243
	(0.107)	(0.0384)	(0.0631)	(0.104)
Panel (d): Number Micro Firms (1-2 workers)				
$\overline{GAP_r} \times Post_t$	-1.479	-0.271	-0.318	-0.350
	(0.0976)	(0.0901)	(0.101)	(0.163)
Panel (e): Average firm size				
$\overline{GAP_r} \times Post_t$	-0.0428	0.154	0.22	0.307
	(0.0607)	(0.0563)	(0.0719)	(0.105)
Panel (f): Average Firm FEs				
$\overline{GAP_r} \times Post_t$	0.414	0.125	0.208	0.282
	(0.0297)	(0.0304)	(0.0307)	(0.0483)
Location fixed effects	yes	yes	yes	yes
Year fixed effects	yes	yes	yes	yes
Local baseline characteristics interacted with linear time trend	no	no	yes	no
Location specific linear time trends	no	yes	no	no
eline characteristics interacted with year fixed effects	no	no	no	yes

Notes: In column (1) of the table, we report difference-in-difference estimates for the impact of the region's exposure to the minimum wage, measured as the average gap measure for the 2011 to 2014 pre-policy years as (equation (3)), on the (log) mean proxied hourly wage in the region (panel (a)); (log) employment in the region (number of workers, panel (b)); the number of firms in the region (panel (c));the number of micro firms with 1 or 2 employees in the region (panel (d)); average firm size in the region (panel (e)); the average firm fixed effect in the region (obtained from an AKM style regression estimated over the pre-policy period, panel (f)). Estimates are based on regression equation (4) and do not include controls for possibly divergent pre-trends in regions heavily and barely affected by the minimum wage. In columns (2) to (4), we account for such differential pre-trends by including, as in regression equation (5), a region-specific linear time trend (column (2)); by including baseline regional characteristics interacted with a linear time trend (column (3)); or by including baseline regional characteristics interacted with fully flexible year fixed effects (column (4)). Regressions are weighted by local employment averaged over the 2011 to 2013 pre-policy period. Standard errors are clustered at the regional level.

Sources: Labor Market Mirror and Employee Histories of the Institute for Employment Research in Nuremberg (BEH), 2011-2016, aggregated across regions (401 counties) and years.

Table 8: Effect of the Minimum Wage on Commuting Distance
(Difference-in-Difference Estimates)

	(1)	(2)	(3)	(4)
	Main Effects (2014 vs 2016)		Placebo Effects (2012 vs 2014)	
Wage bin in *t-2*	[4.5,8.5)	[8.5,12.5)	[4.5,8.5)	[8.5,12.5)
Panel (a): Driving Distance				
Estimated Effect	1.868	0.559	0.518	-0.050
	(0.0972)	(0.0811)	(0.0897)	(0.0790)
Panel (b): Driving Distance - Men vs Women				
Men	3.406	0.578	1.037	-0.106
	(0.1801)	(0.1336)	(0.1632)	(0.1292)
Women	0.866	0.414	0.094	-0.085
	(0.1136)	(0.0977)	(0.1056)	(0.0953)

Notes: In panel (a) of the table, we investigate whether the reallocation of low-wage workers to better firms in response to the minimum wage comes at the expense of increased commuting distance. The dependent variable is the change in the driving distance in kilometres between the centre of the municipality of residence and the municipality of work. In panel (b), we examine whether the change in commuting distance differs for men or women. The table reports difference-in-difference estimates for the 2014 vs 2016 post-policy period (columns (1) and (2)) and the 2012 vs 2014 "placebo" pre-policy period (columns (3) and (4)). These estimates compare the change in driving distance (relative to the 2011 vs 2013 pre-policy period) for workers who earn less than ([4.5, 8.5)), or close to ([8.5, 12.50) the minimum wage at baseline with the change in driving distance for workers who earn more than 12.50 Euro at baseline, as in columns (4) and (5) in Table 2. All regressions control for individual characteristics at baseline (age, education, sex, nationality, location fixed effects and industry fixed effects).

Sources: Labor Market Mirror and Employee Histories of the Institute for Employment Research in Nuremberg (BEH), 2011-2016.

Data Appendix

A1: Correction of raw working hours in the Employee Histories (BEH)

A drawback when working with German administrative labor market data is that the social security notification system does not regularly ask employers for detailed information on hours worked. In this paper, we overcome this limitation by using information on hours worked from the German Statutory Accident Insurance. Employers typically directly report total hours worked to the German Statutory Accident Insurance. For the years 2011 to 2014, however, employer notifications took place through the social security notification system, allowing us to link information on individual working hours to information on earnings and employment histories in the BEH for this period.

Employers had to report total hours worked for each employee separately for every notification period of the job. Four different reporting variants were allowed: i) actual hours worked, ii) contractual hours worked, iii) hours according to a collective bargaining agreement or the annual fixed full-time reference value calculated by the German Statutory Accident Insurance (or fractions thereof for part-time and marginal jobs) and iv) an educated guess. The reported data do not allow us to directly distinguish between those four cases. We develop a simple heuristic to make reported hours comparable across employers. Our final measure for working hours correspond to contractual working hours plus overtime, the measure used by the government to compute hourly wages to insure compliance with the minimum wage law.

In a first step, we adjust reported (contractual or actual) working hours such that they refer to hours per week, as the length of the notification periods varies.[1] In a second step, we separate notifications into two groups: those that most likely include days of annual and sick leave (i.e., contractual hours) and those that most likely do not (i.e., actual hours). We do this in three steps. We first assume that full-time notifications of less than 35 hours per week constitute actual working hours, and full-time notifications of more than 35 hours per week contractual working hours. We further assume that an establishment uses the same notification variant for its employees. We classify establishments where at least 90% of its full-time workers are reported to work less than 35 hours per week as establishments reporting actual working hours. Similarly, establishments where at least 90% of its full-time workers are reported to work more than 35 hours per week are classified as reporting contractual hours. In a third step, we apply an adjustment factor of 1.19 to all full-time workers in establishments classified as reporting actual working hours, to convert actual working hours into contractual working hours.

[1] We divide total working hours reported for the job spell by the length (number of days) of the job spell, and multiply by (365*5/250). This way, we take into account that there are roughly 250 potential working days per year according to the IAB Working Time Measurement Concept (http://doku.iab.de/arbeitsmarktdaten/AZ_Komponenten.xlsx). For more information about the IAB Working Time Measurement Concept, see Wanger et al., 2016.

The adjustment factor of 1.19 is motivated as follows. The number of effective working days is considerably lower than the number of potential working days per year, due to paid days of annual and sick leave. In the period under study, the average number of effective working days was roughly 210, implying an adjustment factor of 1.19 (250/210).[2] We use a reduced adjustment factor to all part-time and marginal employed workers in establishments classified as reporting actual working hours, to account for the fact that part-time and marginally employed workers are entitled to fewer days of annual and sick leave.[3]

There is a small number of establishments that we are not able to classify as reporting either actual or contractual working hours. This can happen in three cases: if the firm does not employ any full-time worker; if the establishment employs more than 10%, but less than 90%, of full-time workers who are reported to work more than 35 hours per week; or if the establishment employs more than 10%, but less than 90%, of workers who are reported to work less than 35 hours per week. For each specific value of reported working hours, we compute the likelihood that the employer reported actual or contractual working hours, based on the sample of establishments that we classify as reporting actual or contractual working hours. We then randomly classify observations as reporting actual versus contractual working hours according to the estimated relative likelihood.

In a final step, we account for the fact that overtime might not be adequately captured in reported working hours. This is certainly the case for establishments that report contractual working hours (option ii), as well as for establishments that report hours according to the collective bargaining agreement or the annual fixed full-time reference value (option (iii)). Since we are likely to classify many of the two latter establishments as reporting actual hours according to our heuristic, we adjust all notifications for overtime, including those classified as reporting actual working hours.[4]

In Table A1.1, we report average unadjusted and adjusted working hours for the years 2011 and 2014. For full-time workers, average unadjusted hours amount to only 34.8 per week and increase to 39.8 per week after adjustment. The difference between unadjusted and adjusted working hours is smaller for part-time and marginally employed workers, as expected.

In columns (1) and (2) of Table A1.2, we contrast adjusted weekly working hours in the BEH with official statistics reported in the Structure of Earnings Survey (Verdienststrukturerhebung) of the German Statistical Office (SES, Statistisches Bundesamt, 2016), arguably the most reliable data source on the distribution of hourly wages in Germany. Average adjusted working hours in the BEH match official average working hours closely within each employment category. In columns (1) and (3) of Table A1.2, we contrast adjusted weekly working hours in the BEH with self-reported measures by

[2] See the IAB Working Time Measurement Concept.

[3] According to the GSOEP, weekly working days of part-time workers and marginally employed workers are on average 88% of the weekly working days typical for full-time workers. We therefore reduce the adjustment factors to 1.167 for part-time workers and 1.125 for marginally employed workers.

[4] The adjustment factors are computed based on the German SOEP data set, which asks respondents about both paid and unpaid monthly overtime hours. We increase weekly hours of full-time, part-time and marginally employed workers in 2014 by 1.24, 0.56 hours and 0.19 hours, respectively. The adjustment factors in 2011 to 2013 vary slightly.

individuals in the German Socio-Economic Panel. Once again, average adjusted working hours in the BEH match self-reported average working hours in the GSOEP quite closely. The largest discrepancy arises for marginally employed workers, possibly due to differences in the definition of marginal employment in the data sets. We conclude that our imputation procedure does a reasonable job in aligning average working hours in the original data to reported weekly hours in other data sets.

A2: Correction of the full-time/part-time variable in the BEH

In 2011, a new occupational code was introduced in the BEH. This switch lead to a significant increase in the number of missing observations in the variable that allows us to distinguish between full-time and part-time (including marginal) employment in that year. We follow the procedure suggested by Ludsteck and Thomsen (2016) to impute missing observations. We perform an additional plausibility check for those individuals who remain employed in the same firm and occupation, but switch full- or part-time status between 2011 and 2012. In case this switch is not accompanied by a plausible change in daily wages (a reduction of at least 15% for full- to part-time switchers and an increase of at least 10% for part- to full-time switchers), we assume that the 2012 information is correct and adjust the imputed full-time/part-time notification for 2011 accordingly.

References

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- Ludsteck, Johannes; Thomsen, Ulrich (2016): "Imputation of the Working Time Information for the Employment Register Data". *FDZ Methodenreport* 01/2016 (en), Nürnberg.

Table A1.1: Unadjusted and Adjusted Working Hours in the BEH

	2011		2014	
	unadjusted	adjusted	unadjusted	adjusted
All	26.7	30.3	26.5	30.1
Full-time	34.8	39.8	34.8	39.7
Part-time	22	24.9	21.8	24.6
Marginally employed	8.4	9.2	8.3	9.1

Note: The table reports unadjusted and adjusted (for days of annual, sick leave and overtime) average working hours in the BEH for the years 2011 and 2014, separately for full-time workers, part-time workers, and marginally employed workers.

Table A1.2: Average Weekly Hours the BEH (after adjustment), in the Structure of Earnings Survey (SES) and the German Socioeconomic Panel (GSOEP) in 2014

		(1) BEH, adjusted	(2) SES	(3) SOEP
Full-time				
	All	38.8	39.1	39.2
	Men	38.9	39.1	39.4
	Women	38.5	39	38.4
Part-time				
	All	24.3	23.9	23.6
	Men	25.2	23.8	24.5
	Women	24	23.9	23.5
Marginally employed				
	All	8.7	8.2	11.6
	Men	8.6	8	14.1
	Women	8.7	8.2	10.7

Note: The table compares average working hours per week in 2014 according to the Structure of Earnings Survey (SES) from the German Statistical Office and the German Socio-Economic Panel (SOEP) with those in the BEH after adjustment. To make the sample in the BEH as similar as possible to that in the official statistics, apprentices and workers in partial retirement are dropped. Activities of households and extra-territorial organisations (T, U according to NACE Rev.2) are excluded. Working hours in the BEH have been adjusted to account for days of annual and sick leave, but exclude overtime adjustment. To reduce the effect of outliers, full-time employment excludes hours below 30, part-time employment excludes hours above 40. and marginal employment excludes hours below 2 and above 20. For the GSOEP, contractual hours are used.