

Rattenhuber, Pia

**Conference Paper**

## Building the Minimum Wage in Germany - Germany's First Sectoral Minimum Wage and its Impact on Wages in the Construction Industry

Beiträge zur Jahrestagung des Vereins für Socialpolitik 2010: Ökonomie der Familie - Session: Labor Market Policies, No. G11-V1

**Provided in Cooperation with:**

Verein für Socialpolitik / German Economic Association

*Suggested Citation:* Rattenhuber, Pia (2010) : Building the Minimum Wage in Germany - Germany's First Sectoral Minimum Wage and its Impact on Wages in the Construction Industry, Beiträge zur Jahrestagung des Vereins für Socialpolitik 2010: Ökonomie der Familie - Session: Labor Market Policies, No. G11-V1, Verein für Socialpolitik, Frankfurt a. M.

This Version is available at:

<https://hdl.handle.net/10419/37370>

**Standard-Nutzungsbedingungen:**

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

**Terms of use:**

*Documents in EconStor may be saved and copied for your personal and scholarly purposes.*

*You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.*

*If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.*

# Building the Minimum Wage in Germany

## Germany's First Sectoral Minimum Wage and its Impact on Wages in the Construction Industry

Pia Rattenhuber\*

This draft version: August 27, 2010

**Preliminary version – please do not quote!**

### Abstract

This study analyzes the impact of the introduction of the first sectoral minimum wage in 1997 in the German construction sector on hourly wages and their distribution. The minimum wage was introduced only in certain sub-sectors of the industry and just blue-collar workers were eligible. In the setting of a natural experiment neighboring 4-digit-industries and white-collar workers are used as control groups for differences-in-differences-in-differences estimation based on two cross sections of a linked employer-employee data set (*GLS*) that covers establishments with 10 or more employees. Descriptive evidence and estimation results show that the minimum wage did not bite in West Germany but that there was a considerable impact in East Germany. On average eligible workers experienced an wage increase of 6.6%. Unconditional quantile regressions show that particularly the lower ranks of non-unionized blue-collar workers benefitted while the minimum wage also exerted an upward pressure on collectively bargained wages in both parts of the country.

**KEYWORDS:** Minimum wage, construction sector, linked employer-employee data, differences-in-differences-in-differences, unconditional quantile regression.

JEL classification: C21, J18, J38.

\* German Institute for Economic Research Berlin (DIW), Mohrenstr. 58, D-10785 Berlin,  
Tel.: +49 30 98789 251, Fax: +49 89789 114, E-mail: prattenhuber@diw.de

# 1 Introduction

Minimum wages (MWs) have been for a long time and continue to be brought up as a panacea in discussions about labor market policy, equality and fairness. MWs are implemented in developed and underdeveloped countries alike. The institutional designs range from a nation-wide MW to region and sector-specific rates. Some countries rely on different levels of pay for younger and older or more and less educated employees. Such great variety of institutional details reveals the manifold opinions and beliefs in governments across the world about the effects of the MW. Germany introduced its first sector-specific MW only in 1997. The fundamental disagreement in the political arena between proponents and opponents of the MW with regard to its impact on employment, poverty and the wage distribution to name just a few has time and again flared up since then.

Although MWs remain one of the most studied fields in economics the evidence does not argue conclusively in favor of one of the two sides of the political debate. Theory has derived antagonistic results with regard employment effects depending on assumptions and empirical evidence is not unambiguous either about effects on employment and wages (see i.e. Card and Krueger (1998), Stewart (2004), Addison et al. (2009), Dolado et al. (1996) and Neumark and Wascher (2007)). A number of studies uses the introduction of the National MW in 1999 in the UK to analyze the impact on wage growth and the wage distribution; Machin et al. find that a significant rise in wages took place (Machin and Wilson, 2004) and that the lower end of the wage distribution was compressed (Machin et al., 2003). Others also detect an effect on the lower end of the distribution and find nearly no spill-over effects in the upper parts of the wage distribution (Dickens and Manning, 2004a,b; Metcalf, 2004).

In 1997 the German government implemented for the very first time a MW; it covered blue-collar workers (*gewerbliche Arbeitnehmer*) in substantial parts of the main construction trade with different rates in East and West Germany. Since then sector-specific binding lower floors for wages have been installed in several other sectors such as cleaning and postal services while more sectors shall follow. There is unison that the MW in the construction sector constituted a breach in the till then dominating reservation against MWs in the political establishment. Despite its seminal importance it has been little evaluated. This can be blamed mainly on the lack of suitable data. König and Möller (2007) studied the impacts on employment and wage growth in the familiar “difference-in-differences” (DD) framework with data from the Federal Employment Office. They found a positive effect of the MW on wage growth and a negative

(slightly positive) effect on employment for East (West) Germany. Particularly the results for West Germany were hotly debated amongst economists and in the media (Storbeck, 2007; Kluge and Schmidt, 2007; Meier and Munz, 2008) in view of data restrictions and choice of control group.

The aim of this study is to shed light on the following issues: Did the MW truly bite? Did entitled workers see greater wage growth due to the MW introduction? Did the MW have any impact on wages of unionized blue-collar workers? Was there a heterogeneous effect of the MW along the wage distribution?

Owing to the initial introduction of the MW only in certain sub-sectors these questions can be evaluated in the setting of a natural experiment. One of the few data sources in Germany that allow for calculation of hourly wages while offering enough observations with industry information on the 4-digit level is the *Gehalts- und Lohnstrukturerhebung* (Wage and Salary Survey). Based on two cross sections of this linked employer-employee data set we can properly distinguish between employees that were eligible to the MW and those that were not. Due to the data structure two groups of employees in the construction sector lend themselves naturally as control groups; blue-collar workers in establishments that make part of the construction sector but are not eligible and white-collar workers in the industry. In the scope of a "differences-in-differences-in-differences" (DDD) estimation strategy these two groups are used as a means to back out the treatment effect of the MW on gross hourly wages. Moreover the impact heterogeneity along the wage distribution is analyzed in the scope of unconditional quantile regression as proposed by Firpo et al. (2009).

The remainder of the paper is structured as follows. Section 2 summarizes the state of the German construction sector at the introduction of the MW and its institutional design. In section 3 details on the data source are presented, sample selection and group assignment discussed and descriptive statistics provided. Section 4 illustrates the estimation strategies whose results are presented in Section 5. Finally, section 6 concludes.

## **2 The German Construction Sector and the MW**

Up till the 1990s the German construction sector was compared to other countries highly unionized and had developed a corporatist system that ensured a comparatively high and stable pay for German workers (Eichhorst, 2005). In the following years the German construction sector was stricken by the aftermath of the reunification boom and the dawn of the European

unification. Earlier the number of posted workers from non-European countries had exceeded those from European countries. But the free movement of labor associated with the Single European Market had brought ever more posted workers from EU countries. Although the number of posted workers from non-EU countries that came to Germany based on bilateral contracts had continually decreased throughout those years labor market tightness continued to increase. With the abolishment of seasonal employment in 1993 policy makers had de facto exhausted the tool kit of then available protectionist policies.

Several other European countries faced a similar dilemma and the European Commission presented a first draft for a directive on posted workers in June 1991. German legislation pre-empted the lengthy EU-level negotiations and passed its own bill. Later on only slight modifications of the German Posted Workers Act (*Arbeitnehmer-Entsendegesetz*) were needed to comply with the final EU directive in 1996. For the Posted Workers Act to become effective the rate of the MW had to be determined in the scope of a collective agreement (CA) and declared generally binding via the extension rule (*Allgemeinverbindlichkeitsklärung*).

The CA on the MW is bargained by the organization(s) of the employers and the unions within the general negotiations between the social partners on contracts for their members. It refers to the establishment level as opposed to the judicial entity of the firm. The extension rule declares the CA compulsory for all employers and blue-collar employees in the sector regardless of whether they are member of the collective bargaining parties or not. For the extension rule to be applicable the CA has to fulfill two requirements; for one it has to be passed in accordance with the law that regulates the collective wage bargaining process (*Tarifvertragsgesetz*). Moreover organized establishments have to employ at least 50% of the concerned employees and the extension rule is of "substantial public interest". In the scope of the collective agreements exemption clauses are agreed upon that allow deviating alas lower wages and higher working hours if the employer faces hard times.

The extension rule has to be passed by the committee of collective bargaining parties (*Tarifausschuss*) that is made up of employee and employer representatives in equal measure before the Ministry of Labor can apply the extension rule.<sup>1</sup> The process to declare the CA compulsory for all employees and employers in the sector of the wage bargain was altered later on. In order to eliminate the employers' right of veto in the committee of collective bargaining parties, the red-green coalition that had come to power in 1999, changed the Posted Workers

---

<sup>1</sup> This also marks the difference to a variety of other sectoral MWs discussed in Germany lately. Most of those rely on the law for minimum working standards and are not negotiated by the social partners directly.

Act; since then the CA on MWs can be declared generally compulsory by statutory regulation through the Minister of Labor.

The Posted Workers Act finally extends the scope of the now binding MW on a national level with regard to foreign firms posting workers to Germany. The Posted Workers Law thus allows to set minimum standards for foreign employees posted to Germany if in conjoint with the commensurate extension rule on the industry level. Along the way it opened the loophole for setting a binding MW for all German employees in the sector.

In the construction industry there exist several unions across sub-sectors. Great parts of the main construction trade are represented by two employers' organization (*Zentralverband Deutsches Baugewerbe* and *Hauptverband der deutschen Bauindustrie*) and one union (*Industriegewerkschaft Bauen-Agrar-Umwelt*). Sub-sectors such as electric installation, roofing, and painting have traditionally their own structures and thus negotiated their own CAs. Despite efforts to quickly bring negotiated wages in East Germany up to the West German wages up until today most wage bargains include a geographic differentiation of rates.<sup>2</sup> Sub-sectors other than the main construction trade thus had their own schedule in terms of timing and level for the introduction of a MW. Electric installation, roofing, painting, and wreckage in construction introduced sooner or later their own MWs. Therefore a sizable part of employees in the construction sector became eligible later and/or at a different rate than the majority of 4-digit-level sectors in the main construction trade. The MW for most of the main construction trade was passed in 1997. It came into effect with a delay of approximately 12 months owing to the ongoing disaccord on the employers' side. As a compromise with regard to employers' opposition to its introduction, the MW was to be reduced after its first phase.

The MW is an hourly and establishment based concept that is differentiated with regard to its validity in terms of sectors covered and employees covered. The covered sectors include the greater part of establishments in the main construction trade. On the employee level only blue-collar workers above 18 and not on vocational training are eligible, regardless of their tasks and level of education. A few professions are explicitly excluded (i.e. kitchen aids, security guards, delivery and cleaning personnel). With the introduction of the MW a new wage group was created in the skill group structure of the CAs.<sup>3</sup> It was agreed that this group should earn between the till then lowest paid group of unskilled laborers in non-construction occupations and the lowest paid group of blue-collar workers fulfilling construction tasks. Setting the MW

---

<sup>2</sup>In some sectors wage differentiation on the federal state level was common.

<sup>3</sup>Since September 2003 an additional MW for workers with vocational training was implemented ("ML2").

lower than the smallest pay for a unionized worker doing construction jobs was supposed to account for the fact that wages not subject to CAs were substantially lower. Table 1 shows the path of the MW from its introduction in January 1997 up till August 2002. The nominal MW increased by 7.86% (12,77%) in East (West) Germany during this time.

Table 1: The Development of the Minimum Wage across Time (in €)

	East	West
January 1997 – August 1997	8.00	8.69
September 1997 – August 1999	7.74	8.18
September 1999 – August 2000	8.32	9.46
September 2000 – August 2001	8.49	9.65
September 2001 – August 2002	8.63	9.80

*Source:* Tarifsammlung Bauwirtschaft 1997/1998, 1998/1999, 1999/2000 and 2001/2002, Elsner Verlag.

## 3 Data

### 3.1 The Data (Gehalts- und Lohnstrukturerhebung (GLS)) and the Sample

This study is based on official micro data from the *Gehalts- und Lohnstrukturerhebung*<sup>4</sup> (Salary and Wage Survey) (see Hafner and Lenz (2007)) . It collects every few years a cross section of data from establishments (*Betrieb*)<sup>5</sup> with 10 or more employees. On the employee level the *GLS* assembles information on wages, hours worked, over time, (payroll) taxes, education, job description, difficulty of task, time with the employer amongst other things. On the establishment level the region, the industry code, number of employees, fraction of blue and white-collar workers, fraction of men and women, participation in CAs are provided i.a. The data does not contain any information on job quits. As the *GLS* makes part of the official micro data statistics establishments are liable to respond if sampled and non-response is low.

We use two cross sections of the data for October of the years 1995 and 2001 and restrict the sample to employees between 18 to 65 years old, not on vocational training or internships. The data allow for an accurate calculation of hourly wages since the gross wage can be broken down into normal labor income and labor income due to over-time, time worked on

<sup>4</sup>Since 2006 it is called *Verdienststrukturerhebung*.

<sup>5</sup>When referring to establishment the level of *Betrieb* is meant, as opposed to enterprise, company or firm referring to the concept of the *Unternehmen*.

weekends, bank holidays etc. Any extra pay is subtracted from the pay bill of October and hours according to contract are used to compute hourly wages since the variable on hours paid only exists for 70% of observations in the sample.<sup>6</sup> Hourly wages calculated to be lower (higher) than 3 (150) Euro were not considered in the analysis because they can be presumably attributed to measurement error. Collective, firm and establishment agreement were combined in the variable “Under (collective) agreement”. If not explicitly mentioned otherwise the term “collective agreement” (CA) will be used as a synonym for all three types of agreements in the following.

## 3.2 Treatment and Control Groups

The sectoral MW was passed on a national scale and differentiated with regard to East and West Germany. For that reason we cannot use geographical variation to construct treatment and control group as is commonly done in the literature. Yet we can exploit the fact that not all workers in the construction industry became eligible. Two subgroups within the industry lend themselves readily as control groups; other sub-sectors in construction and white-collar workers. As explained in more detail in section 4 these two control groups are used to back out the treatment effect that goes beyond general time, (sub)industry, and worker type effects.

Table 2: Treatment and Control Group along the lines of the 4-digit-industry classification, sectors that cannot be assigned in gray font

<b>Treated sectors</b>	<b>Industry code</b>
General constructions or parts thereof; civil engineering	4521
Construction highways, roads, airfields and sport facilities	4523
Construction of water projects	4524
Other construction work involving special trades	4525
<b>Control sectors</b>	
Plumbing	4533
Other building installation	4534
Floor and wall covering	4543
Painting and glazing	4544

*Notes:* Structure of the sectors and subsectors according to the *Klassifikation der Wirtschaftszweige*, Edition 1993.

*Source:* *Klassifikation der Wirtschaftszweige*, Edition 1993, available in English from [www.destatis.de](http://www.destatis.de).

<sup>6</sup>Hourly wage=[gross wage for October-remuneration for extra work-remuneration for shifts worked-remuneration for work on weekends/bank holidays-remuneration for night shifts]/(weekly work time according to contract\*4.3)



Table 2 outlines the choice of treatment and control group in terms of the 4-digit-industry classification. Establishments are assigned the 4-digit-code in which they generate the major part of value added. The observations chosen for treatment and control group were selected in view of maximum discriminatory power for treatment and non-treatment. Some sub-sectors of the construction industry can be considered suitable neither for the treatment nor for the control group. The excluded observations were overridden due to one of the following two reasons; (1) Industry classification on the 4-digit-level changed between 1995 and 2001 from SYPRO code to WZ93 in 2001. Conversion from one to the other is in some cases not unambiguously possible. (2) As explained in section 2 a few other sector-specific MWs were introduced from 1997 on. Sectors that passed their own MW rate in 1997 and sectors that introduced their own MW between 1997 and 2001 were excluded. For simplicity the finally chosen sectors are referred to as "treatment and control sectors" below.

Another source of differentiation within the construction industry is the distinction between blue and white-collar workers. MW legislation covers exclusively blue-collar workers in treatment sectors. As the data set is a linked employer-employee data set one observes wages for blue- and white-collar workers that are employed at exactly the same establishments. White-collar workers thus constitute another comparison group.

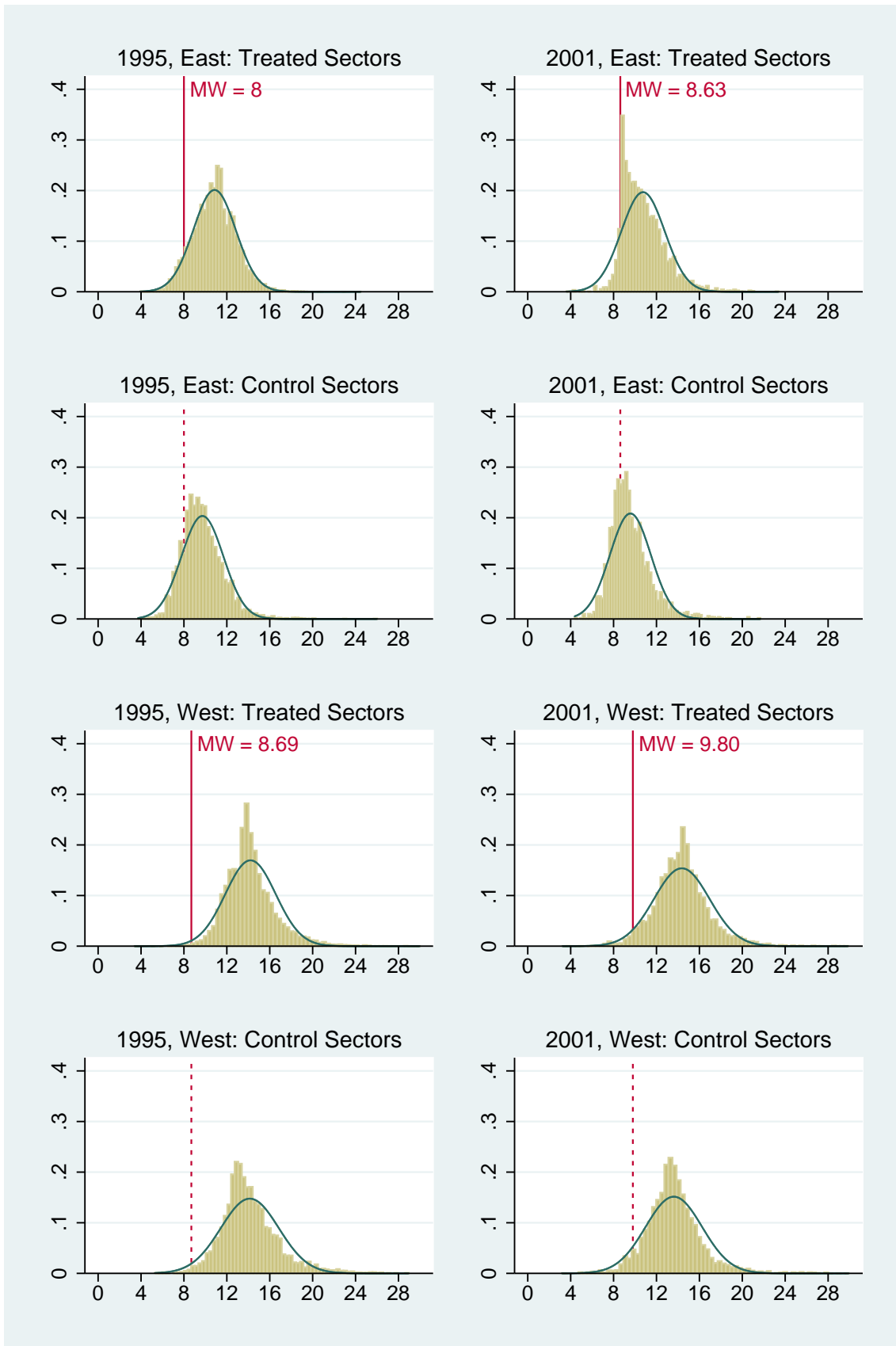
### 3.3 Descriptive Evidence

Figure 1 displays the distribution of gross hourly wages in East and West Germany before and after the introduction of the MW for blue-collar workers in establishments in the treated and the control sectors. For comparison gross hourly wages in 1995 were inflated to 2001 and the MW rate as of October 2001 was added as a reference in all subfigures. The plots reveal the typical heaping of wages around the MW for East Germany in 2001 but not so for West Germany. This suggests that in East Germany a relatively great number of eligible employees earned hourly wages below the planned MW prior to its introduction.

Table 3 confirms this; while in East Germany 10.65% of eligible workers have hourly wages below the MW, this only holds true for 0.44% in West Germany. The Kaitz index as the ratio of the nominal MW the median of hourly wages further supports that the MW bit a lot more in East Germany than in the West Germany. While the MW amounted to 81% of the median of gross hourly wages of all employees in East Germany, the Kaitz index for West Germany was calculated to be 63%. The ratio of the MW and the wages of all eligible observations amounts

to the same fraction in West Germany. In East Germany the Kaitz index based on the median of wages for all entitled blue-collar workers is a few percentage points less.

Figure 1: Distribution of Gross Hourly Wages in 1995 and 2001 for blue-collar workers in East and West Germany



Source: GLS 1995 and GLS 2001, own calculations. Gross hourly wages of October 1995 inflated to October 2001 using data from [www.destatis.de](http://www.destatis.de). Reference lines plot the respective minimum wage rate as of October 2001.

Yet who were those earning labor income below the MW in East Germany in 1995? Table 7 in the Appendix shows average values for all workers in both periods. Nearly all blue-collar workers in the treated establishments are male and work full-time (columns 2 and 3), union coverage is particularly high in West Germany. Not surprisingly Table 3 shows that it is on average the younger employees with less than half of the average tenure that are paid below the level of the MW to be introduced. The fraction contracted under a collective, firm, establishment agreement is also substantially lower. While barely 12% of those earning below the MW have union membership, more than half of the blue-collar workers are covered by a CA in the full sample. Those paid less than €8 also work predominantly in positions requiring less skills and training. On average they are employed in smaller establishments.

Table 3: Details on Eligible Employees with Gross Hourly Wages below the Initial Minimum Wage in 1997

	East	West
Kaitz index (median of wages in all sectors)	81%	63%
Kaitz index (median of wages for all eligible observations)	77%	63%
Eligible workers below the minimum wage		
... number of observations	877	61
... average establishment size	36	48
... as a fraction of all eligible workers	10.65%	0.44%
... percentage under (collective) agreement	12%	55%
... average age	34	30
... fraction low-skilled	55%	74%
... average tenure in months	23	25
Wage growth in case of full compliance		
... for eligible workers paid below the minimum wage only	10.96%	11.80%
... for all eligible workers	1.17%	0.05%

Source: Own calculations based on GLS 1995. Wage inflated to level of 1/1997 using data from [www.destatis.de](http://www.destatis.de).

Compliance with the nominal MW rate would have meant a wage growth of 10.96% on average for entitled workers below the MW in East Germany before the policy reform. Adjusting wages for those below the new threshold and keeping all other workers in the eligible group at their actual wage level reveals a hypothetical average increase of 1.17% for the overall group. In the Western part of the country such nominal adjustment would have entailed a 11.80% and respectively a 0.05% increase.

In view of the point of departure described above one can come up with different scenarios

about the impact of the MW introduction on wages. It seems obvious to expect some effect on wages for East Germany but less so for West Germany. Given that the greater part of observations below the MW is not working under a collective, firm or establishment agreement in East Germany this effect should be particularly pronounced for employees that do not rely on such contracts. A positive effect could either be due to a general upward shift of the whole wage distribution or due to a bigger effect on some (presumably the lower) part of the wage distribution.

Hypotheses with regard to the effect on unionized workers are ambiguous. A lot of studies show a significant union wage premium. In the institutional scheme unions are the main actor representing the unionized workers in the wage bargain. They are pivotal in setting the MW rate which nominally had mostly an effect on non-unionized workers at its introduction. If the initial MW was introduced as a lowest floor below the smallest union wage this could have exerted no influence at all on wages of unionized workers. But if unions have an interest in sustaining the union wage premium the MW introduction could result in positive effects also for unionized workers. Maintaining the wage differentials between different skills groups stable over time in the collective agreements would entail a general upward shift of the wage distribution of unionized workers. Alternatively more and more workers under collective agreement could get paid at the MW and the union wage rate immediately above. This would entail bunching up the distribution of union wages at its lower end.

## **4 Methodology**

### **4.1 Difference-in-Differences-in-Differences Estimation**

The aim of this study is to isolate the causal effect of the MW on gross hourly wages. The construction sector went through troubled times in the 90s. The industry contracted as a whole while anecdotal and descriptive evidence suggest further that some sub-industries and establishments were hit harder than others by the downturn. In order to not confound the effects of the policy with general time, industry and worker type effects the two control groups defined in section 3.2 are used to separate out the treatment effect. In the familiar DD framework the common trend assumption must not be violated. Given the unequal pressure on the labor market of construction industry's sub-sectors described above it is implausible to hold up the assumption that in the absence of the policy wages of blue-collar workers in the treated and

the control sectors would have experienced the same time trend. White-collar workers in the treated sectors make a poor control group as well; apart from the general concern about comparable time trends for blue- and white collar workers head masons and foremen belong to the group of white collar workers. Yet their tasks are obviously very closely related to those of their blue-collar colleagues eligible to the MW which casts doubt on their acceptability as a control group.

The DDD framework holds the advantage that its identifying assumption is considerably less restrictive. In this particular case it requires that in the absence of the policy the difference in time trends of wages for blue- and white-collar workers in the treated sectors would have been the same as the difference in time trends of wages of blue- and white-collar workers in the control sectors. The DDD framework thus allows for a differential overall trend in control and treatment sectors as much as for a differential time trend in blue- and white-collar workers' wages.

Let the DDD estimator be defined as:

$$\begin{aligned}
\log(wage_{gm}) = & \beta_0 + \beta_1 * blue_{gm} + \beta_2 * post_g + \beta_3 * sector_g \\
& + \beta_4 * (blue_{gm} * post_g) + \beta_5 * (blue_{gm} * sector_g) + \beta_6 * (post_g * sector_g) \\
& + \beta_7 * (blue_{gm} * post_g * sector_g) \\
& + \mathbf{e}'_g \boldsymbol{\mu} + \mathbf{p}'_{gm} \boldsymbol{\delta} + v_{gm}, \tag{1}
\end{aligned}$$

where establishments are indexed by  $g = 1, \dots, G$ . Blue- and white-collar employees 1 through  $M_g$  work for establishment  $g$ .  $\log(wage_{gm})$  is thus the log gross hourly wage for individual  $m$  working at establishment  $g$ .  $e_g$  is a  $K \times 1$  vector of establishment specific covariates and  $p_{gm}$  is a  $L \times 1$  vector capturing explanatory variables that vary within and across establishments, thus for each individual.  $blue_{gm}$  is a dummy variable equal to one if the observed individual is a blue-collar worker;  $post_g$  is a dummy equal to one if the individual is observed after the policy change;  $sector_g$  is the industry dummy and equal to one if the individual works for an establishment in the treated sector; the error term is denoted  $v_{gm}$ . The coefficients of the double interactions with  $post_g$  capture reform-independent differential time trends that affect all blue-collar workers or all workers in the construction industry covered by the reform. The double interactions with  $blue_{gm}$  control for time-invariant differences between blue-collar workers and other workers in the covered sector. The coefficient of the third-level interaction,  $\beta_7$ , is the DDD estimate of the impact of the MW reform. It captures the mean treatment effect

of the MW introduction on wages of eligible blue-collar workers in the treated sectors.

Issues with regard to the downward bias of standard errors in clustered data (particularly in view of the DD(D) framework) have been discussed by several authors, foremost by (Wooldridge, 2006; Bertrand et al., 2004; Donald and Lang, 2007; Cameron et al., 2008). With a large enough number of clusters,  $G \rightarrow \infty$ , the cluster-robust variance estimator adjusts for the bias entailed by the data structure:

$$\widehat{Avar}(\hat{\lambda}) = \left( \sum_{g=1}^G \mathbf{W}_g' \mathbf{W}_g \right)^{-1} \left( \sum_{g=1}^G \mathbf{W}_g' \widehat{v}_g \widehat{v}_g' \mathbf{W}_g \right) \left( \sum_{g=1}^G \mathbf{W}_g' \mathbf{W}_g \right)^{-1},$$

where  $\mathbf{W}_g$  is the  $M_g \times (1 + K + L)$  matrix of all regressors for establishment  $g$  and  $\widehat{v}_g$  is the  $M_g \times 1$  vector of pooled OLS residuals for  $g$ . This controls for both error heteroscedasticity across clusters and general correlation or heteroscedasticity (or both) within clusters.<sup>7</sup> Cluster robust standard errors estimated for specification 1 up to tripled conventional robust standard errors. This confirms the necessity to account properly for the underlying structure of the linked employer–employee data set. For brevity only clustered standard errors are displayed in the results section.

## 4.2 Unconditional Quantile Regression

The DD(D) methodology allows for identification of the mean treatment effect of a policy. In the public debate the MW was presented as a means to better support those employees receiving the worst pay. The target group of the policy are thus the lower ranks of the wage distribution. If this promise of policy makers had come true, we should be able to identify higher effects at the lower quantiles of the wage distribution and lower, possibly zero or even negative effects in the higher ranks of the wage distribution. In contrast to conventional OLS, quantile regression (QR) models as first introduced by Koenker and Bassett (1978) allow to capture such heterogeneous effects across the wage distribution.

Often covariates other than the industry dummy change along the wage distribution, e.g. observations in the lower tail of the wage distribution are typically less educated and younger. Conditional QR estimates describe how the wage is affected at a particular quantile given the explanatory variables. A drawback of the traditional quantile regression approach is its limited

---

<sup>7</sup>In Stata this is implemented via the approximation of the estimated error term by  $\sqrt{t} \widehat{v}_g$  where  $t = \sqrt{\left(\frac{G}{G-1}\right) \frac{N-1}{N-k}} \approx \frac{G}{G-1}$ .

scope for interpretation. Unlike conditional means in a least-squares regression do conditional QR estimates not average up to the unconditional mean. We can thus interpret conditional QR coefficients only as effects on the distribution conditional on observations sharing the same values of covariates. Recently Firpo et al. (2009) proposed a new method to estimate the impact of changes in the explanatory variables on the unconditional quantiles of the outcome variable which they termed the Recentered Influence Function (RIF) regression.

RIF regression basically consists of two steps; first the dependent variable is transformed via the RIF, second, a regression is run of the transformed dependent variable on the explanatory variables. For simplicity  $i = 1, \dots, N$  represents an index across individuals that uniquely identifies each observation in the full sample and across time in the following. Each element of  $i$  thus corresponds to one single combination out of the employer  $g$  and employee  $m$  identifier. Let the unconditional (marginal) distribution function of wages,  $Y$ , be  $F_Y(y) = \int F_{Y|X}(y|X = x) \cdot dF_X(x)$  such that the the density of  $Y$  evaluated at  $\tau$ th population quantile,  $q_\tau$ , is  $f_Y(q_\tau)$ .

The RIF is defined as the sum of the distributional statistic of interest and its influence function which measures the influence of an individual observation on the distributional statistic. In the case of quantiles the RIF is

$$RIF(y; q_\tau) = q_\tau + IF(y; q_\tau) = q_\tau + \frac{\tau - \mathbb{1}\{y \leq q_\tau\}}{f_Y(q_\tau)} = c_{1,\tau} \cdot \mathbb{1}\{y > q_\tau\} + c_{2,\tau},$$

where  $c_{1,\tau} = 1/f_Y(q_\tau)$  and  $c_{2,\tau} = q_\tau - c_{1,\tau} \cdot (1 - \tau)$ . The RIF equals the underlying distributional statistic in expectation. Conditional on some explanatory variables  $X$  the expectation of the RIF can be written as  $E[RIF(Y; q_\tau)|X = x] = c_{1,\tau} \cdot Pr[Y > q_\tau|X = x] + c_{2,\tau}$  and is termed unconditional quantile regression because its average derivative corresponds to the marginal effect on the unconditional quantile. The authors further show that the unconditional effect  $E[dE[RIF(Y, q_\tau)|X]/dx]$  is closely related to the average marginal probability response model  $Pr[Y > q_\tau|X]$  and the family of conditional quantile effects. In case of a simple linear relationship between covariates  $X$  and the dependent variable estimation of the conditional expectation  $E[RIF^{OLS}(Y; q_\tau, F_Y)|X = x] = X' \gamma_\tau$  leads to the unconditional quantile regression coefficient  $\hat{\gamma}_\tau = \sum_{i=1}^N (X_i X_i')^{-1} \sum_{i=1}^N X_i * \widehat{RIF}(Y; \hat{q}_\tau)$ .

For computation of  $\widehat{RIF}(Y; \hat{q}_\tau, F_Y)$   $\hat{q}_\tau$  and  $f_Y(\hat{q}_\tau)$  need to be estimated. The estimate of the  $\tau$ th sample quantile is deduced by solving

$$\hat{q}_\tau = \arg \min_q \sum_{i=1}^N (\tau - \mathbb{1}\{Y_i - q \leq 0\}) \cdot (Y_i - q).$$



The density of the  $Y$  is estimated using the kernel density estimator. In the second step  $\widehat{RIF}(Y; \hat{q}_\tau)$  is regressed on the independent variables.

In order to analyze treatment effect heterogeneity along the wage distribution RIF regression is combined with linear DDD model described in section 4.1. Regressors for the RIF regression are just the same as in the least squares specification written out in equation (1).

## 5 Results

### 5.1 Differences-in-Differences-in-Differences Results

For all specifications additional controls such as age, gender, skill, tenure and establishment size were included. Table 4 and 5 summarizes the main estimation results of the differences-in-differences-in-differences specification for East and West Germany. Detailed regression output is supplied in the Appendix (Tables 8 and 9).

Table 4: Overview of Main Differences-in-Differences-in-Differences Results for West Germany

	DDD	DDD-CA	DDD-CA, $\leq 200$	DDD-CA, no firm CA
<b>Blue*post*sector</b>	0.013 (0.022)	0.061 (0.043)	0.057 (0.045)	0.061 (0.043)
Blue*post*sector*CA		-0.031 (0.048)	-0.054 (0.048)	-0.029 (0.048)
<b>Blue*post*sector + blue*post*sector*CA</b>		0.030 (0.025)	0.003 (0.023)	0.032 (0.025)
F-Test for differential effects across union status				
... on intercept & slopes		9.54	2.26	9.60
... p-value		0.000	0.021	0.000
... on slopes		8.66	2.27	8.78
... p-value		0.000	0.027	0.000
$R^2$	0.568	0.571	0.536	0.572
$N$	53651	53651	36939	53525

*Notes:* standard errors clustered on the establishment level in parentheses. \*\*\*significant at 1% level, \*\*significant at 5% level, \*significant at 10% level. The dependent variable is log hourly wages. "CA" refers to collective, firm or establishment agreement. "DDD-CA" stands for least squares estimation of the differences-in-differences-in-differences specification differentiated along union status. "<200" restricts the sample to observations in establishments with up to 200 employees. "no firm CA" excludes observations from establishments with a firm or establishment level agreement. For further details and the full regression output refer to Table 9.

The first column ("DDD") of table 4 shows estimation results for the base specification (1). In the rest of the columns interactions of the variables *blue*, *sector*, *post*, *blue \* post*, *blue\*sector*, *sector\*post*, and *blue\*post\*sector* with union status were added and different

sample restrictions made. Model “DDD-CA,  $\leq 200$ ” restricts the sample to establishments with up to 200 employees. This excludes only a few establishments yet they provide many observations. “DDD-CA, no firm CA” is estimated on employees whose wage contract is not part of a firm or establishment level agreement. Firm and establishment level agreements are typical for the biggest employers in the sector but not restricted to only those.

Results for West Germany confirm that there was no significant mean treatment effect of the MW. This holds across the different specifications and sample restrictions. While point estimates suggest a positive impact none of the coefficients is significantly different from zero. It catches one’s eye that overall point estimate ( $blue * post * sector + blue * post * sector * CA$ ) for the effect on unionized blue-collar workers is considerably higher for the bigger establishments and close to zero with a very large standard error for the sample restricted to establishments with 200 employees. The F-Tests reject that slopes (and intercept) in the interacted model are jointly zero and support caution with regard to effect heterogeneity along union status. Allowing for differential effects across skill levels did not show an additional treatment effect for those in the positions requiring the least skill<sup>8</sup>.

Table 5: Overview of Main Differences-in-Differences-in-Differences Results for East Germany

	DDD	DDD-CA	DDD-CA, $\leq 200$	DDD-CA, no firm CA
<b>Blue*post*sector</b>	0.066** (0.029)	0.110*** (0.037)	0.085** (0.038)	0.110*** (0.036)
Blue*post*sector*CA		0.000 (0.075)	0.023 (0.078)	-0.026 (0.083)
<b>Blue*post*sector + blue*post*sector*CA</b>		0.110* (0.061)	0.108* (0.063)	0.084 (0.069)
F-Test for differential effects across union status				
... on intercept & slopes		28.30	28.32	29.44
... p-value		0.000	0.000	0.000
... on slopes		4.64	4.97	3.69
... p-value		0.000	0.000	0.001
$R^2$	0.579	0.583	0.544	0.586
$N$	27645	27645	21991	26908

Notes: Refer to Table 4 for general details and to Table 8 for full regression output.

In East Germany the mean treatment effect is clearly positive and significant. While the MW introduction led to a wage growth of 6.6% for all entitled blue-collar workers the impact was

<sup>8</sup>Results available from the author upon request.

different across union status. Wage growth for non-unionized eligibles was smaller in the not so big establishments. The positive overall effect for blue-collar workers under collective, firm, or establishment agreement amounts to roughly 11% yet is on the brink of becoming insignificant on conventional levels. Significance of the overall effect on wages of unionized eligible workers vanishes completely if the few establishments with establishment or firm agreements are taken out of the sample. While F-Tests soundly reject jointly zero slopes (and intercept) the coefficient estimates for non-unionized blue-collar workers are never significantly different from those for unionized eligible individuals. Differentiation along the skill dimension did not reveal impact heterogeneity with regard to the difficulty of task fulfilled. Results also were robust to the exclusion of head masons and foremen from the group of white-collar workers.

Mean treatment effects appear more or less in line with expectations based on descriptive statistics. For West Germany no significant treatment effects are identifiable in the differences-in-differences-in-differences estimation. In East Germany wages for all eligible individuals increased less than the theoretical wage raise required for full compliance based on those observations paid below the MW (10.96%) suggested but by a lot more than a nominal adjustment would have brought across the board for all eligible observations. Mean coefficients moreover show that firm and establishment level agreements influence results for unionized workers. In the next section heterogeneity along the wage distribution will be analyzed.

## 5.2 Unconditional Quantile Regression Results

Beyond effect heterogeneity along the dimension of union status heterogeneity across the wage distribution is of interest. Basically one can imagine three patterns of coefficients along the distribution that can be associated with a positive mean treatment effect. (1) Only some part of the distribution benefited from the policy while the rest of the distribution saw no effect. In case of the studied policy change the obvious hypothesis would be that the lower ranks of the wage distribution saw an increase and the medium to upper quantiles a zero effect. (2) The whole distribution experienced a location shift meaning that there was no effect heterogeneity along the distribution. This could be explained with maintaining the wage structure yet on a higher level. Such hypothesis may also be related to the fact that MW rate is fixed in the context of collective agreements. (3) Finally a combination of the prior two scenarios is thinkable generating a more irregular pattern. I.e. positive effects in the lower quantiles could be complemented by lower possibly even negative effects in the upper quantiles.

Table 6: Summary of Effects from Differences-in-Differences-in-Differences RIF Regressions

		q10	q20	q30	q40	q50	q60	q70	q80	q90	
East Germany	DDD-CA	Without CA	0.173*** (0.052)	0.150** (0.040)	0.082** (0.032)	0.074** (0.031)	0.061** (0.029)	0.053* (0.028)	0.081** (0.035)	0.109** (0.046)	0.183 (0.137)
		With CA	0.085 (0.063)	0.113 (0.069)	0.097 (0.062)	0.109* (0.060)	0.124** (0.058)	0.109* (0.059)	0.177* (0.075)	0.207*** (0.109)	0.270** (0.305)
	DDD-CA, ≤200	Without CA	0.128*** (0.046)	0.168*** (0.040)	0.132*** (0.030)	0.070** (0.031)	0.070** (0.032)	0.050 (0.030)	0.061* (0.040)	0.089** (0.045)	0.158 (0.116)
		With CA	0.117* (0.066)	0.173** (0.072)	0.159** (0.070)	0.133** (0.063)	0.186*** (0.066)	0.173** (0.070)	0.211*** (0.080)	0.178* (0.106)	0.243 (0.224)
	DDD-CA, no firm CA	Without CA	0.178*** (0.053)	0.146** (0.042)	0.074** (0.033)	0.077** (0.032)	0.06** (0.030)	0.051** (0.029)	0.088** (0.036)	0.131** (0.047)	0.189 (0.143)
		With CA	0.088 (0.070)	0.108 (0.076)	0.080 (0.069)	0.092 (0.068)	0.100 (0.069)	0.149** (0.070)	0.159** (0.079)	0.177* (0.105)	0.178 (0.323)
West Germany	DDD-CA	Without CA	0.070 (0.065)	0.025 (0.041)	0.030 (0.030)	0.017 (0.026)	0.024 (0.027)	0.050* (0.030)	0.040 (0.040)	0.054 (0.065)	0.115 (0.115)
		With CA	0.039 (0.027)	0.051** (0.022)	0.020 (0.020)	0.029 (0.019)	0.082*** (0.023)	0.101*** (0.030)	0.095*** (0.030)	0.055 (0.052)	-0.106 (0.077)
	DDD-CA, ≤200	Without CA	0.073 (0.076)	0.037 (0.047)	0.030 (0.030)	0.025 (0.027)	0.044* (0.026)	0.068** (0.030)	0.059* (0.030)	0.070 (0.056)	0.037 (0.112)
		With CA	0.021 (0.032)	0.038 (0.024)	0.010 (0.020)	0.004 (0.018)	0.050** (0.021)	0.094*** (0.020)	0.086*** (0.030)	0.083* (0.046)	-0.118 (0.080)
	DDD-CA, no firm CA	Without CA	0.067 (0.059)	0.025 (0.035)	0.033 (0.031)	0.016 (0.025)	0.023 (0.026)	0.051** (0.027)	0.039 (0.033)	0.054 (0.063)	0.115 (0.117)
		With CA	0.042 (0.030)	0.052** (0.023)	0.023 (0.020)	0.027 (0.019)	0.082*** (0.022)	0.103*** (0.024)	0.097*** (0.034)	0.057 (0.056)	-0.099 (0.077)

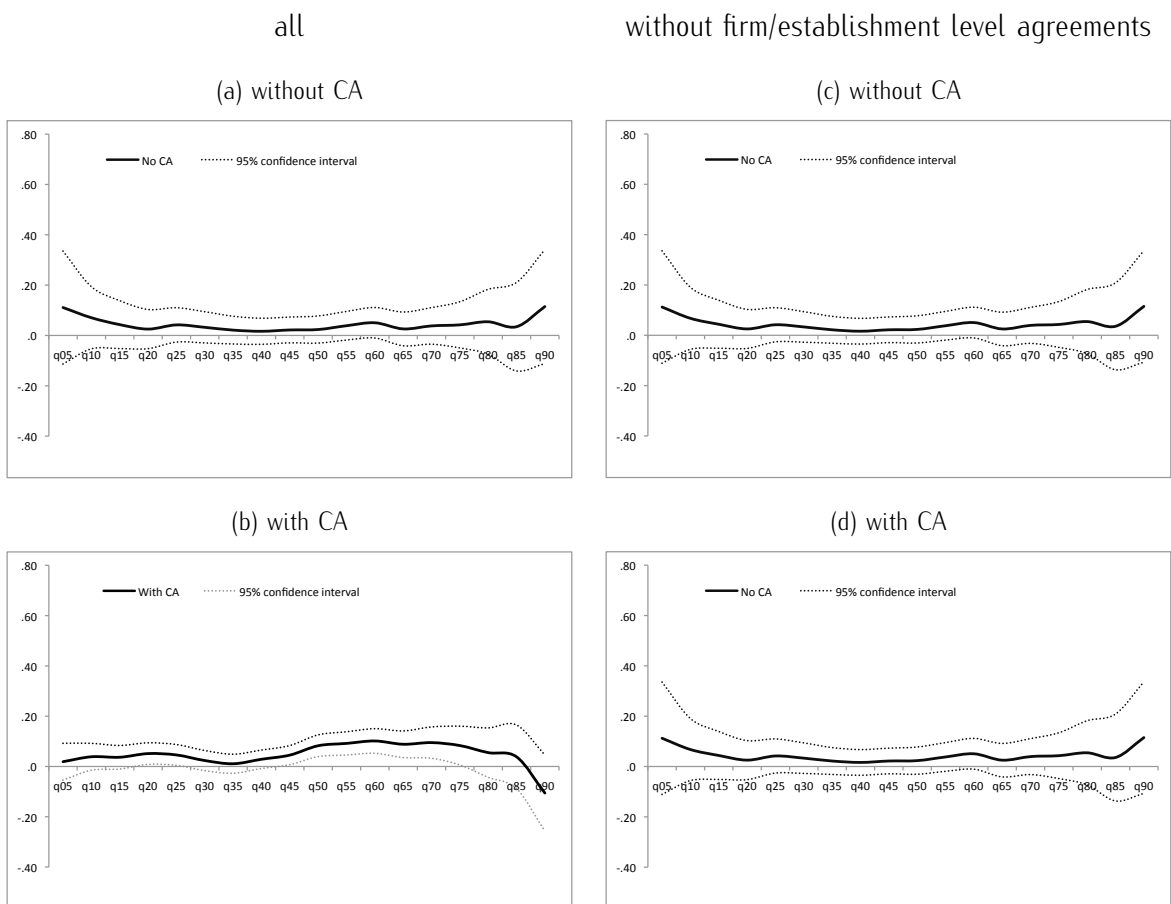
Notes: standard errors clustered on the establishment level in parentheses (1000 repetitions for West Germany and sample restriction to establishments ≤200, 3000 repetitions for East Germany). \*\*\*significant at 1% level, \*\*significant at 5% level, \*significant at 10% level. Results from RIF regressions along the quantiles of the distribution of log hourly wages of the differences-in-differences-in-differences specification. "CA" refers to collective, firm or establishment agreement. For details on the specification and full estimation output at selected quantiles refer to Table 10.

Table 6 summarizes the results of the RIF regressions for the differences-in-differences-in-differences specification. Figures 2 and 3 show graphically the main coefficients and the respective confidence intervals for the full sample (panels (a) and (b) respectively) and the sample restricted to establishments without firm or establishment agreement (panels (c) and (d) respectively). Table 10 in the Appendix provides more detailed estimation results at selected quantiles.

Estimation results show that the policy clearly did not exert a uniform and continuously significant influence across the distribution. Point estimates show a different effect at different points of the wage distribution. Significance of the estimates varies considerably with widening confidence bands particularly at the higher quantiles. For the western part of the country the insignificant least squares estimates are complemented by mostly insignificant RIF estimates except for the quantiles ranging between the median and the 75% quantile for unionized workers. This pattern looks quite similar for point estimates in the restricted samples. The region beyond the median and the 80% percentile corresponds approximately to the level of the medium to higher wage groups bargained in the collective agreements given that employers do not make use of the exemption clause.

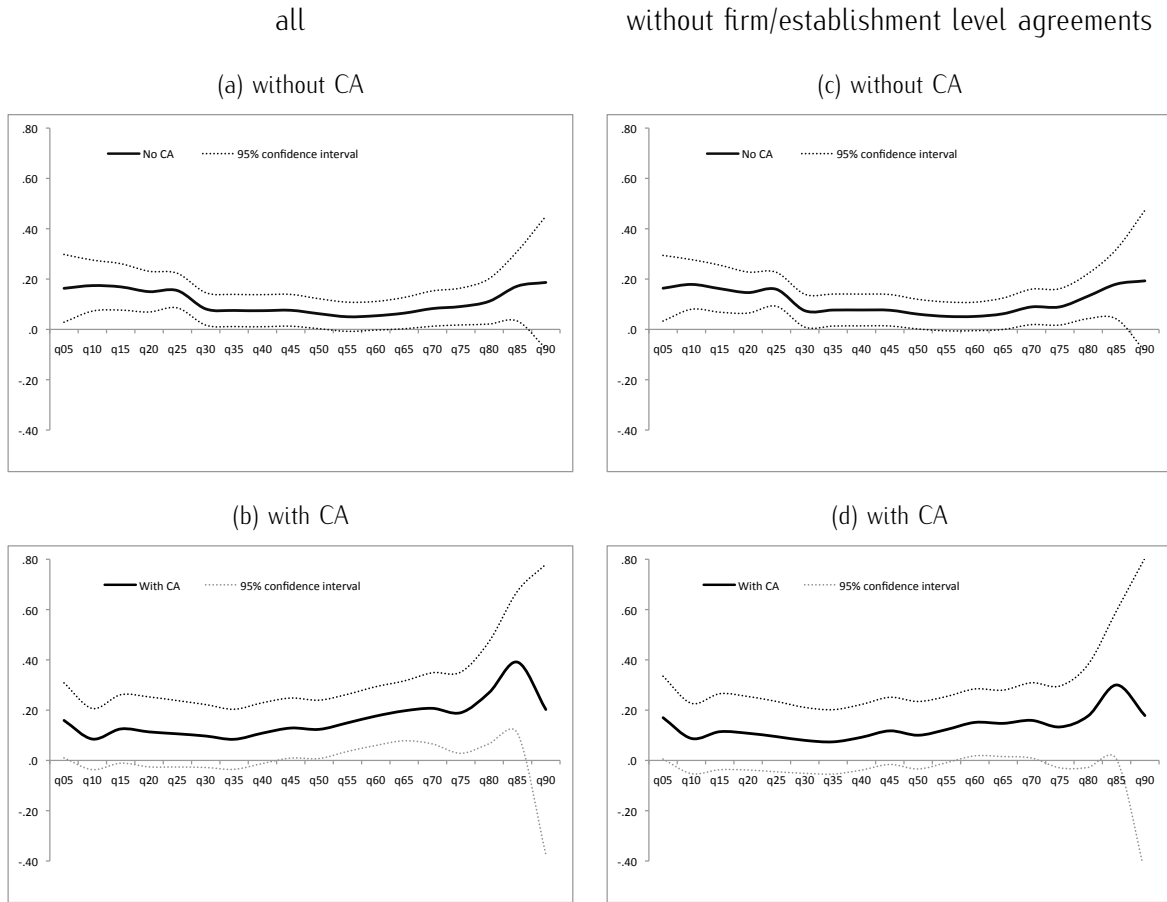
For East Germany estimation results show a strong effect for the lower ranks of eligible employees not under collective agreement. Estimates for unionized blue-collar employees are

Figure 2: RIF Regression Estimates of the Treatment Effect (DDD) on log Hourly Wages for West Germany



Notes: standard errors clustered on the establishment level in parentheses (3000 repetitions). Results from RIF regressions along the quantiles of the distribution of log hourly wages of the differences-in-differences-in-differences specification. "CA" refers to collective, firm or establishment agreement. For details on the specifications and full estimation output at selected quantiles refer to Table 10.

Figure 3: RIF Regression Estimates of the Treatment Effect (DDD) on log Hourly Wages for East Germany



Notes: standard errors clustered on the establishment level in parentheses (3000 repetitions). Results from RIF regressions along the quantiles of the distribution of log hourly wages of the differences-in-differences-in-differences specification. "CA" refers to collective, firm or establishment agreement. For details on the specifications and full estimation output at selected quantiles refer to Table 10.

also positive yet again mostly for the wage groups directly above the MW group in the collective agreements. While the pattern of the treatment effect remains stable in the restricted sample for non-unionized workers, point estimates for those unionized become significant beyond the median only. Excluding the few establishments with a firm level agreement shows that wages under collective agreement did also benefit significantly from the MW. This pattern is not captured by the mean effect.

The MW brought about a wage hike for the wage groups just beyond the MW in both parts of the country. It increased wages for non-unionized blue-collar workers in the lowest quartile significantly. Extending the fraction of eligible blue-collar workers in East Germany marginally increased wages of non-unionized employees at the first quartile by 15.4% compared to an increase of 12.4% for their unionized colleagues. In West Germany it entailed a 8.2% wage increase at the median for organized employees.

## 6 Conclusion

This study analyzes the impact of the introduction of the first sectoral MW in 1997 in Germany on hourly wages and their distribution. The reform was aimed at setting a lower wage floor for blue-collar workers in the construction sector but was not implemented across all sub-sectors due to institutional peculiarities in the wage bargain. We use this as a natural experiment to differentiate between treatment and control group on the 4-digit-industry classification level. Based on two cross sections of a linked employer-employee data set, the *GLS*, we can extend the DD framework to include as a further comparison group the white-collar workers in just the same establishments to even better isolate the reform effects. Unconditional quantile (RIF) regressions are then used to examine the effect heterogeneity along the wage distribution.

Descriptive results reveal that the MW did bite a lot more in East Germany than in the western part of the country. Estimation results suggest that there is two sources of heterogeneity: group heterogeneity with regard to union status and impact heterogeneity along the wage distribution. Mean effects in the differences-in-differences-in-differences specification are not significantly different from zero for unionized and non-unionized blue-collar workers in West Germany. But RIF regressions reveal a significant positive effect for the group of unionized workers in the range of collectively agreed wages beyond the MW. In East Germany we find a positive and significant treatment effect of 6.6%. While the mean effect for those under the general collective agreement is not significant unconditional quantile regression shows that employees in the upper ranks of the wage distribution did actually benefit from the MW. The treatment effect is highest in the lower quarter of the wage distribution for non-unionized workers.

Altogether these results suggest that the introduction of the MW has had a sizable impact on wages and distribution of eligible blue-collar workers in establishments with 10 or more employees in East Germany. The evidence also suggests that wages of unionized eligible employees above the MW were also affected by the MW introduction. Given that the MW rate is determined in the context of the overall wage bargain this may not come as a complete surprise. The identification of possible mechanisms in the interaction of wage bargaining and MWs are beyond the scope of this study but pose interesting questions for future research in economic theory as much as empirical work.

## References

- Addison, J. T., M. L. Blackburn, and C. D. Cotti (2009). Do minimum wages raise employment? evidence from the u.s. retail-trade sector. *Labour Economics* 16(4), 397 – 408.
- Bertrand, M., E. Duflo, and S. Mullainathan (2004). How much should we trust differences-in-differences estimates? *Quarterly Journal of Economics* 119(1), 249–275.
- Cameron, A. C., J. B. Gelbach, and D. L. Miller (2008). Bootstrap-based improvements for inference with clustered errors. *Review of Economics and Statistics* 90(3), 414–427.
- Card, D. and A. B. Krueger (1998, January). A reanalysis of the effect of the new jersey minimum wage increase on the fast-food industry with representative payroll data. (6386).
- Dickens, R. and A. Manning (2004a). Has the national minimum wage reduced uk wage inequality? *Journal of the Royal Statistical Society. Series A (Statistics in Society)* 167(4), 613–626.
- Dickens, R. and A. Manning (2004b). Spikes and spill-overs: The impact of the national minimum wage on the wage distribution in a low-wage sector. *The Economic Journal* 114(494), C95–C101.
- Dolado, J., F. Kramarz, S. Machin, A. Manning, D. Margolis, C. Teulings, G. Saint-Paul, and M. Keen (1996). The economic impact of minimum wages in Europe. *Economic Policy* 11(23), 319–372.
- Donald, S. G. and K. Lang (2007). Inference with difference-in-differences and other panel data. *Review of Economics and Statistics* 89(2), 221–233.
- Eichhorst, W. (2005). Equal pay for equal work in the same place? the posting of workers in the european union. *Journal for Labour Market Research* 38(2/3), 197–217.
- Firpo, S., N. M. Fortin, and T. Lemieux (2009). Unconditional quantile regressions. *Econometrica* 77(3), 953–973.
- Hafner, H.-P. and R. Lenz (2007). Gehalts- und Lohnstrukturerhebung: Methodik, Datenzugang und Forschungspotential. *FDZ-Arbeitspapier* (18).
- Kluve, J. and C. M. Schmidt (2007). Mindestlöhne ohne Reue – eine aussichtsreiche Option für Deutschland? *Gastbeitrag Handelsblatt, 10. Dezember 2007*.



- Koenker, R. and J. Bassett, Gilbert (1978). Regression quantiles. *Econometrica* 46(1), 33–50.
- König, M. and J. Möller (2007). Minimum wage effects of the worker posting law? : a micro data analysis for the german construction sector. IAB Discussion Paper 30, Institute for Employment Research, Nuremberg, Germany.
- Machin, S., A. Manning, and L. Rahman (2003). Where the minimum wage bites hard: Introduction of minimum wages to a low wage sector. *Journal of the European Economic Association* 1(1), 154–180.
- Machin, S. and J. Wilson (2004). Minimum wages in a low-wage labour market: Care homes in the UK. *The Economic Journal* 114(494), C102–C109.
- Meier, V. and S. Munz (2008). Beschäftigungseffekte von Mindestlöhnen unter Vernachlässigung der Hauptbetroffenen: Kommentar zu König und Möller. *ifo Schnelldienst* 61(5), 30–32.
- Metcalf, D. (2004). The impact of the national minimum wage on the pay distribution, employment and training. *The Economic Journal* 114(494), C84–C86.
- Neumark, D. and W. Wascher (2007). Minimum wages and employment. In *Foundations and Trends in Microeconomics*, Volume 3, pp. 1–182.
- Stewart, M. B. (2004). The employment effects of the national minimum wage. *The Economic Journal* 114(494), C110–C116.
- Storbeck, O. (2007). Ökonomenstimmen zur Mindestlohn-Studie von Möller und König. *Handelsblatt*, 19. November 2007.
- Wooldridge, J. M. (2006). Cluster-sample methods in applied econometrics: an extended analysis. Technical report.

Table 7: Descriptive Statistics for East and West Germany

	Treated Sectors				Control Sectors				
	Blue-collar		White-collar		Blue-collar		White-collar		
	Before MW	After MW	Before MW	After MW	Before MW	After MW	Before MW	After MW	
East Germany	Average establishment size	43	31	46	33	28	19	29	20
	Percentage under (collective) agreement	54%	33%	54%	35%	40%	18%	41%	11%
	Percentage female	0%	0%	44%	37%	1%	1%	49%	49%
	Percentage working full-time	100%	98%	93%	89%	100%	99%	90%	83%
	Average Age	37	39	42	43	36	38	41	43
	Fraction low-skilled	30%	27%	14%	13%	15%	11%	22%	22%
	Fraction medium-skilled	59%	60%	55%	54%	73%	73%	47%	51%
	Average tenure in months	72	76	89	98	76	76	91	90
	Average hourly wage	9.93	10.48	14.36	15.9	9.03	9.32	11.56	12.85
	Average contracted monthly hours	169	168	166	161	171	171	166	158
	Number of employees (unweighted)	11595	3871	2886	983	4646	1902	1229	528
Number of establishments (unweighted)	533	185	511	173	312	126	300	121	
West Germany	Average establishment size	40	37	44	37	22	20	22	20
	Percentage under (collective) agreement	92%	77%	80%	58%	69%	53%	54%	40%
	Percentage female	0%	0%	32%	32%	2%	2%	47%	48%
	Percentage working full-time	100%	98%	90%	87%	99%	97%	85%	73%
	Average age	41	41	42	43	37	38	41	42
	Fraction low-skilled	26%	27%	15%	17%	16%	22%	22%	32%
	Fraction medium-skilled	50%	50%	49%	43%	55%	51%	50%	41%
	Average tenure in months	112	109	133	122	108	111	137	122
	Average hourly wage	13.13	14.29	18.48	20.79	12.95	13.51	16.22	16.83
	Average contracted monthly hours	168	167	161	157	164	163	153	141
	Number of employees (unweighted)	18254	9512	6275	3394	5956	5605	2173	2482
Number of establishments (unweighted)	719	460	679	456	391	393	375	392	

Notes: The calculations are weighted unless stated otherwise.

Source: GLS 1995 and GLS 2001.

Table 8: Differences-in-Differences-in-Differences Estimation Results for East Germany

	DDD	DDD-CA	DDD-CA, $\leq 200$	DDD-CA, no firm CA
Blue*post*sector	0.067** (0.029)	0.111*** (0.037)	0.086** (0.038)	0.111*** (0.036)
Blue*post*sector*CA		-0.001 (0.075)	0.021 (0.078)	-0.028 (0.083)
Blue*post*CA		-0.087 (0.065)	-0.063 (0.069)	-0.065 (0.074)
Blue*sector*CA		0.081*** (0.028)	0.045 (0.030)	0.075*** (0.028)
Post*sector*CA		0.012 (0.074)	0.008 (0.064)	0.002 (0.079)
Blue*CA		-0.033 (0.024)	-0.024 (0.026)	-0.031 (0.024)
Post*CA		0.003 (0.064)	-0.028 (0.054)	0.013 (0.069)
Sector*CA		-0.008 (0.029)	0.040 (0.029)	-0.001 (0.029)
Blue*post	-0.064*** (0.023)	-0.058** (0.027)	-0.056** (0.028)	-0.058** (0.027)
Blue*sector	-0.107*** (0.013)	-0.153*** (0.021)	-0.134*** (0.021)	-0.153*** (0.021)
Post*sector	-0.065** (0.032)	-0.074** (0.038)	-0.054 (0.039)	-0.075** (0.038)
Blue	-0.319*** (0.012)	-0.304*** (0.017)	-0.307*** (0.018)	-0.304*** (0.017)
Post	0.152*** (0.026)	0.151*** (0.029)	0.152*** (0.030)	0.152*** (0.029)
Sector	0.176*** (0.015)	0.183*** (0.020)	0.164*** (0.021)	0.183*** (0.020)
With CA	0.109*** (0.008)	0.110*** (0.025)	0.099*** (0.025)	0.110*** (0.025)
Female	-0.298*** (0.009)	-0.297*** (0.009)	-0.307*** (0.010)	-0.298*** (0.009)
Age	0.012*** (0.001)	0.012*** (0.001)	0.013*** (0.001)	0.012*** (0.001)
Age*age	-0.000*** (0.000)	-0.000*** (0.000)	-0.000*** (0.000)	-0.000*** (0.000)
Low-skilled	-0.297*** (0.011)	-0.300*** (0.011)	-0.306*** (0.010)	-0.303*** (0.011)
Medium-skilled	-0.178*** (0.009)	-0.182*** (0.009)	-0.186*** (0.008)	-0.185*** (0.009)
Full-time	0.147*** (0.014)	0.147*** (0.014)	0.140*** (0.015)	0.148*** (0.014)
Tenure in months	0.000*** (0.000)	0.000*** (0.000)	0.000*** (0.000)	0.000*** (0.000)
20<size $\leq$ 50	0.016 (0.011)	0.018 (0.011)	0.017 (0.011)	0.019* (0.011)
50<size $\leq$ 100	0.027** (0.012)	0.028** (0.012)	0.024** (0.012)	0.030** (0.012)
100<size $\leq$ 200	0.037*** (0.013)	0.036*** (0.013)	0.031** (0.013)	0.034** (0.013)
Size>200	0.092*** (0.015)	0.088*** (0.015)	0.000 (0.000)	0.091*** (0.015)
Constant	2.158*** (0.027)	2.163*** (0.028)	2.162*** (0.031)	2.164*** (0.029)
$R^2$	0.579	0.583	0.544	0.586
N	27640	27640	21986	26903
Blue*post*sector + blue*post*sector*CA		0.110* (0.061)	0.108* (0.063)	0.084 (0.069)
F-Test for differential effects across union status				
... on intercept & slopes		28.29	28.32	29.44
... p-value		0.000	0.000	0.000
... on slopes		4.63	4.99	3.68
... p-value		0.000	0.000	0.001

Notes: standard errors clustered on the establishment level in parentheses. \*\*\*significant at 1% level, \*\*significant at 5% level, \*significant at 10% level. The dependent variable is log hourly wages. The reference category for establishment size variables ( $\# < \text{size} \leq \#$ ) is 20 or less employees. CA refers to collective, firm or establishment agreement. "DDD-CA" stands for least squares estimation of the differences-in-differences-in-differences specification differentiated along union status. "DDD-CA,  $< 200$ " restricts the sample to observations in establishments with up to 200 employees and "DDD-CA, no firm CA" refers to all observations except for those under firm or establishment level agreements.

Table 9: Differences-in-Differences-in-Differences Estimation Results for West Germany

	DDD	DDD-CA	DDD-CA, $\leq 200$	DDD-CA, no firm CA
Blue*post*sector	0.013 (0.022)	0.061 (0.043)	0.057 (0.045)	0.061 (0.043)
Blue*post*sector*CA		-0.031 (0.048)	-0.054 (0.048)	-0.029 (0.048)
Blue*post*CA		-0.064* (0.035)	-0.014 (0.031)	-0.065* (0.035)
Blue*sector*CA		0.087*** (0.033)	0.095*** (0.035)	0.087*** (0.033)
Post*sector*CA		0.054 (0.042)	0.054 (0.041)	0.052 (0.042)
Blue*CA		0.055** (0.024)	0.000 (0.022)	0.055** (0.024)
Post*CA		0.058* (0.033)	0.014 (0.030)	0.060* (0.033)
Sector*CA		-0.084*** (0.028)	-0.062** (0.030)	-0.084*** (0.028)
Blue*post	0.031* (0.019)	0.069** (0.029)	0.015 (0.028)	0.069** (0.029)
Blue*sector	-0.069*** (0.014)	-0.156*** (0.032)	-0.132*** (0.034)	-0.156*** (0.032)
Post*sector	0.039* (0.022)	-0.026 (0.038)	-0.021 (0.039)	-0.026 (0.038)
Blue	-0.355*** (0.012)	-0.390*** (0.022)	-0.340*** (0.021)	-0.390*** (0.022)
Post	0.032 (0.020)	0.001 (0.029)	0.058** (0.028)	0.001 (0.029)
Sector	0.049*** (0.013)	0.130*** (0.028)	0.111*** (0.029)	0.130*** (0.028)
With CA	-0.023*** (0.007)	-0.059*** (0.022)	-0.015 (0.021)	-0.059*** (0.022)
Female	-0.278*** (0.008)	-0.275*** (0.008)	-0.286*** (0.008)	-0.275*** (0.008)
Age	0.014*** (0.001)	0.014*** (0.001)	0.015*** (0.001)	0.014*** (0.001)
Age*age	-0.000*** (0.000)	-0.000*** (0.000)	-0.000*** (0.000)	-0.000*** (0.000)
Low-skilled	-0.292*** (0.006)	-0.289*** (0.006)	-0.282*** (0.007)	-0.288*** (0.006)
Medium-skilled	-0.139*** (0.004)	-0.137*** (0.004)	-0.123*** (0.005)	-0.136*** (0.004)
Full-time	0.108*** (0.011)	0.111*** (0.011)	0.121*** (0.013)	0.112*** (0.011)
Tenure in months	0.000*** (0.000)	0.000*** (0.000)	0.000*** (0.000)	0.000*** (0.000)
20<size≤50	0.021*** (0.008)	0.021*** (0.007)	0.019** (0.007)	0.021*** (0.007)
50<size≤100	0.036*** (0.008)	0.033*** (0.008)	0.028*** (0.008)	0.034*** (0.008)
100<size≤200	0.036*** (0.008)	0.034*** (0.008)	0.027*** (0.008)	0.035*** (0.008)
Size>200	0.051*** (0.009)	0.049*** (0.009)		0.049*** (0.009)
Constant	2.548*** (0.024)	2.567*** (0.028)	2.478*** (0.029)	2.566*** (0.028)
$R^2$	0.568	0.571	0.536	0.572
N	53651	53651	36939	53525
Blue*post*sector + blue*post*sector*CA		0.030 (0.025)	0.003 (0.023)	0.032 (0.025)
F-Test for differential effects across union status				
... on intercept & slopes		9.54	2.26	9.60
... p-value		0.000	0.021	0.000
... on slopes		8.66	2.27	8.78
... p-value		0.000	0.027	0.000

Notes: standard errors clustered on the establishment level in parentheses. \*\*\*significant at 1% level, \*\*significant at 5% level, \*significant at 10% level. The dependent variable is log hourly wages. The reference category for establishment size variables ( $\# < \text{size} \leq \#$ ) is 20 or less employees. CA refers to collective, firm or establishment agreement. "DDD-CA" stands for least squares estimation of the differences-in-differences-in-differences specification differentiated along union status. "DDD-CA,  $\leq 200$ " restricts the sample to observations in establishments with up to 200 employees and "DDD-CA, no firm CA" refers to all observations except for those under firm or establishment level agreements.

Table 10: Differences-in-Differences-in-Differences Results in the RIF Framework

	East Germany			West Germany		
	q25	q50	q75	q25	q50	q75
Blue*post*sector	0.154*** (0.035)	0.062** (0.030)	0.091** (0.037)	0.042 (0.035)	0.024 (0.028)	0.042 (0.047)
Blue*post*sector*CA	-0.048 (0.080)	0.061 (0.070)	0.099 (0.091)	0.004 (0.041)	0.059* (0.036)	0.041 (0.059)
Blue*post*CA	-0.155** (0.074)	-0.064 (0.065)	0.024 (0.079)	-0.017 (0.029)	-0.015 (0.027)	-0.020 (0.047)
Blue*sector*CA	0.109*** (0.031)	0.114*** (0.028)	0.092** (0.038)	0.046 (0.030)	-0.010 (0.024)	-0.065 (0.041)
Post*sector*CA	-0.046 (0.046)	-0.036 (0.043)	0.017 (0.072)	0.011 (0.023)	0.006 (0.022)	-0.003 (0.048)
Blue*CA	0.054** (0.026)	0.002 (0.024)	-0.104*** (0.033)	-0.027 (0.022)	-0.031* (0.018)	-0.007 (0.034)
Post*CA	0.024 (0.044)	-0.006 (0.039)	-0.056 (0.066)	0.007 (0.021)	0.013 (0.020)	0.056 (0.043)
Sector*CA	-0.027 (0.021)	-0.003 (0.020)	-0.021 (0.033)	-0.024 (0.015)	-0.014 (0.014)	0.013 (0.032)
Blue*post	0.061** (0.026)	-0.011 (0.023)	-0.109*** (0.029)	0.076*** (0.023)	0.078*** (0.019)	0.017 (0.034)
Blue*sector	-0.035 (0.023)	-0.041** (0.019)	-0.123*** (0.022)	-0.064** (0.027)	-0.024 (0.020)	-0.071** (0.035)
Post*sector	-0.052** (0.023)	-0.034 (0.022)	-0.067** (0.034)	0.004 (0.019)	-0.002 (0.018)	-0.008 (0.037)
Blue	-0.174*** (0.019)	-0.219*** (0.017)	-0.340*** (0.022)	-0.103*** (0.020)	-0.207*** (0.017)	-0.608*** (0.036)
Post	0.076*** (0.020)	0.075*** (0.018)	0.139*** (0.027)	0.005 (0.016)	0.013 (0.015)	0.020 (0.030)
Sector	0.089*** (0.016)	0.075*** (0.014)	0.146*** (0.021)	0.024* (0.014)	0.022 (0.014)	0.078*** (0.027)
With CA	0.084*** (0.019)	0.083*** (0.017)	0.137*** (0.030)	0.052*** (0.014)	0.029** (0.013)	-0.031 (0.029)
Low-skilled	-0.191*** (0.012)	-0.236*** (0.012)	-0.325*** (0.015)	-0.289*** (0.008)	-0.234*** (0.007)	-0.284*** (0.011)
Female	-0.107*** (0.010)	-0.114*** (0.008)	-0.271*** (0.012)	-0.077*** (0.006)	-0.120*** (0.006)	-0.411*** (0.018)
Age	0.017*** (0.002)	0.013*** (0.001)	0.007*** (0.001)	0.017*** (0.001)	0.014*** (0.001)	0.013*** (0.001)
Age*age	-0.000*** (0.000)	-0.000*** (0.000)	-0.000*** (0.000)	-0.000*** (0.000)	-0.000*** (0.000)	-0.000*** (0.000)
Medium-skilled	-0.065*** (0.008)	-0.098*** (0.008)	-0.190*** (0.013)	-0.045*** (0.004)	-0.090*** (0.005)	-0.174*** (0.009)
Full-time	0.103*** (0.019)	0.098*** (0.014)	0.111*** (0.016)	0.056*** (0.008)	0.030*** (0.007)	0.063*** (0.013)
Tenure in months	0.000*** (0.000)	0.000*** (0.000)	0.000** (0.000)	0.000*** (0.000)	0.000*** (0.000)	0.000*** (0.000)
20<size≤50	0.024* (0.015)	0.010 (0.012)	0.007 (0.011)	0.009 (0.008)	0.015** (0.007)	0.027** (0.011)
50<size≤100	0.041*** (0.016)	0.018 (0.013)	0.005 (0.013)	0.002 (0.009)	0.022*** (0.008)	0.059*** (0.012)
100<size≤200	0.043*** (0.016)	0.022 (0.014)	0.015 (0.015)	-0.002 (0.008)	0.021*** (0.007)	0.069*** (0.012)
Size>200	0.079*** (0.017)	0.086*** (0.016)	0.075*** (0.017)	0.000 (0.009)	0.031*** (0.009)	0.084*** (0.013)
Constant	1.693*** (0.042)	2.048*** (0.029)	2.508*** (0.032)	2.124*** (0.026)	2.427*** (0.021)	2.943*** (0.035)
$R^2$	0.273	0.349	0.414	0.280	0.356	0.478
$N$	27640	27640	27640	53651	53651	53651
Blue*post*sector*CA + Blue*post*sector	0.106 (0.067)	0.124** (0.059)	0.190** (0.082)	0.046 (0.021)	0.082** (0.023)	0.083** (0.040)

Notes: standard errors clustered on the establishment level in parentheses (3000 repetitions). \*\*\*significant at 1% level, \*\*significant at 5% level, \*significant at 10% level. The dependent variable is log hourly wages. The reference category for establishment size variables ( $\# < \text{size} \leq \#$ ) is 20 or less employees. \*CA\* refers to collective, firm or establishment agreement. Results from RIF regressions of the differences-in-differences specification differentiated along union status at the 25th, 50th and 75th quantile. See specification \*DDD-CA\* in Table ?? for the least squares analogue.