Ifo Institute – Leibniz Institute for Economic Research at the University of Munich

Dissecting between-plant and within-plant wage dispersion
Evidence from Germany

Daniel Baumgarten
Gabriel Felbermayr
Sybille Lehwald

Ifo Working Paper No. 216

April 2016

Dissecting between-plant and within-plant wage dispersion: Evidence from Germany

Daniel Baumgarten*[1], Gabriel Felbermayr†[2], and Sybille Lehwald‡[3]

[1]University of Munich
[2]Ifo-Institute, University of Munich, CESifo
[3]Ifo-Institute

April 2016

Abstract

We analyze the most important drivers of the recent rise in overall German wage dispersion and pin down the relative contribution of central establishment and worker characteristics. Moreover, we separately investigate the drivers of between as well as within establishment wage dispersion. Using rich linked employer-employee data for the German manufacturing sector between 1996 and 2010, we explicitly account for the role of a plant's collective bargaining regime, its technological status and its export behavior. In order to disentangle the contribution of each single variable to the rise in wage dispersion, relative to other variables, requires a rich and comprehensive framework. To this end we apply a state-of-the-art decomposition method which is based on recentered influence function (RIF) regressions. We find that the decline in collective bargaining coverage as well as changes in the skill- and occupation-related wage structure are main sources of increased overall wage dispersion. Regional employment shifts, differences between collectively covered and uncovered plants and increased sorting play a key role for changes in between establishment wage dispersion, while the technology intenstiy of a plant is the most important driver of within plant wage inequality.

Keywords: Wage inequality; Decomposition; RIF-Regression; Linked employer-employee data.

JEL classification: J 31; F 16.

*E-mail: daniel.baumgarten@econ.lmu.de
†E-mail: felbermayr@ifo.de
‡E-mail: lehwald@ifo.de; Corresponding author.
We are very thankful for valuable comments to Thomas Lemieux, Bernd Fitzenberger, Steffen Mueller, Jakob Munch, Mette Foged, Anna Gumpert, participants of the IO-and trade seminar at the LMU, and the EDGE Jamboree in Copenhagen. We further thank the Research Data Center of the German Federal Employment Agency at the Institute for Employment Research (IAB) for their great support with accessing the data. All remaining errors are our own. This research project originally builds on a study on behalf of the Bertelsmann Foundation. We thank the Foundation for financial support.

1 Introduction

Wage inequality has been on the rise in most (industrialized) countries in the last few decades.[1] Recent research has pointed to the growing importance of workplace heterogeneity for this development: a large fraction of the increase in overall wage inequality is due to increased wage dispersion between as opposed to within firms or establishments. While this trend is shared by many countries[2], the sources of this increase are still underexplored.

In this paper, we pin down the role of important establishment and worker characteristics for the increase in overall wage inequality. For this purpose, we use detailed linked-employer-employee data of the German manufacturing sector, covering the years 1996 to 2010. In addition to personal characteristics such as age, education, occupation and nationality, we evaluate the contribution of explicit establishment characteristics such as a plant's collective bargaining regime, its technological status or its export behavior.[3] Since the effect of exporting is assumed to be strongest and most direct for the manufacturing sector, we restrict our analysis to this sector only. Disentangling the role of each single variable to the rise in wage dispersion, taking other variables explicitly into account, requires a rich and comprehensive framework. To this end we apply a state-of-the-art decomposition method which is based on recentered influence function (RIF) regressions (Firpo et al. 2009). This approach allows us to implement a detailed decomposition with respect to each variable and has the advantage of being path-independent. We contribute to the existing literature by quantifying the relative importance of a large set of characteristics to the rise in wage inequality using a considerably rich and comprehensive framework. As a further central contribution we separately perform a detailed decomposition of changes in between-establishment and within-establishment wage dispersion, thus shedding light on the (possible divergent) sources of these two important subcomponents of wage inequality. We find that the decline in collective bargaining coverage as well as changes in the skill- and occupation-related wage structure are main sources of increased overall wage dispersion. Regional employment shifts, differences between collectively covered and uncovered plants and increased sorting play a key role for changes in between establishment wage dispersion, while the technology intenstiy of a plant is the most important driver of within plant wage inequality.

Germany is an interesting point in case, as it has long been known for a rather stable wage distribution, but recently experienced a strong increase in wage inequality. In fact, the German wage structure shares many of the developments observed in the US, although inequality at the bottom of the wage distribution started to rise only in the 1990s, one decade later than in the US (Dustmann et. al. 2009). Previous research has already hinted at some important sources of rising (West) German wage inequality. In their seminal contribution, Dustmann et al. (2009) stress the importance of changes in workforce composition (in line

[1] Acemoglu and Autor (2011) provide a detailed overview of changes in the wage structure in the US and other advanced economies.

[2] Davis and Haltiwanger 1991, Dunne et al. 2004, and more recently, Barth et al. 2014, Handwerker and Spletzer 2015, and Song et al. 2015 provide evidence for the US; Faggio et al. 2010 for the UK; Card et al. 2013 for Germany; and Helpman et al. 2012 for Brazil. In contrast, the between-firm component seems to be less important in Sweden (Akerman et al 2013).

[3] We also control for region and industry.

with Lemieux 2006) and the decline in collective bargaining.[4] In addition, they provide indicative evidence that technological change has played a role for the widening of the wage distribution at the top. In line with most traditional studies, Dustmann et al. (2009) mostly rely on plain individual-level data, the bargaining status of the plant being the only establishment-level characteristic considered.

However, more recent research puts special emphasis on the firm or establishment component of wage dispersion. Most notably, Card et al. (2013) use (West) German linked employer-employee data and document that about 60 percent of the increase in cross-sectional wage dispersion are due to establishment effects and the covariance between establishment and person effects. The exploration of the underlying sources of this growing importance of establishment-level pay is still in its infancy, however. Also, it is unclear to what extent increased between-establishment wage dispersion is linked to the drivers of aggregate wage inequality highlighted in the previous literature. Card et al. (2013) provide tentative evidence that the decline in collective bargaining discussed above has likely contributed to this development, yet they do not explore the quantitative importance of this channel. Other research has focused on selected alternative (potential) drivers. Goldschmidt and Schmieder (2015) analyse the importance of domestic (on-site) outsourcing of food, cleaning, security and logistics services and find that this channel can account for around 9 percent of the increase in German wage inequality since the 1980s. Turning to international evidence, Handwerker and Spletzer (2015), having in mind a similar hypothesis as Goldschmidt and Schmieder (2015), analyse whether an increasing concentration of occupations at establishments has played a role. They find that this channel can only account for a small amount of the increase in (between-establishment) wage dispersion in the US. Other firm or establishment characteristics that have been found to be relevant – either for changes in overall wage inequality or for changes in between-establishment heterogeneity – are the industry of the workplace (Antonczyk et al. 2010; Barth et al. 2014) and the export status of the plant (Helpman et al. 2012; Baumgarten 2013; Egger et al. 2013).[5]

In this study, we adopt a more agnostic approach. Instead of pursuing one specific hypothesis, we account for a whole set of potential driving factors and quantify their respective contributions to the increase in overall as well as in between- and within-establishment wage dispersion. Our main findings are as follows. First, we confirm that the strong decline in collective bargaining, even conditional on an abundant set of control variables, is indeed a major source of the rise in wage dispersion and explains about a quarter of the observed increase in wage inequality in German manufacturing over the period 1996–2010. We find this effect to be disproportionately strong in the eastern region of Germany. Furthermore, we show that this decline has affected wage dispersion in very specific ways. It is a primary source of increasing between-plant wage dispersion, but it is, if at all, negatively related to within-plant wage inequality. It has affected lower-tail as opposed to upper-tail wage in-

[4] In subsequent research, Dustmann et al. 2014 also point to greater wage flexibility within the covered sector, which they attribute to an increased use of "opening clauses" in industry-level collective agreements.

[5] The focus on the export status is motivated by recent trade theories, which analyse the link between international trade and wage inequality in a setting with heterogenous firms and labour market imperfections (e.g. Helpman et al. 2010; Egger and Kreickemeier 2012; Felbermayr et al. 2014). In these models, the exporter wage premium, the wage differential between workers employed at exporters and the ones employed at non-exporters, is the key transmission channel from trade to wage inequality.

equality, and its inequality-increasing effect is mostly concentrated in the first (1996–2003) rather than the second (2003–2010) half of the period of analysis.

Second, employment shifts towards more highly skilled workers and, even more so, changes in the skill-related wage structure, particularly in the high-to-medium skill wage gap, have also played important roles. They contributed to both within-plant and between-plant wage dispersion. Interestingly, we find that the skill-related wage structure effect is quantitatively even more important for between-plant than for within-plant wage inequality, reflecting that a major part of changes in the skill-wage gaps has arisen from increasing between-establishment wage differentials. We put this finding down to increased assortative matching along the skill dimension and provide supporting evidence in this respect.

Third, the technology intensity and the export status of the establishment are generally of little quantitative importance for the increase in overall wage dispersion over the full period of analysis. *We do find, however, a sizable technology-related wage structure effect for western Germany, indicating that the reward to a plants technology differs substantially between the two regions.* Both establishment characteristics do matter for subcompents of wage dispersion and subperiods, respectively. The technology-related wage structure effect is the main driver of increasing within-plant wage inequality, reflecting that technology investments affect workers differently within establishments. In contrast, technology is negatively related to between-establishment wage inequality. The export-related wage structure effect is negatively related to between-establishment wage dispersion in the first period, but becomes an important factor in the second. This is because the export-related wage structure effect captures two (diverging) effects. On the one hand, wage dispersion among exporters has increased less than among non-exporters, contributing to lower inequality. On the other hand, there has been an increase in the exporter wage premium, the wage differential between workers employed at exporters and the ones employed at non-exporters, contributing to higher inequality. While the former effect dominates in the early period, the latter becomes more important in the later period.

Fourth, shifts in the regional structure of employment also contributed to increased (between-establishment) wage dispersion. This captures the relative increase in manufacturing employment experienced by eastern Germany over the period of analysis. Given that there is a pronounced East-West gap in wages, this relative increase of eastern German employment supposes a relative shift towards the group whose (mean) wages are relatively far from the grand mean, implying greater dispersion.

The remainder of the paper is organized as follows. In Section 2, we describe the linked employer-employee data used for our analysis. In Section 3, we briefly discuss the key developments in the German wage structure. Section 4 explains the decomposition analysis. We present a first descriptive overview of changes in the composition of workers and establishments as well as changes in the wage structure associated with worker and establishment characteristics, the ingredients to our decomposition analysis, in Section 5. In Section 6, we provide a detailed discussion of our decomposition results. Section 7 concludes.

2 Data

We base our analysis on the German LIAB data, which is a linked employer-employee data set provided by the Institute for Employment Research (IAB) in Nuremberg. It combines the IAB Establishment Panel with social security data on all workers who were employed in one of the establishments as of the 30th of June of a given year.

The IAB Establishment Panel is a stratified sample of all establishments that employ at least one worker subject to social security. The strata variables are defined over regions, industries and size classes. Appropriate weights, which are inverse to the sampling probability, are provided to assure the representativeness of the results. The IAB Establishment Panel started in 1993 with West-German establishments, while East-German plants have been included from 1996 onwards. Although participation in the IAB Establishment Panel is voluntary, the response rate is very high (up to 80 percent). The survey is very detailed and covers many different topics. For our analysis, information regarding the share of exports in total sales, investment in communication technology, the plant's technology status, and information related to the wage bargaining regime are most important. This information is surveyed in every year.[6]

The employee data stem from social security registrations by the employer that are mandated by law. Hence, only workers covered by social security are included in the Employment Statistics. Civil servants and self-employed are not registered. It still covers, however, about 80 percent of the German workforce. These compulsory social security records contain personal information such as gender, citizenship, the level of education, the year of birth, detailed information about the occupation (on a three-digit level), and the (top-coded) daily wage.

Similar to previous research (e.g. Dustmann et al. (2009), Card et al. (2013)) we limit our attention to full-time jobs held by men in the age range 18–65. We exclude marginal jobs that are subject to reduced social security contributions as well as workers that undergo training. For workers who hold multiple jobs, we only keep the highest paying one. We exclude observations that are reported to have an (implausibly) low daily wage of less than ten euros. Furthermore, we restrict our analysis to manufacturing since the effect of exporting on wages is assumed to be strongest and most direct in this sector and information about the establishments' exports are patchy for other sectors.[7] Our period of analysis covers the years from 1996 to 2010 and our main specifications are based on the reunified Germany. In order to be comparable to previous research, we briefly discuss the results of our main analysis on a sample for West-Germany as well. Taking these restrictions into account we end up with 558,152 (388,621) workers and 1,524 (2,836) establishments in 1996 (2010). It is worth noting that our sample restrictions may lead to an underestimation of the overall level and growth of wage inequality among German male workers in the manufacturing sector. However, since we cannot control for hours worked, such restrictions are needed to avoid measurement error.

[6]Further establishment variables, such as the industry affiliation on a three-digit level and regional information, are provided from the Establishment History Panel.

[7]Moreover, we do not consider those establishments, where the reporting unit in the Establishment Panel has changed over time. This is due to the fact that such a change in the reporting unit might not be accompanied by a corresponding change in the workforce data, since the establishment id stays the same.

An important caveat of the data is the censoring of wages at the annual social security maximum. In our sample, between 9 and 14 percent of the wage observations are censored in every year. To address this problem, we follow Dustmann et al. (2009) and impute the missing upper tail of the wage distribution using a series of Tobit regressions.[8] Using the estimated parameters from these models, we replace each censored wage value with a random draw from the upper tail of the appropriate conditional wage distribution. All wage information is converted into constant year-2000 euros by deflating them with the Consumer Price Index as provided by the German Federal Statistical Office. Table 7 in the appendix shows summary statistics of our main variables.

3 Trends in German wage inequality

Panel (a) of Figure 1 displays the evolution of the variance of log real wages in the manufacturing sector as a measure of overall wage inequality. It can be seen that wage inequality has been rising up to pre-crisis year 2008 before declining slightly during the main crisis year 2009 and remaining at this level in 2010. In terms of magnitude, the increase between 1996 and 2010 amounts to about 44 percent of the initial value, which is substantial.

The figure also shows the development of between- and within-establishment wage dispersion. The variance has the attractive property that the between- and the within-component add up to the total, fulfilling the criterion of an additively separable inequality measure (Shorocks, 1980). Technically, this can be formalized as follows:

$$\underbrace{\frac{1}{N_t}\sum_i (w_{it}-\bar{w}_t)^2}_{\text{overall variance}} = \underbrace{\frac{1}{N_t}\sum_j N_{jt}\,(\bar{w}_{jt}-\bar{w}_t)^2}_{\text{between-plant variance}} + \underbrace{\frac{1}{N_t}\sum_j\sum_{i\in j}(w_{it}-\bar{w}_{jt})^2}_{\text{within-plant variance}},$$

where workers are indexed by i and plants by j. N_t and N_{jt} denote the overall number of workers and the number or workers in plant j at time t, respectively. In addition, w_{it} denotes the log wage of individual i, $\bar{w}_{jt}$ the mean log wage within plant j, and $\bar{w}_t$ the overall mean log wage at time t.

While in 1996, the within-establishment component was slightly larger than the between-establishment component, accounting for 52 percent of overall wage inequality, between-establishment wage dispersion has grown considerably faster, accounting for 54 percent of the level of wage inequality in 2010 and for about two thirds of the increase in wage inequality over the period of analysis. This is in line with findings of the related literature, which also stresses the growing importance of between-establishment wage dispersion.

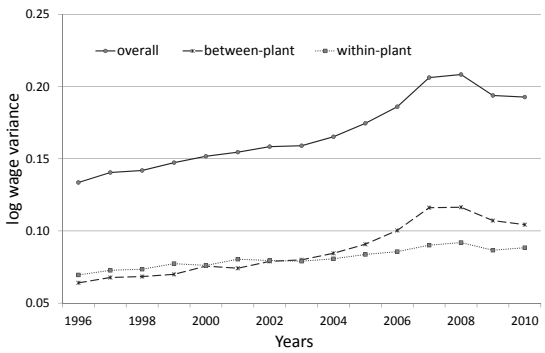
While the variance is a good and frequently used summary measure of overall wage dispersion, it does not allow one to analyse changes at different parts of the wage distribution. Therefore, Panel (b) of Figure 1 shows changes in log real wages over time at different percentiles of the earnings distribution (normalized to the year 1996). Up to the year 2007 workers at the median and at the 85th percentile have realized real wage gains,

[8] We run a series of Tobit regressions for each year, education-group and region (east/west). The explanatory variables are the ones that we also use in our analysis: five age-group dummies, industry and federal-states dummies, occupation dummies as well as indicator variables for export behavior, the investment in technology of plants and the collective bargaining status.

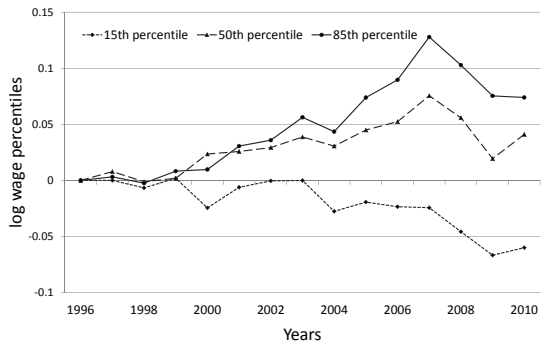
while workers at the 15th percentile have faced moderate declines in real wages.[9] During the three most recent years of our sample (2007-2010) all workers up to the 85th percentile have realized real wage losses. Considering the 85-50 and 50-15 log wage differential as measures of upper-tail and lower-tail wage inequality, it becomes apparent that most of the overall increase in wage inequality is due to changes in the lower part of the earnings distribution.

Figure 1. Wage dispersion

(a) Different inequality measures



(b) Wage growth at percentiles



Notes: Figure 1a shows the evolution of overall, between-plant and within-plant wage variance. We construct the measure of between-plant (within-plant) variance by using yearly regressions of log real individual wages on a full set of establishment fixed effects. We then take the variance of predicted (residual) wages as a measure of between-plant (within-plant) inequality. Figure 1b shows indexed log real wage growth of the 15th, 50th and 85th percentile. Since at most 14 percent of wage observations are censored in each year, the 85th wage percentile is not affected. Both figures are based on LIAB data and refer to the manufacturing sector. The sample corresponds to full-time male workers between 18 and 65 years of age.

4 Empirical approach and methodology

In order to quantify the economic impact of (changes in) certain covariates on (changes in) the distribution of wages, our empirical approach has to meet different requirements: Firstly, it needs to allow us to "go beyond the mean", meaning that we need to estimate the effects not simply on the mean but on the whole distribution of our dependent variable of interest. Secondly, we need to account for several covariates in a comprehensive framework. This is simply because we are interested in the *conditional effects* of our covariates and, in addition to that, we want to evaluate the relative impact of each covariate with respect to the other included factors. Thirdly, for each single covariate we want to distinguish between a composition effect, which is linked to changes in the distribution of this factor, and a wage structure effect that reflect changes in the conditional wage distribution over time. The latter two requirements are usally referred to as allowing for a *detailed decomposition*.

[9]Note that the characteristics of a worker at each percentile might have changed over time.

A decomposition method which can be applied beyond the mean and allows for a detailed decomposition with respect to each single covariate in a unified framework is the so called RIF regression approach, which is based on recentered influence function (RIF) regressions and was introduced by Firpo et al. (2009). A simple intuition for this methodology is that it can be regarded as a generalization of a standard Oaxaca-Blinder decomposition from the mean to other distributional statistics. A key advantage of this RIF regression approach is related to its linearization. It makes the procedure computationally relatively simple and, even more importantly, the resulting decomposition path-independent.[10] In the following, we sketch the key mechanisms underlying this approach.[11]

4.1 RIF-regression approach

A RIF-regression is similar to a standard regression with the exception that the dependent variable Y is replaced by the recentered influence function of the statistic of interest. Consider $IF(y; \upsilon)$, the influence function corresponding to an observed wage y for the distributional statistic $\upsilon(F_Y)$ of interest (e.g., a quantile, the variance, the gini coefficient). The recentered influence function is defined as $RIF(y; \upsilon) = \upsilon(F_Y) + IF(y; \upsilon)$ so that it aggregates back to the statistic of interest: $\int RIF(y; \upsilon) \cdot dF(y) = \upsilon(F_Y)$. In non-technical terms, the influence function represents the contribution of a given observation to the distributional statistic of interest.

Assuming that the conditional expectation of $RIF(y; \upsilon)$ can be modeled as a linear function of the explanatory variables,

$$E[RIF(y; \upsilon)|X] = X\gamma + \epsilon,$$

the corresponding parameters γ can be estimated by OLS. Applying this approach to quantiles, the RIF regression corresponds to an unconditional quantile regression, which allows one to estimate the marginal effect of any explanatory variable, say, the share of workers covered by collective bargaining, on the τth quantile of the wage distribution. Different from a standard conditional quantile regression, which only captures within-group (or residual) wage effects of the covariates, the unconditional quantile regression captures both within-group and between-group effects. For example, in the case of collective bargaining, the (typically negative) within-group effect on wage inequality stems from the fact that within the covered sector, wages (among comparable workers) tend to be more compressed than in the non-covered sector. On the other hand, the (typically positive) between-group effects results from covered workers usually earning a higher conditional mean wage than non-covered workers. As this example illustrates, the within-group and the between-group effects may go into different directions, and one or the other may dominate at different points of the wage distribution. The RIF coefficients as such, however, do not allow one to

[10] Path-independency implies that we do not have to take a stand on the sequential ordering of covariates in the decomposition analysis. Alternative approaches that also allow for detailed decompositions generally do not share this property, often face non-monotonicity problems and are computationally more cumbersome (see e.g. Chernozhukov et al. 2013 and DiNardo et al. 1996).

[11] This section is very much based on Firpo et al. (2014) and Fortin et al. (2011). We refer the interested reader to these original contributions for a more extensive description of the empirical approach.

disentangle the within-group and the between-group component so that we will resort to auxiliary evidence in cases where this distinction is of interest.

Due to the linearization, it is straightforward to apply the standard Blinder-Oaxaca decomposition to the RIF regression. Thus, if one is interested in decomposing changes in the distributional parameter $v(F_Y)$ between two different time periods ($t = 0$ and $t = 1$), the decomposition reads as

$$\hat{\Delta}_O^v = \underbrace{\overline{X}_1 \left(\hat{\gamma}_1^v - \hat{\gamma}_0^v\right)}_{\text{wage structure effect}} + \underbrace{\left(\overline{X}_1 - \overline{X}_0\right) \hat{\gamma}_0^v}_{\text{composition effect}} \tag{1}$$

where $\hat{\Delta}_O^v$ denotes the overall change in the statistic v. The first term on the right-hand side denotes the wage structure effect, $\hat{\Delta}_S^v$, which is obtained by holding the distribution of covariates constant and only modifying the conditional wage structure (represented by the RIF coefficients). The second term denotes the composition effect, $\hat{\Delta}_X^v$, which is obtained by holding the conditional wage structure (RIF coefficients) constant and varying the distribution of covarriates according to the observed changes between $t = 0$ and $t = 1$.

As Firpo et al. (2014) explain, there may be a bias in the decomposition because the linear specification used in the regression is only a local approximation that does not generally hold for larger changes in the covariates. In particular, the RIF coefficients might change if the distribution of the covariates changes even though the true wage structure remains the same. To circumvent this problem, Firpo et al. (2014) propose to combine the RIF regressions with a reweighting approach, where the counterfactual $\hat{\gamma}_{01}^v$ coefficients are obtained from a RIF regression on the period 0 sample reweighted to mimic the period 1 sample (such that $plim(\overline{X}_{01}) = plim(\overline{X}_1)$). Taken this adjustment into account, the pure wage structure effect[12] amounts to

$$\overline{X}_1 \left(\hat{\gamma}_1^v - \hat{\gamma}_{01}^v\right)$$

and the pure composition effect[13] to

$$\left(\overline{X}_{01} - \overline{X}_0\right) \hat{\gamma}_0^v.$$

Just like in the standard Blinder-Oaxaca decomposition, it is possible to obtain the detailed elements of the wage structure and the composition effects which are attributable to different subsets of the vector of explanatory variables, X. However, in case of the wage structure effect, the detailed elements are not unique and, for categorical variables, depend on the choice of the base category which has to be taken into account when interpreting the results.

It is important to stress that the decomposition method, like many other decomposition approaches, relies on the assumption of the invariance of the conditional distribution and therefore ignores general equilibrium effects. For our analysis this implies, e.g., that the

[12]The "naive" wage structure effect can be devided into the pure wage structure effect and the reweighting error. See Firpo et al. (2014) for details.

[13]The "naive" composition effect can be divided into a pure composition effect and a component measuring the specification error. The specification error captures the difference between the composition effect estimated using a non-parametric reweighthing approach and the linear approximation obtained using the RIF-regression.

collective bargaining wage premium is assumed to be independent of collective bargaining coverage. Moreover, the decomposition takes all covariates are exogenously given and not themselves determined by the same factors that also raise wage inequality. This however implies that a "causal" interpretation of the estimated effects is not possible.

We apply this approach to quantify the contribution of our explanatory factors to changes in the wage distribution between 1996 and 2010. These factors cover the personal characteristics education (four categories)[14], age (five categories)[15], nationality (two categories)[16], and dummies for more than 300 different occupations. Moreover, we consider a dummy variable that indicates the export status of an establishment, two dummy variables capturing the bargaining regime of the establishment (sector-level and firm level agreement, respectively, where no collective bargaining agreement is the base category) and two dummy variables that equal one if the plant has invested in communication or information technology and if the (self-assessed) technology status of the plant is above average compared to other establishments in the same industry, respectively. Finally, we include a full set of two-digit industry dummies to capture sectoral shifts during our period under study and include an indicator variable for the former eastern region of Germany.[17]

We apply the decomposition method to changes in overall wage distribution as well as to changes in between- and within-establishment wage dispersion. For statistical inference, we rely on a bootstrap (200 replications) of the whole decomposition. To account for the correlation of wages within industries, a block bootstrap procedure is applied where all observations within an industry are resampled.

5 Preliminary evidence on changes in workforce composition and the wage structure

Before discussing the detailed decomposition results of changes in wage dispersion, we provide descriptive evidence on changes in the composition of workers and establishments as well as changes in the wage structure related to worker and establishment characteristics. These basically constitute the ingredients, albeit in an unconditional and simplified way, to our decomposition analysis where we quantify their respective contributions to the increase in wage inequality.

5.1 Changes in the composition of workers and establishments

The first two columns of Table 1 illustrate the composition of workers according to various individual and establishment characteristics for the years 1996 and 2010.

[14] 1) Low: no vocational training, no high school. 2) Medium: high school and/or vocational training. 3) High: university or technical college. The fourth category consists of observations with missing educational information.

[15] 1) 18-25 years. 2) 26-35 years. 3) 36-45 years. 4) 46-55 years. 5) 56-65 years.

[16] German versus not-German.

[17] We choose our base category to be a worker employed at a non-exporting establishment, which is not covered by a collective bargaining agreement and which has not invested into information communication technology and who is employed in west Germany. Regarding the remaining categorial variables, we choose the modal categories in 1996 to be our base categories. These are medium skilled workers, in the age of 26 to 35, metalworkers in the manufacture of machinery and equipment industry.

In terms of sociodemographic characteristics, there is a visible trend towards more highly skilled and, even more so, older workers. The share of workers with university education in our sample increased from 8.0 percent in 1996 to 10.0 percent in 2010.[18] Also, the share of workers in the age group 46–55 (56–65) increased from 22.4 percent (9.4 percent) to 32.9 percent (13.4 percent). In contrast, there is a decline in the share of foreign workers. It has to be noted, however, that in the present data, workers are classified as foreigners/natives based on their nationality. Since the German nationality law was reformed during our sample period, making it easier to obtain German citizenship, this decline most likely reflects changes in citizenship rather than a decline in the number of migrant workers.

Regarding establishment characteristics, the share of workers employed at exporters increased from 67.7 percent to 75.6 percent, reflecting the substantial increase in trade openness experienced by Germany over the period of analysis and, more generally, underscoring the importance of exporting establishments in the German manufacturing employment structure. In contrast, the employment share of high-technology plants (no matter whether defined according to investments in communication and information technology or according to the subjective assessment of the plant's technology status) remained fairly stable. This might be due to the fact that a lot of investments in technology already took place before the mid 1990s when our period of analysis starts.

The most drastic change in terms of establishment characteristics, however, relates to changes in collective bargaining coverage rates. In Germany the recognition of trade unions regarding collective bargaining purposes is at the discretion of the firm. Once a firm has recognized a union, collective bargaining outcomes apply de facto to all workers in that firm, regardless of whether they are union members or not (for a discussion see e.g. Dustmann et al. 2009 and Fitzenberger et al. 2013). Such collective agreements are either formed at the firm or at the regional-industry level. Firms that once have recognized a collective contract, however, can later decide to opt at their own discretion. Table 1 shows that the share of workers covered by a sector-level bargaining agreement declined by 25 percentage points (from 77.8 percent to 52.9 percent), which was hardly offset by the small increase in the share of workers covered by firm-level bargaining agreements.[19] Note that, since we are considering an unbalanced panel of establishments, this decline comes about by both previously covered establishments leaving collective bargaining and entering (young) plants being less likely to follow a collective agreement.

In addition, the regional structure of manufacturing employment changed slightly, with an increasing share of workers employed in eastern Germany (up from 11 to 14 percent).[20]

[18] In addition, the share of workers with missing education information also increased. According to their (unconditional) mean wages, this group seems to resemble most closely the group of low-skilled workers (which decreased by an amount similar to the increase of the missings), suggesting that particularly the share of medium-skilled workers declined.

[19] A similar pattern emerges when considering the fraction of establishments instead of workers. Thus, this decline is not (primarily) driven by covered and uncovered establishments growing at differemt rates.

[20] We find a similar employment pattern using a representative 2 percent sample of all employment biographies, the SIAB data, which is also provided by the IAB. Accoding to the SIAB, manufacturing employment in eastern Germany increased from 10 to 12 percent between 1996 and 2010 (see Table 7).

Table 1. Worker shares, within group wage dispersion and mean values

	Worker share		Within group wage dispersion and mean values											
			overall wages				**between-plant wages**				**within-plant wages**			
	1996	2010	1996		2010		1996		2010		1996		2010	
worker-level characteristics			mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd
education: missing	0.04	0.08	4.30	0.44	4.26	0.45	4.36	0.32	4.30	0.36	-0.05	0.26	-0.05	0.36
education: low	0.16	0.12	4.34	0.24	4.36	0.29	4.49	0.18	4.50	0.26	-0.14	0.18	-0.14	0.20
education: medium	0.73	0.70	4.47	0.34	4.49	0.38	4.48	0.25	4.51	0.31	0.00	0.24	-0.02	0.26
education: high	0.08	0.10	4.99	0.38	5.11	0.45	4.65	0.26	4.74	0.30	0.35	0.32	0.37	0.38
age: 18-25	0.07	0.06	4.21	0.27	4.17	0.34	4.41	0.26	4.42	0.35	-0.20	0.20	-0.24	0.22
age: 26-35	0.32	0.18	4.42	0.30	4.40	0.38	4.47	0.25	4.48	0.34	-0.04	0.21	-0.08	0.23
age: 36-45	0.29	0.30	4.53	0.37	4.56	0.43	4.50	0.25	4.53	0.31	0.03	0.26	0.03	0.30
age: 46-55	0.22	0.33	4.58	0.39	4.58	0.45	4.52	0.26	4.54	0.31	0.06	0.29	0.05	0.31
age: 56-65	0.09	0.13	4.59	0.41	4.54	0.45	4.51	0.25	4.51	0.32	0.08	0.31	0.03	0.31
foreign citizenship (yes)	0.10	0.08	4.39	0.28	4.44	0.35	4.51	0.21	4.54	0.28	-0.11	0.21	-0.10	0.24
foreign citizenship (no)	0.90	0.92	4.50	0.37	4.52	0.45	4.49	0.26	4.51	0.33	0.01	0.27	0.01	0.30
establishment-level characteristics														
exporter (yes)	0.68	0.76	4.55	0.35	4.67	0.43	4.55	0.21	4.58	0.28	0.00	0.28	0.00	0.31
exporter (no)	0.32	0.24	4.35	0.36	4.44	0.47	4.35	0.28	4.31	0.35	0.00	0.23	0.00	0.26
investment in ICT (yes)	0.62	0.59	4.53	0.37	4.59	0.43	4.53	0.24	4.59	0.29	0.00	0.28	0.00	0.31
investment in ICT (no)	0.38	0.41	4.42	0.35	4.40	0.43	4.42	0.25	4.40	0.33	0.00	0.24	0.00	0.27
high technological status (yes)	0.20	0.16	4.51	0.38	4.56	0.45	4.51	0.27	4.56	0.33	0.00	0.27	0.00	0.31
high technological status (no)	0.80	0.84	4.48	0.36	4.51	0.44	4.48	0.25	4.50	0.32	0.00	0.26	0.00	0.30
collective agreement firm-level (yes)	0.10	0.12	4.39	0.35	4.57	0.39	4.39	0.24	4.57	0.26	0.00	0.26	0.00	0.29
collective agreement firm-level (no)	0.90	0.88	4.50	0.37	4.51	0.44	4.50	0.25	4.51	0.33	0.00	0.26	0.00	0.30
collective agreement sector-level (yes)	0.78	0.53	4.53	0.34	4.64	0.40	4.53	0.21	4.64	0.26	0.00	0.27	0.00	0.31
collective agreement sector-level (no)	0.22	0.47	4.33	0.39	4.37	0.43	4.33	0.30	4.37	0.32	0.00	0.25	0.00	0.29
east Germany (yes)	0.11	0.14	4.13	0.37	4.15	0.42	4.13	0.28	4.15	0.33	0.00	0.24	0.00	0.26
east Germany (no)	0.89	0.86	4.53	0.34	4.57	0.41	4.53	0.21	4.57	0.28	0.00	0.27	0.00	0.30

Notes: Analysis based on LIAB data, manufacturing sector. Sample includes full-time male workers between 18 and 65 years of age. Education groups are defined as: 1) low: no vocational training, no high-school; 2) medium: high school and/or vocational training; 3) high: university or technical college. The fourth category consists of observations with missing educational information. Sampling weights are employed. We construct the measure of between-plant (within-plant) variance by using yearly regressions of log individual wages on a full set of establishment fixed effects. We then take the variance of predicted (residual) wages as a measure of between-plant (within-plant) inequality.

5.2 Changes in the wage structure relating to worker and establishment characteristics

5.2.1 Intra-group wage dispersion

The second part of Table 1 displays the structure and development of intra-group wage dispersion, where these groups are again formed according to varying worker and establishment characteristics.

It portrays two main findings. First, intra-group wage dispersion differs substantially across groups. At the individual level, it increases in the workers' skill level and age, and it is larger for natives than for foreigners. At the establishment level, it is, not surprisingly, substantially larger among establishments not covered by collective bargaining agreements than among covered ones as well as slightly larger among exporters, eastern German establishments, and high-technology plants than among their respective counterparts.

Thus, most of the compositional changes outlined in the previous subsection entail a relative shift towards groups with larger within-group wage dispersion, suggesting that there should be a substantial contribution of composition effects to the increase in wage inequality.[21]

Second, in all groups, with no single execption, intra-group wage dispersion increased markedly over the period of analysis. Thus, in addition to composition effects, wage structure effects have also played a role. The magnitude of this increase again differs across groups, sometimes reenforcing initial differences in intra-group wage dispersion (e.g. in the case of education where it increased the most for the high-skilled) and sometimes dampening them (e.g. in the case of collective bargaining where intra-group wage dispersion increased more among covered than among uncovered workers).

We also display the structure and development of between- and within-establishment wage dispersion by subgroup.[22] Generally, the relative importance of both subcomponents of wage inequality differs quite substantially across subgroups. For example, the larger intra-group wage dispersion of more highly skilled and older workers is mostly driven by the within-establishment component. Relatedly, and on top of this, those groups that have high levels of intra-group wage dispersion in one subcomponent of wage inequality are not necessarily the ones that also have high levels of intra-group wage dispersion in the other subcomponent. In particular, there is smaller between-establishment, but larger within-establishment wage dispersion among establishments covered by a collective bargaining agreement than among uncovered ones. The same goes for exporting versus non-exporting establishments while the opposite holds true for establishments in eastern versus western Germany.

Over time, the between-establishment component has grown more strongly for most

[21] In fact, the only exception is the slight decrease in the share of workers employed at high-technology establishments.

[22] Note, however, that between-establishment and within-establishment wage dispersion do not have to add up to the total for every single subgroup as they are still based on the establishment-mean wages and within-establishment wage residuals that we calculated for the entire sample. The covariance between these two terms will be zero if subgroups are formed according to establishment-level characteristics – where the mean within-group wage residual is always zero by construction – but will generally not be equal to zero if subgroups are formed according to individual characteristics.

subgroups, the exception being high-skilled workers and establishments with either a firm-level or no collective agreement.

5.2.2 Mean wage gaps between groups

The overall wage structure is not only shaped by wage dispersion within groups but also by (mean) wage gaps between groups.

Note that these mean differences matter for both the composition effect and the wage structure effect of the decomposition analysis. To the extent that between-group wage differentials change, they will contribute to the wage structure effect. On the other hand, to the extent that there are compositional shifts towards groups whose (initial) group-mean wages are relatively far from (close to) the grand mean, these will contribute to greater (lower) wage inequality via the composition effect.

Table 1 also shows (unconditional) mean wages by subgroups. A strong increase in the high-to-medium skill wage gap as well as in the collective bargaining wage premium can be observed. Again, we also show separately the structure and development of between- and within-establishment mean wages.[23] Interestingly, we see that, in the skill dimension, about two thirds in the increase in the high-to-medium skill wage gap are due to the between-establishment component, providing some tentative evidence that skill-related sorting has become more important over time.

6 Decomposition results

We now turn to our detailed decomposition results based on RIF regressions and first discuss our findings for overall wage inequality. Our main specifications generally refer to the reunified Germany, but we briefly review the main results for a sample of West-Germany as well. We then turn to our separate decomposition results for between- and within-establishment wage dispersion and in further extensions, explore differences between lower-tail and upper-tail wage dispersion as well as changes over time.

6.1 Baseline decomposition of overall wage inequality

The results of our baseline decomposition of changes in the log wage variance between 1996 and 2010 are presented in Table 2, where the values represent log percentage points and generally give the joint contribution of groups of (dummy) variables belonging to the explanatory factors listed in the left column of the table. In addition to composition and wage structure effects, we also report the specification and reweighting errors for each decomposition.

Looking first at the total composition and wage structure effects, respectively, reveals that both contribute equally to the increase in wage dispersion over the sample period. Among the different factors, compositional changes associated with collective bargaining

[23] Due to the aforementioned reason that mean within-establishment wage residuals are zero by construction at the establishment level, this distinction is only interesting for groupings defined according to individual-level as opposed to establishment-level characteristics.

Table 2. Decomposition results of overall variance, 1996-2010

Observed change	5.92***	
	[0.77]	
	Composition	**Wage-structure**
Export	-0.10	-1.31
	[0.07]	[1.01]
Collective bargaining	1.55***	0.61
	[0.30]	[0.88]
Technology	-0.02	-0.20
	[0.04]	[0.62]
Occupation	0.22	2.42
	[0.23]	[2.01]
Education	0.50***	2.03***
	[0.14]	[0.39]
Age	0.71***	-0.37
	[0.09]	[0.07]
Foreign	0.03*	0.08
	[0.02]	[0.09]
East	0.53***	0.24
	[0.14]	[0.28]
Industry	0.00	0.15
	[0.12]	[3.97]
Constant		0.15
		[4.41]
Reweighting error		-0.31
		[0.20]
Specification error		-0.62
		[0.34]
Total	3.43***	3.42***
	[0.52]	[0.60]

Notes: Decomposition is based on LIAB data, manufacturing sector. Sample includes full-time male workers between 18 and 65 years of age. Table contains bootstraped standard errors in parenthesis (200 replications of the entire procedure and clustered at the industry level). Asteriks indicate statistical significance at the 1%(***), 5%(**) or 10% (*) level. To account for the rather low level of degrees of freedom, statistical inference is based on the Student's t-distribution with 14-1=13 degrees of freedom rather then the standard normal distribution.

coverage contribute the most to the increase in wage dispersion. This reflects the strong decline in (particularly sector-level) collective bargaining coverage rates discussed in Section 3. As shown in the same section, this decline supposes a relative shift towards the group of (uncovered) workers which is characterized by both higher intra-group wage dispersion and group-mean wages that are relatively far from the grand mean. The contribution of the bargaining-related composition effect amounts to 1.55 log percentage points, which corresponds to 26 percent of the total increase and almost half of the total composition effect, respectively.[24]

Among the remaining composition effects, shifts in the education and age profile of workers and in the regional structure of employment have played important roles for the increase in wage dispersion. These compositional shifts are associated with an increase in inequality of 0.50 (education), 0.71 (age), and 0.53 (region) log percentage points, respectively. As far as the education and age-related composition effect are concerned, they capture the relative shifts towards higher-educated and older workers, i.e. groups that are charecterized by a greater within-group wage dispersion (cf. Section 5.2.1; see also, e.g., Lemieux 2006 and Dustmann 2009). The region-related composition effect captures the relative increase in employment experienced by eastern Germany over the period of analysis (from 11 percent of total manufacturing employment in 1996 to 14 percent in 2010 in our sample). Given that there is a pronounced East-West gap in wages, this relative increase of eastern German employment supposes a relative shift towards the group whose (mean) wages are relatively far from the grand mean, implying greater dispersion.

In contrast, the remaining composition effects, including the ones relating to the establishments' export and technology status, are small in magnitude and/or insignificant.

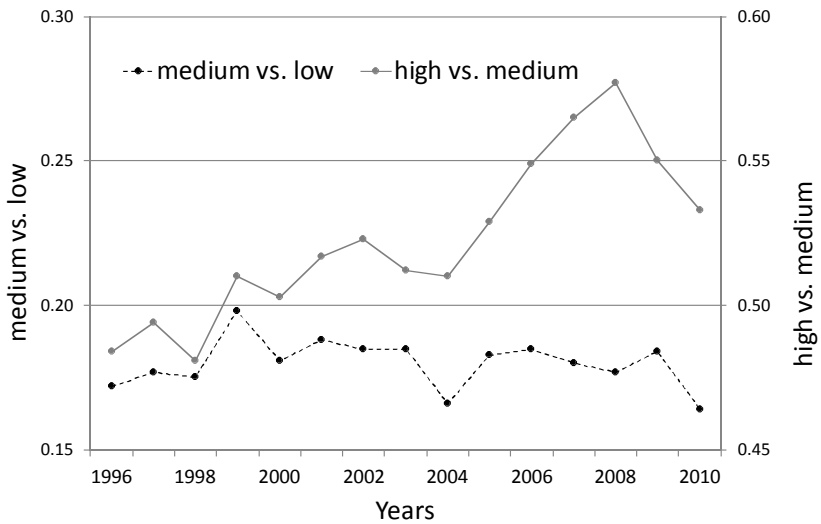
Turning to the wage structure effects, the ones associated with education and occupation of workers are the quantitavely most important ones, although only the former is statistically significant. Recall that the wage structure effects capture both a between component, that is changes in wage differentials between groups (e.g. education groups, occupations), and a within component, that is changes in wage dispersion within groups (compared to the base group). In the case of education, both of these components are at work and contribute to greater wage dispersion. On the one hand, wage dispersion among high-skilled (and low-skilled) workers increased relative to wage dispersion among medium-skilled workers, our base group. On the other hand, the skill wage premium particularly for university graduates increased markedly over the period of analysis. While the unconditional mean wage gaps discussed in Section 5.2.2 already provided some suggestive evidence in this respect, the same pattern carries through using standard Micerian wage regressions. Figure **??** plots the wage differentials between the low- and medium-skilled (left y-axis) and the medium- and high-skilled (right y-axis) over time, where the shown coefficients are based on yearly regressions of log wages on education and age dummies, as well as on sector and region indicators. While the relative skill premium between low- and medium skilled workers remained relatively stable over time, the premium of high-skilled wokers increased

[24]The magnitude of this effect is not easily comparable to previous findings by e.g. Dustmann et al. (2009) or Antonczyk et al. (2010), since they have focussed on different time periods, and - more importantly, on West-Germany only. We briefly discuss our decomposition results for the former west of Germany in Section 6.1.1.

substantially, in particular during the second half of our period of observation.

With respect to the occupation wage structure effect, we also find an inequality increasing contribution which is particularly strong at the upper part of the wage distribution. Figure 3 illustrates this finding by showing changes in smoothed wages between 1996 and 2010 for each occupation-skill percentile. It can be seen that those occupations ranked above the median-skill percentile realized increasing wage growths, while those occupations ranked below the median only show very moderate wage increases: a pattern which leads to an overall increase in wage inequality.

Figure 2. Relative skill premia.

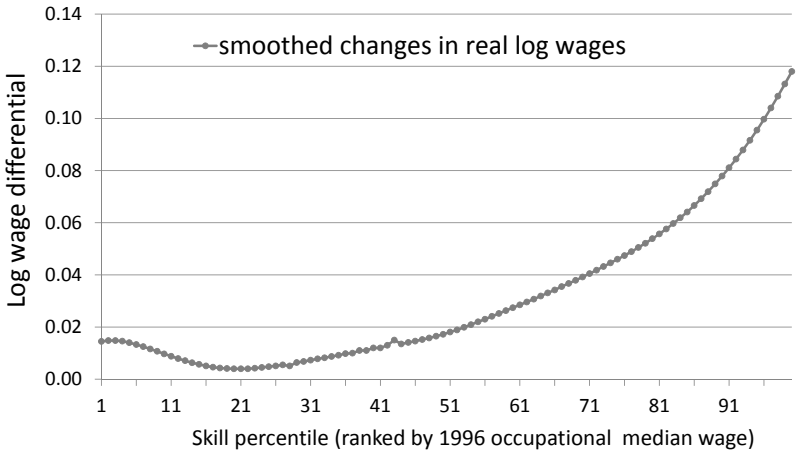


Notes: Figure 2 shows relative skill premia of medium versus low (left axis) and high versus medium (right axis) educated workers. The results are based on yearly regressions of imputed (log) wages on indicator variables for four education-, five age- , 16 region- and 23 sector-groups. Regressions are based on the LIAB data, manufacturing sector. The sample corresponds to full-time male workers between 18 and 65 years of age.

Coming back to the remaining wage structure effects, only the one related to collective bargaining coverage contributes in a quantitative important way to greater wage dispersion, although its contribution is not statistically significant. The positive point estimate reflects both a (slightly) rising collective bargaining wage premium over the period of analysis as well as rising wage dispersion among covered relative to not covered workers. The latter development has also been highlighted by Dustmann et al. (2014) and is related to an increasing flexibility within collective agreements. Interestingly, we even find the wage structure effect related to exporting to be inequality-reducing, albeit again not significant.[25] The other wage structure effects are not important determinants of greater wage dispersion.

[25]This result stands in contrast to the one obtained by Baumgarten (2013) who explicitly analyses the contribution of establishment-level exporting to wage inequality and finds that the increase in the exporter wage premium has contributed, albeit not very strongly, to increasing wage inequality. Apart from a different sampling period – the analysis of Baumgarten (2013) ends in 2007, that is before the exporter wage premium decreased during the Great Recession (cf. Dauth et al. 2015) – the main difference is that he focused only on the between

Figure 3. Wage differentials by skill percentile, 1996-2010



Notes: Figure 3 shows changes in smoothed wages, 1996-2010. It is constructed by sorting three-digit-occupations according to their median wages in 1996 (employment weighted) and then grouped into 100 equally sized groups. We employ a smoothed regression with bandwith 0.8. The analysis is based on LIAB data, manufacturing sector. The sample corresponds to full-time male workers between 18 and 65 years of age.

6.1.1 Baseline decomposition for West-Germany

pointed out: Firstly, the composition effect related to the decline in collective bargaining coverage is sizeably smaller and amounts to 0.68 log percentage points only, indicating that changes in the collective bargaining structure affected the increase in wage inequality in the eastern part of Germany disproportionately strong. For West-Germany, the composition effects related to the decline in collective bargaining coverage is roughly as important as the impact of compositional changes related to the education and age structure of the workforce.[26] Secondly, the wage structure effect related to the technology intensity of an establishment is found to have a statistically significant and economically large impact on increasing wage inequality (amounting to 1.23 log percentage points). This reflects that the technology premium increased substantially in West-Germany between 1996 and 2010 and that wage dispersion among workers employed at high technology firms inreased strongly.

component of the wage structure effect, i.e. a greater difference between exporters and non-exporters, and not on the within-component, i.e. the relatively smaller increase in wage dispersion among exporters than among non-exporters. The results of our analysis suggest that the negative within component of the wage structure effect exceeds the positive between component.

[26]The magnitude of the bargaining related composition effect is of similar size to the one obtained by Dustmann et al. (2009) who, however, did not control for any other factors except for age and education and consider the years 1995–2004. Antonczyk et al. (2010) estimate a smaller contribution of deunionization to rising wage inequality using a sequential decomposition approach which also accounts for other explanatory factors such as the industry and the size of the firm. Note, however, that the analysis of Antonczyk et al. (2010) is also based on a much shorter period of analysis (2001–2006) and does not capture the full decline in collective bargaining coverage rates.

Summing up the decomposition analysis shows that the main sources of the increase in overall wage dispersion, as measured by the log wage variance, in the German manufacturing sector over the period 1996 to 2010 are changes in the education and occupation-related wage structures as well as changes in the composition of collective bargaining coverage. The latter effect is disproportionately strong in East-Germany.

6.2 Decomposition of between- and within-plant inequality

We now separately decompose changes in between-plant and within-plant wage dispersion. For this purpose, we apply the same decomposition technique to changes in the variance of predicted wages and wage residuals, respectively, of a regression of log individual wages on a full set of establishment fixed effects. At first sight, a natural expectation could be that establishment characteristics, with their composition and wage structure effects, should be the main drivers of between-establishment wage dispersion while individual characteristics should be the main drivers of within-establishment wage dispersion. However, that does not need to be the case. To the extent that individual characteristics also matter for between-establishment wage inequality, this suggests that workers with different characteristics are unevenly distributed across establishments, providing (indirect) evidence for assortative matching. Indeed, previous research has already shown the growing importance of assortative matching, as measured by the correlation between individual and establishment effects, for wage inequality (cf. Card et al. 2013). On the other hand, to the extent that establishment characteristics matter for within-establishment wage dispersion, this suggests that these characteristics affect individual workers' wages unevenly.

We first turn to the detailed decomposition results of between-establishment wage inequality, shown in the first two columns of Table 3. As was the case with the overall variance, aggregate composition effects are roughly as important as aggregate wage structure effects. Among the composition effects, the largest contribution to the increase in between-establishment wage inequality comes again from changes in collective bargaining coverage rates. The bargaining-related composition effect amounts to 1.85 log percentage points (corresponding to 46 percent of the total increase in between-plant wage inequality or 72 percent of the total composition effect) and is, thus, even larger than its contribution to overall inequality, both in relative and absolute terms. Thus, the decline in collective bargaining, driven primarily by a strongly decreasing share of establishments covered by sector-level agreements, has been associated with a greater dispersion of wages across establishments.

The second largest contribution (0.66 log percentage points, about a quarter of the total composition effect) comes from the regional shift towards a larger share of eastern German employment. Like in the case of the overall variance, this is due to the pronounced East-West gap in establishment-level wages so that a relative increase in the group of workers whose mean wages are relatively far from the grand mean contributes to greater inequality.

Composition effects related to individual characteristics also matter, but to a much smaller extent. This applies to the explanatory factors education, occupation, and age, where only the former is statistically significant. This reflects that those worker groups with larger between-establishment wage differentials and those that are overrepresented at

Table 3. Decomposition of between-plant and within-plant variance, 1996-2010

	between-plant variance		**within-plant variance**	
Observed change	4.03***		1.89***	
	[0.56]		[0.20]	
	Composition	**Wage-structure**	**Composition**	**Wage-structure**
Export	-0.23**	0.45	0.13**	-0.75*
	[0.09]	[0.74]	[0.06]	[0.42]
Collective bargaining	1.85***	1.37	-0.27***	-0.19
	[0.26]	[0.95]	[0.08]	[0.38]
Technology	-0.02	-1.00	-0.01	0.82***
	[0.03]	[0.62]	[0.01]	[0.27]
Occupation	0.15	1.30	0.08	0.55
	[0.11]	[1.82]	[0.13]	[0.59]
Education	0.16*	0.54***	0.25***	0.38
	[0.08]	[0.16]	[0.07]	[0.22]
Age	0.06	-0.81*	0.35***	-0.01**
	[0.04]	[0.44]	[0.03]	[0.25]
Foreign	-0.01	-0.08	0.01	0.11**
	[0.01]	[0.05]	[0.01]	[0.05]
East	0.66***	0.17	-0.09***	0.23
	[0.17]	[0.23]	[0.03]	[0.10]
Industry	-0.06	0.67	0.07	-0.16
	[0.13]	[3.88]	[0.05]	[2.67]
Constant		-0.17		0.28
		[4.36		[2.81]
Reweighting error		-0.30		-0.03
		[0.17]		[0.08]
Specification error		-0.67***		0.15**
		[0.21]		[0.07]
Total	2.56***	2.44***	0.05**	1.25***
	[0.37]	[0.65]	[0.19]	[0.18]

Notes: See notes of Table 2. We construct the measure of between-plant (within-plant) variance by using yearly regressions of log individual wages on a full set of establishment fixed effects. We then take the variance of predicted (residual) wages as a measure of between-plant (within-plant) inequality.

the tails of the establishment-level wage distribution (such as high-skilled workers) have grown relative to worker groups with smaller between-establishment wage differentials and those that are overrepresented in the middle of the establishment-level wage distribution (such as medium-skilled workers). In total, the sum of composition effects associated with individual-level variables amounts to 0.36 log percentage points, corresponding to 9 percent of the total increase in between-establishment wage inequality or 14 percent of the total composition effect.

When it comes to the wage structure effects, the ones associated with collective bargaining and exporting are positively related to increasing between-establishment wage inequality, albeit not statistically significant. They reflect increasing collective bargaining and exporter wage premia as well as rising wage dispersion among covered relative to uncovered establishments. In contrast, the wage structure effect associated with technology is negative, reflecting that between-establishment wage dispersion has increased less among high-technology than among low-technology plants. Among the wage structure effects associated with worker-level variables, the ones related to education are positive, while the ones related to age are negative. The education-related wage structure effect mainly captures that establishment-level wage differentials between education groups have increased. That is, in particular the gap between the mean establishment wage of a high-skilled versus a medium-skilled worker, and the mean establishment wage gap of a worker with missing information on education versus a medium-skilled worker, has increased over time. This is likely the result of an increased assortative matching along the skill dimension, where high-skilled workers are more and more concentrated at high-wage paying plants and low skilled workers at low-wage paying plants.[27] To provide some illustrative evidence in this respect, we plot the distribution of skill groups across establishment-level wage deciles (Figure 4). It becomes apparent that from 1996 to 2010 the share of workers with missing education (low skilled) disproportionately increased at low-wage establishments, while the share of high skilled workers disproportionately sorted into high-wage plants.

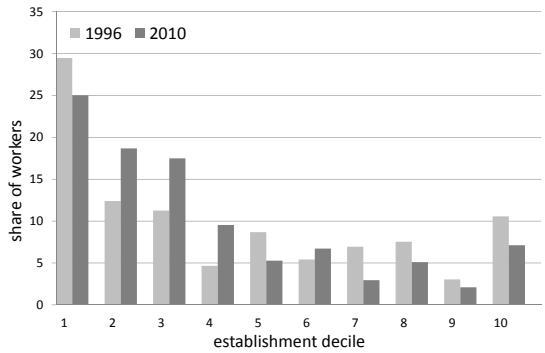
We now turn to the results on within-establishment wage inequality. Total composition effects are less important for this subcomponent of wage inequality than for between-establishment wage dispersion, contributing only slightly more than one quarter to the total increase. Partly, this is due to the very different implication of the decline in collective bargaining, which has contributed to a decline rather than an increase in within-establishment wage dispersion. This is due to the fact that, surprisingly, within-plant wage dispersion is larger among covered establishments, which most likely reflects that they are typically larger. In contrast, the composition effect associated with exporting is inequality-increasing, reflecting that the share of workers employed at exporters, which are characterized by higher within-plant wage dispersion, further increased.

Both the age and the education-related composition effects, brought about by increasing employment shares of more highly skilled and older workers, are inequality-increasing, in line with the notion that wage dispersion among these worker groups, even within estab-

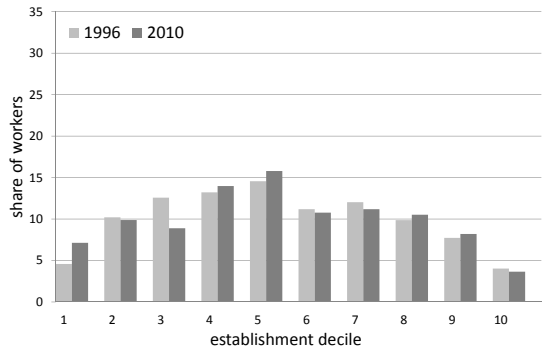
[27] Here we assume that workers with missing educational information are most likely low skilled workers. According to their unconditional mean wage gap this is a plausible assumption, see Table 1.

Figure 4. Distribution of workers on establishment deciles

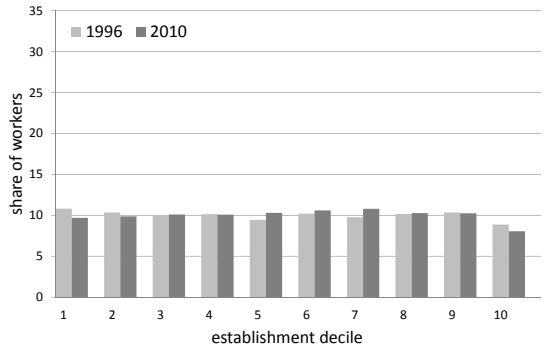
(a) Missing education



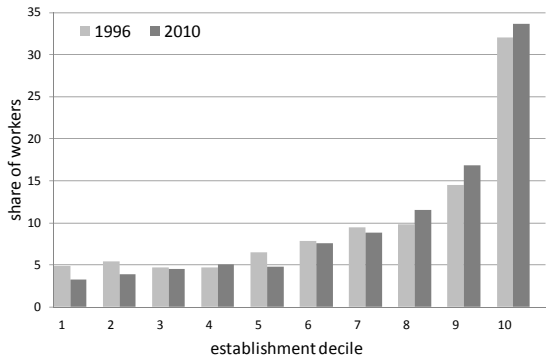
(b) Low skilled



(c) Medium skilled



(d) High skilled



Notes: Figure 4 shows the distribution of workers by education on establishment deciles for the years 1996 and 2010. Establishment groups are formed according to employment-weighted mean plant wages in both years. Figure 4a refers to workers where the information on education is missing (4 percent (8 percent) of the workforce in 1996 (2010)). According to their unconditional mean wages, this group of workers most closely resembles low skilled workers (see Table 1). All Figures are based on LIAB data and refer to the manufacturing sector. The sample corresponds to full-time male workers between 18 and 65 years of age.

lishments, is larger than for younger and less-skilled workers.

Regarding the wage structure effects, both the one associated with collective bargaining and the one associated with exporting are negative, although only the latter is (weakly) statistically significant. This implies that export behavior as well as collective coverage at the plant level have an inequality reducing impact on workers within plants. In contrast, the wage structure effect associated with technology is positive, reflecting that technology investments have an inequality increasing impact on wages within establishments. In fact, the technology-related wage structure effect is the single most important contributing factor to increasing within-plant wage inequality, amounting to 0.8 log percentage points, which corresponds to 43 percent of the overall increase and 65 percent of the total wage structure effect, respectively.

6.2.1 Between- and within-plant wage decomposition for West-Germany

Table 6 reports the results of a decomposition of between- and within-plant wages for West-Germany, respectively. Considering first the results related to the between-plant wage decomposition, again most findings of our previous analysis carry through. The most notable difference is once again related to the composition effect of collective bargaining, which are found to be smaller in magnitude for the sample of West-Germany. Turning to the decomposition of within-plant wages it can be seen that the positive wage structure effect related to technology is primarily driven by West-German plants.

In summary, this analysis shows that the main drivers of between- and within-establishment wage dispersion differ and several explanatory factors even are related to both subcomponents of wage inequality in opposing ways. While the decline in collective bargaining contributes to the increase in between-establishment wage inequality, it is negatively related to the increase in within-establishment wage inequality. In contrast, technology is correlated with growing within-establishment wage dispersion, but does not seem to matter for between-establishment wage inequality. The worker-level characteristics occupation and education are the only ones, where both the composition and wage structure effects are positively correlated with both subcomponents of wage dispersion, although the occupation-related effects are never statistically significant. Interestingly, the wage structure effect associated with education is quantitatively even more important for between-plant than for within-plant wage inequality. This mirrors the finding that most of the increase in the high-to-medium skill wage gap arises from an increase in between-establishment rather than within-establishment wage differentials, reflecting increased assortative matching along the skill dimension (in line with Card et al., 2013).

6.2.2 Top vs bottom

Although the log wage variance has the advantage that the between-plant and the within-plant subcomponents add up to the total, the downside is that it does not allow one to distinguish sources of wage dispersion at the top and the bottom of the wage distribution. Therefore, we also do our decomposition analysis for the the 50–15 log wage differential (as a measure of lower-tail wage inequality) and the 85–50 log wage differential (as a measure of upper-tail wage inequality) of both mean establishment wages and within-establishment wage residuals, respectively. Note that, now, the between-plant and the within-plant component of any inequality measure do not anymore (necessarily) add up to the total.

As far as between-plant wage inequality is concerned, more than two thirds of the increase in wage dispersion over the period of analysis (12.44 of 18.33 log percentage points) occured at the lower part of the wage distribution. And also all relevant composition effects relate to lower-tail wage inequality. This applies in particular to the composition effect associated with collective bargaining, which is 0 in the case of upper-tail wage inequality, but amounts to 5.8 log percentage points (46 percent of the total increase or 94 percent of the total composition effect) in the case of lower-tail wage inequality. Thus, the decline in collective bargaining has been associated with a widening of the lower part of the plant wage distribution, which is not surprising since there, union wages should be the most binding. A similar pattern, although quantitatively less important, can be found for the composition

effect related to the regional shift towards more eastern German employment.

When it comes to wage structure effects, it is again the one related to collective bargaining which works strongly inequality-increasing for lower-tail wage inequality. Thus, not only the decline in collective bargaining (composition effect), but also changes in the collective bargaining wage premium and rising wage dispersion within the covered (relative to the non-covered) sector (wage structure effect) have contributed to increasing wage dispersion in the lower part of the wage distribution. Considering the wage structure effects related to education we find, albeit not statistically significant, that about two thirds of the sorting along the skill dimension can be attributed to the lower part of the wage distribution, implying that assortative matching from low wage workers to low wage plants is particularly important for the rise in between-establishment wage inequality.

Regarding within-establishment wage inequality, about three quarters of the increase in total wage dispersion over the sample period took place in the upper half of the wage distribution (2.42 of 3.25 log percentage points). Turning to the individual factors and focusing primarily on the ones that previously have been found to be relevant for the development of within-plant wage dispersion, we find that the wage structure effect associated with the establishment's technology contributes the most to both lower-tail and upper-tail wage inequality. Thus, wage dispersion within high-technology plants has been strongly and monotonically increasing relative to low-technology plants. There is less monotonicity involved with other factors, which contribute asymetrically (and sometimes in opposing ways) to lower-tail and upper-tail within-plant wage dispersion. For example, the decline in collective bargaining coverage rates has been associated with an increase in lower-tail wage inequality, which, however, was compensated by an even larger decrease in upper-tail wage inequality, again reflecting the notion that union wages are binding at the bottom, but less so at the top of the wage distribution. The same pattern, although less significant, can be found for the bargaining-related wage structure effect. In contrast, age- and education-related composition effects, brought about by a relative shift towards older and more educated workers, have had an inequality-increasing effect particularly in the upper half of the wage distribution.

6.2.3 Dynamics

So far, we have analysed the contributions of the different factors to the increase in wage dispersion over the entire period of analysis, 1996 to 2010. However, these associations do not have to be constant, and it might well be the case that by focusing on a rather long time period, we omit some potentially interesting dynamics. Therefore, we redo our decomposition analyses of changes in both between-plant and within-plant wage dispersion for two equally spaced subperiods: 1996 to 2003 and 2003 to 2010. For simplicity, we now again focus on the variance of wages as a summary measure of overall wage dispersion. Results are displayed in Table 5.

Focusing first on the total observed increase, it can be seen that between-plant wage inequality increased more strongly in the later period, while within-plant wage inequality have grown more steadily.

Turning to between-plant wage dispersion, the relative importance of composition and

Table 4. Decomposition of quantile differences, 1996-2010

	between-plant			within-plant		
Inequality measure	**85-15**	**50-15**	**85-50**	**85-15**	**50-15**	**85-50**
Observed change	18.33***	12.44***	5.89	3.25***	0.83	2.42***
	[3.34]	[2.39]	[3.56]	[1.08]	[0.52]	[0.79]
Composition						
Export	-1.70**	-1.14**	-0.56	0.55**	-0.02	0.57*
	[0.67]	[0.44]	[0.43]	[0.25]	[0.07]	[0.29]
Collective bargaining	5.76**	5.76**	0.00	-1.35***	0.43*	-1.78***
	[2.76]	[2.23]	[1.12]	[0.46]	[0.23]	[0.39]
Technology	-0.14	-0.04	-0.10	-0.01	0.00	-0.02
	[0.28]	[0.15]	[0.25]	[0.07]	[0.03]	[0.06]
Occupation	0.68	-0.01	0.68	0.45	0.05	0.41
	[0.90]	[0.55]	[0.71]	[0.82]	[0.26]	[0.64]
Education	0.62	0.23	0.39	0.52**	0.01	0.51**
	[0.36]	[0.25]	[0.24]	[0.23]	[0.07]	[0.20]
Age	0.02	-0.14	0.16	1.90***	0.17***	1.73***
	[0.19]	[0.19]	[0.17]	[0.21]	[0.08]	[0.23]
Foreign	-0.10	-0.09*	-0.01	-0.01	0.00	-0.01
	[0.08]	[0.05]	[0.04]	[0.02]	[0.02]	[0.02]
East	2.42**	2.27*	0.16	-0.35**	-0.17**	-0.18
	[1.08]	[1.17]	[0.33]	[0.14]	[0.07]	[0.11]
Industry	-0.53	-0.69	0.16	0.30	-0.15	0.45
	[0.96]	[0.48]	[0.74]	[0.28]	[0.11]	[0.29]
Total	7.03	6.15*	0.89	2.00*	0.33	1.68*
	[4.29]	[3.00]	[1.66]	[1.06]	[0.33]	[0.84]
Wage-structure						
Export	5.53	7.45	-1.92	-2.07	-0.46	-1.61
	[9.21]	[8.48]	[3.64]	[2.39]	[1.04]	[2.00]
Collective bargaining	13.34*	20.55***	-7.21	-2.46	1.33	-3.79*
	[6.88]	[7.11]	[5.44]	[2.52]	[1.29]	[2.04]
Technology	0.39	-0.07	0.46	4.36**	2.02**	2.34*
	[4.16]	[3.54]	[3.57]	[1.64]	[0.74]	[1.24]
Occupation	-1.50	-7.04	5.54	-0.10	-2.15	2.05
	[8.18]	[8.31]	[4.09]	[2.66]	[1.80]	[3.12]
Education	2.41	1.62	0.80	0.40	-0.04	0.44
	[1.45]	[1.38]	[0.67]	[1.11]	[0.40]	[0.85]
Age	-3.27	-1.87	-1.40	-0.62	-0.81	0.19
	[2.84]	[2.25]	[1.17]	[1.34]	[0.85]	[1.09]
Foreign	-0.39	-0.49	0.10	0.43*	0.30**	0.13
	[0.41]	[0.40]	[0.21]	[0.22]	[0.11]	[0.18]
East	-10.96**	-10.44**	-0.52	0.93	0.31	0.62
	[4.38]	[4.41]	[0.92]	[0.57]	[0.20]	[0.51]
Industry	1.21	-1.96	3.17	-3.62	-0.28	-3.34
	[27.12]	[22.89]	[24.22]	[10.82]	[6.45]	[11.44]
Constant	3.62	-3.38	7.00	3.23	-0.10	3.33
	[32.59]	[26.76]	[25.41]	[11.82]	[6.86]	[11.52]
Reweighting error	-1.32	-1.15	-0.17	-0.28	-0.03	-0.26
	[1.19]	[1.13]	[0.35]	[0.46]	[0.13]	[0.36]
Specification error	2.23	3.08	-0.85	1.04	0.41	0.63
	[3.25]	[3.06]	[1.25]	[0.62]	[0.32]	[0.64]
Total	10.39**	4.36	6.02**	0.49	0.12	0.37
	[4.43]	[3.56]	[2.80]	[1.07]	[0.36]	[1.08]

Notes: See notes of Table 2. We construct the measure of between-plant (within-plant) variance by using yearly regressions of log individual wages on a full set of establishment fixed effects. We then take the variance of predicted (residual) wages as a measure of between-plant (within-plant) inequality.

Table 5. Decomposition of variance, 1996-2003 & 2003-2010

	1996-2003	2003-2010	1996-2003	2003-2010
	between-plant		within-plant	
Inequality measure	**variance**	**variance**	**variance**	**variance**
Observed change	1.59***	2.44***	0.95***	0.93***
	[0.43]	[0.53]	[0.17]	[0.14]
Composition				
Export	-0.13*	-0.16*	0.08	0.03
	[0.07]	[0.09]	[0.05]	[0.02]
Collective bargaining	1.05***	0.32*	-0.15***	0.00
	[0.15]	[0.18]	[0.05]	[0.03]
Technology	0.02	0.06	0.02	-0.07**
	[0.05]	[0.08]	[0.02]	[0.03]
Occupation	0.08	0.07	0.05	0.05
	[0.08]	[0.07]	[0.08]	[0.09]
Education	0.05	0.06*	0.10***	0.19***
	[0.03]	[0.04]	[0.03]	[0.06]
Age	0.01	0.03	0.15***	0.18***
	[0.02]	[0.02]	[0.02]	[0.03]
Foreign	0.00	-0.01	0.00	0.01
	[0.00]	[0.01]	[0.00]	[0.00]
East	0.30***	0.28**	-0.04***	-0.03**
	[0.10]	[0.11]	[0.01]	[0.02]
Industry	0.02	-0.05	0.03	-0.01
	[0.11]	[0.16]	[0.03]	[0.04]
Total	1.40***	0.59*	0.23*	0.33**
	[0.26]	[0.33]	[0.13]	[0.12]
Wage-structure				
Export	-1.22*	1.16**	-0.46	-0.31
	[0.62]	[0.54]	[0.35]	[0.28]
Collective bargaining	1.92***	-0.32	-0.66	0.04
	[0.84]	[0.56]	[0.40]	[0.28]
Technology	-0.53	-0.66**	0.64**	0.07
	[0.53]	[0.11]	[0.30]	[0.35]
Occupation	-0.26	0.99*	0.48	-0.85
	[1.25]	[0.16]	[0.35]	[0.67]
Education	0.22*	0.33***	0.24*	0.16
	[0.12]	[0.33]	[0.13]	[0.11]
Age	-0.02	-0.51**	-0.27	0.54***
	[0.22]	[0.22]	[0.18]	[0.18]
Foreign	-0.03	-0.03	0.01	0.07**
	[0.05]	[0.05]	[0.04]	[0.03]
East	-0.13	0.13	0.04	0.11**
	[0.17]	[0.18]	[0.07]	[0.04]
Industry	-0.04	0.19	-0.11	0.12
	[5.78]	[6.16]	[2.22]	[2.37]
Constant	0.67	0.87	0.82	0.68
	[5.84]	[6.12]	[2.22]	[2.54]
Reweighting error	-0.13	-0.04	-0.05	-0.02
	[0.09]	[0.06]	[0.04]	[0.03]
Specification error	-0.26*	-0.26***	0.05	-0.02
	[0.13]	[0.09]	[0.03]	[0.05]
Total	0.58	2.14***	0.72***	0.64***
	[0.46]	[0.52]	[0.15]	[0.10]

Notes: See notes of Table 2. We construct the measure of between-plant (within-plant) variance by using yearly regressions of log individual wages on a full set of establishment fixed effects. We then take the variance of predicted (residual) wages as a measure of between-plant (within-plant) inequality.

wage structure effects also changed over time. While in the first period the ratio of total composition to wage structure effects is 2.4 to 1, it inverts to 1 to 4 in the second period. Changes in collective bargaining seem to be at the core of this development. In the first period, both the composition and the wage structure effect of collective bargaining are by far the most important determinants of the increase in between-plant wage dispersion, while in the second period, the bargaining-related composition effect is still positive, but much smaller in magnitude and only weakly statistically significant, and the bargaining-related wage structure effect is insignificant. In contrast, several other wage structure effects, most notably the ones relating to exporting, occupation (though insignificant), and education gain substantial importance in the later period. It is conceivable that these patterns are interrelated. That is, it seems quite likely that in a setting, where collective bargaining coverage rates have already gone down (to some extent) and wages within the unionized sector have become more flexible/dispersed, productivity characteristics at the individual (e.g. education) and the establishment level (e.g. exporting) become more relevant in the wage setting process, which in turn leads to greater wage dispersion.

Changes with respect to within-plant wage dispersion are less drastic. For example, composition effects associated with age and education contribute almost equally to greater within-plant wage dispersion in both subperiods. Still, some differences between the subperiods do exist. The (now again negative) composition effect related to collective bargaing is again concentrated in the earlier subperiod, while several wage structure effects (relating to age, nationality, and region) become more important in the later subperiod, similar to the pattern found for between-plant wage inequality. However, interestingly and in contrast to this general pattern, the most important determinant of the change in within-establishment wage dispersion, the wage structure effect associated with technology, refers almost entirely to the earlier period 1996 to 2003. It is reasonable to assume that this finding primarily reflects technological reasons – e.g., the internet revolution mainly occured in the first subperiod.

7 Summary and conclusion

Like many other countries, Germany experienced a strong increase in wage dispersion in the recent past. Much of this increase took place between as opposed to within establishments, in line with an increasing international evidence.

In this paper, we have used rich linked employer-employee data and applied a detailed decomposition analysis based on recentered influence function (RIF) regressions to identify the sources of this increase in wage dispersion in the German manufacturing sector. In doing so, we have paid particular attention to the importance of establishment characteristics and to the divergent sources of between-establishment and within-establishment wage dispersion, respectively.

Our main decomposition results point to the decline in collective bargaining as a main driver for the increase in wage inequality and we find that this effect is stronger in eastern than in western Germany. In addition to that, changes in the skill- and occupation-related wage structure are main sources of increased overall wage dispersion.

The same factors and in addition, shifts in the regional employment structure and a widening of the wage distribution among establishments covered by collective bargaining, also contributed to increased between-establishment wage inequality. Thus, not only characteristics attached to the establishments – most notably the wage bargaining regime – , but also changes in the wage structure associated with specific individual-level attributes – i.e., education – are responsible for the increasing divergence of wages paid at different establishments. This individual-level component of rising between-establishment wage dispersion reflects increased sorting of workers along the skill dimension.

Among the remaining establishment characteristics, both the technology intensity and the export status are of little quantitative importance for the increase in overall wage dispersion over the full period of analysis. However, they do matter for subcompents of wage dispersion and subperiods, respectively. In particular, technology is a main driver of increased within-plant wage inequality (but negatively related to between-establishment wage dispersion), reflecting that particularly in high-technology plants, workers' wages have developed very unevenly. In contrast, the incresing exporter wage premium has become an important factor of rising between-establishment wage inequality in more recent years.

Not only the export status of the establishment, but also the education and the occupation of the worker have become more important for the wage-setting process over time. In contrast, the decline in collective bargaining coverage rates as well as an increasing dispersion within the covered sector have been more relevant in the first half of our period of analysis. We interpret this as tentative evidence that the decline in collective bargaining did not only have an immediate impact on the wage structure but also gave rise to an increasing importance of other productivity characteristics. Digging deeper into this interrelation is an interesting avenue for future research.

It is important to note, however, that, while the decomposition analysis has enabled us to identify the proximate sources of increased wage dispersion between and within establishments, we are not able to attach to them a causal interpretation in a deeper, structural sense. For example, the decline in collective bargaining came not about exogenously but was the result of firms' endogeneous choices.[28] It is perfectly conceivable that these in turn are caused by changes in the competitive environment, potentially induced, e.g., by an accelerated globalization.[29] Therefore, relating the proximate sources of rising wage inequality identified in our analysis to deeper structural causes is a high priority for future research.

[28]In the German institutional setting, firms are essentially free to choose their bargaining regime.

[29]Dustmann et al. (2014) indeed suggest that rising opportunities to offshore production induced by the fall of the iron curtain contributed to a rising flexibilisation of wages within the covered sector.

Table 6. Main decomposition results for West-Germany only

	overall variance		between-plant variance		within-plant variance	
Observed change	5.40***		3.41***		2.04***	
	[0.91]		[0.77]		[0.21]	
	Composition effects	**Wage-structure effects**	**Composition effects**	**Wage-structure effects**	**Composition effects**	**Wage-structure effects**
Export	-0.09	-0.74	-0.21***	1.21	0.14**	-0.88
	[0.05]	[1.11]	[0.07]	[0.86]	[0.06]	[0.60]
Collective bargaining	0.68**	-0.63	1.01***	0.71	-0.29**	-0.37
	[0.31]	[1.05]	[0.24]	[1.05]	[0.12]	[0.60]
Technology	-0.02	1.23**	-0.02	0.18	0.00	1.02***
	[0.04]	[0.45]	[0.03]	[0.44]	[0.02]	[0.34]
Occupation	0.18	2.54**	0.02	0.67	0.24	1.28
	[0.29]	[1.01]	[0.11]	[0.95]	[0.19]	[0.82]
Education	0.76***	1.40***	0.23**	0.26	0.36***	0.03
	[0.23]	[0.45]	[0.09]	[0.25]	[0.10]	[0.23]
Age	0.63***	-0.14	-0.01	-0.36	0.38***	-0.25
	[0.08]	[0.66]	[0.02]	[0.32]	[0.04]	[0.31]
Foreign	0.01	0.00	-0.01*	-0.11	0.00	0.12**
	[0.01]	[0.09]	[0.01]	[0.07]	[0.01]	[0.06]
Industry	0.22	0.19	0.12	1.26	0.11	-0.24
	[0.23]	[6.06]	[0.18]	[3.62]	[0.07]	[3.29]
Constant		-0.28		-1.27		0.34
		[6.34]		[3.91]		[3.58]
Reweighting error		-0.13		0.02		-0.15
		[0.25]		[0.13]		[0.15]
Specification error		-0.37		-0.28		0.20*
		[0.34]		[0.19]		[0.10]
Total	2.36***	3.59***	1.13***	2.55***	0.94***	1.05***
	[0.01]	[0.68]	[0.35]	[0.69]	[0.28]	[0.22]

Notes: Analysis is based on West-Germany only. For additional information see notes of Table 2. We construct the measure of between-plant (within-plant) variance by using yearly regressions of log individual wages on a full set of establishment fixed effects. We then take the variance of predicted (residual) wages as a measure of between-plant (within-plant) inequality.

Table 7. Means and Standard Deviations of Main Variables

LIAB	**1996**		**2010**	
(A) worker-level	mean	std. dev.	mean	std. dev.
log daily real wage	4.488	0.365	4.514	0.439
education: missing	0.035	0.185	0.082	0.274
education: low	0.160	0.367	0.120	0.325
education: medium	0.725	0.447	0.698	0.459
education: high	0.080	0.271	0.100	0.300
age: 18-25	0.074	0.261	0.060	0.238
age: 26-35	0.321	0.467	0.178	0.383
age: 36-45	0.287	0.452	0.298	0.457
age: 46-55	0.224	0.417	0.329	0.470
age: 56-65	0.094	0.292	0.134	0.341
foreign citizenship (0/1)	0.103	0.324	0.075	0.263
east Germany (0/1)	0.111	0.314	0.142	0.349
exporter (0/1)	0.677	0.468	0.756	0.429
investment in ICT (0/1)	0.616	0.486	0.594	0.491
high technological status (0/1)	0.195	0.396	0.161	0.367
collective agreement sector-level (0/1)	0.778	0.416	0.529	0.499
collective agreement firm-level (0/1)	0.105	0.306	0.121	0.326
Number of observations (unweighted)	558152		388621	
(B) establishment-level	mean	std. dev.	mean	std. dev.
exporter (0/1)	0.200	0.400	0.314	0.464
investment in ICT (0/1)	0.340	0.474	0.288	0.453
high technological status (0 /1)	0.156	0.363	0.120	0.325
collective agreement sector-level (0/1)	0.534	0.499	0.321	0.467
collective agreement firm-level (0/1)	0.106	0.308	0.035	0.185
east Germany (0/1)	0.199	0.400	0.232	0.422
Number of observations (unweighted)	1524		2836	

SIAB	**1996**		**2010**	
(C) worker-level	mean	std. dev.	mean	std. dev.
log daily real wage	4.438	0.374	4.492	0.472
education: missing	0.049	0.216	0.087	0.292
education: low	0.175	0.380	0.112	0.316
education: medium	0.687	0.464	0.679	0.470
education: high	0.089	0.285	0.122	0.327
age: 18-25	0.081	0.273	0.062	0.062
age: 26-35	0.317	0.465	0.194	0.194
age: 36-45	0.281	0.450	0.299	0.299
age: 46-55	0.222	0.416	0.315	0.315
age: 56-65	0.099	0.298	0.129	0.129
foreign citizenship (0/1)	0.116	0.321	0.083	0.277
east Germany (0/1)	0.095	0.293	0.115	0.320
Number of observations	106402		88721	

Notes: Panel (A) and (B) are based on the LIAB data and refer to our estimation sample for the years 1996 and 2010. For sample restrictions see Section 2. Education groups are defined as: 1) low: no vocational training, no high-school; 2) medium: high school and/or vocational training; 3) high: university or technical college. The fourth category consists of observations with missing educational information. Sampling weights are employed. In panel (C) we report comparable statistics based on the SIAB data, a representative two percent sample of all employment biographies, which is also provided by the IAB. The statistics are based on a comparable sample of all employment spells as of the 30. June in the SIAB data. The statistics are very similar across both datasets, ensuring the representativeness of the LIAB data.

References

Acemoglu, D., Autor, D.H., 2011. Skills, Tasks and Technologies: Implications for Employment and Earnings. in: Ashenfelter, O., Card, D., Handbook of Labor Economics, 4B, Elsevier, Amsterdam, 1043-1171.

Akerman, A., Helpman, E., Itskhoki, O., Muendler, M.A., Redding, S, 2013. Sources of Wage Inequality. American Economic Review Papers & Proceedings 103 (3), 214-19.

Antonczyk, D., Fitzenberger, B., Sommerfeld, K., 2010. Rising wage inequality, the decline of collective bargaining, and the gender wage gap. Labour Economics 17 (5), 835-847.

Autor, D.H., Katz, L.F., Kearney, M.S., 2006. The polarization of the U.S. labor market. American Economic Review Papers & Proceedings 96 (2), 189-194.

Autor, D.H., Katz, L.F., Kearney, M.S., 2008. Trends in US wage inequality: revisting the revisionists. The Review of Economics and Statistics, 90, 300-323.

Autor, D.H., Levy, F., Murnane,R.J., 2003. The skill content of recent technological change: an empirical exploration. Quarterly Journal of Economics 118 (4), 1279-1333.

Barth, E., Bryson, A., Davis, J.C., Freeman, R., 2014. It's where you work: Increases in earnings dispersion across establishments and individuals in the U.S. NBER Working Paper No. 20447.

Baumgarten, D., 2013. Exporters and the rise in wage inequality: Evidence from German linked employer-employee data. Journal of International Economics 90 (1), 201-217.

Card, D., Heining, J., Kline, P., 2013. Workplace heterogeneity and the rise of West German wage inequality. Quarterly Journal of Economics 128 (3), 967-1015.

Chernozhukov, V., Fermandez-Val, I., Melly, B., 2013. Inference on Counterfactual Distributions. Econometrica 81 (6) 2205-2268.

Dauth, W., Schmerer, H.J., Winkler, E., forthcoming. Exporters and Wage Inequality during the Great Recession - Evidence from Germany. Economics Letters.

Davis, S.J., Haltiwanger, J., 1991, Wage Dispersion between and within U.S. Manufacturing Plants, 1963-86. Brookings Papers on Economic Activity. Microeconomics 115-200.

DiNardo, J., Fortin, N., Lemieux, T., 1996. Labor market institutions and the distribution of wages, 1973-1992: A semiparametric approach. Econometrica 64 (5), 1001-1044.

Dunne, T., Foster, L., Haltiwanger, J., Troske, K.R., 2004. Wage and productivity dispersion in United States manufacturing: the role of computer investment. Journal of Labor Economics 22 (2), 397-429.

Dustmann, C., Fitzenberger, B., J., Schönberg, U., Spitz-Oener, A., 2014. From Sick Man of Europe to Economic Superstar: Germany's Resurgent Economy. Journal of Economic Perspectives 28 (1), 167-188.

Dustmann, C., Ludsteck, J., Schönberg, U., 2009. Revisting the German wage structure.

Quarterly Journal of Economics 124 (2), 843-881.

Egger, H., Egger, P., Kreickemeier, U., 2013. Trade, wages, and profits. European Economic Review 64, 332-350.

Egger, H., Kreickemeier, U., 2012. Fairness, trade, and inequality. Journal of International Economics 86(2), 184-196.

Faggio, G., Salvanes, K.G., van Reenen, J., 2010. The evolution of inequality in productivity and wages: panel data evidence. Industrial and Corporate Change 19 (6), 1919-1951.

Felbermayr, G. Prat, Impullitti, G., Prat, J., 2014. Firm dynamics and residual inequality in open economies. CESifo Working Paper Series No. 4666.

Firpo, S., Fortin, N.M., Lemieux, T., 2009. Unconditional quantile regressions. Econometrica 77 (3), 953-973.

Firpo, S., Fortin, N. M., Lemieux, T., 2014. Occupational Tasks and Changes in the Wage Structure. mimeo: University of British Columbia.

Fitzenberger, B., Kohn, K., Lembcke, A.C., 2013. Union Density and Varieties of Coverage: The Anatomy of Union Wage Effects in Germany. Industrial Labor Relations Review 66(1):169-97.

Fortin, N., Lemieux, T., Firpo, S., 2011. Decomposition Methods in Economics. in: Ashenfelter, O., Card, D., Handbook of Labor Economics, 4A, Elsevier, Amsterdam, 1-102.

Goldschmidt, D., Schmieder, J.F., 2015. The rise of domestic outsourcing and the evolution of the German wage structure.

Goos, M., Manning, A., 2007. Lousy and lovely jobs: the rising polarization of work in Britain. Review of Economics and Statistics 89 (1), 118-133.

Goos, M., Manning, A., Salomons, A., 2009. Job Polarization in Europe. American Economic Review Papers & Proceedings 99 (2), 58-63.

Handwerker, E.W., Spletzer, J.R., 2015. The role of establishments and the concentration of occupations in wage inequality. IZA Discussion paper No. 9294.

Helpman, E., Itskhoki, O., Muendler, M.-A., Redding, S., 2012. Trade and Inequality: From Theory to Estimation. NBER Working Paper No. 17991.

Helpman, E., Itskhoki, O., Redding, S., 2010. Inequality and unemployment in a global economy. Econometrica 78 (4), 1239-1283.

Lemieux, T., 2006. Increasing residual wage inequality: Composition effects, noisy data, or rising demand for skill? The American Economic Review 96 (3), 461-498.

Shorrocks, A.F., 1980. The class of additively decomposable inequality measures. Econometrica 48 (3), 613-625.

Song, J., Price, D.J., Guvenen, F., Bloom, N., 2015. Firming up inequality. CEP Discussion Paper No. 1354.

Ifo Working Papers

No. 215 Felbermayr, G., Economic Analysis of TTIP, April 2016.

No. 214 Karmann, A., F. Rösel und M. Schneider, Produktivitätsmotor Gesundheitswirtschaft: Finanziert sich der medizinisch-technische Fortschritt selbst?, April 2016.

No. 213 Felbermayr, G., J. Gröschl and T. Steinwachs, The Trade Effects of Border Controls: Evidence from the European Schengen Agreement, April 2016.

No. 212 Butz, A. und K. Wohlrabe, Die Ökonomen-Rankings 2015 von Handelsblatt, FAZ und RePEc: Methodik, Ergebnisse, Kritik und Vergleich, März 2016.

No. 211 Qian, X. and A. Steiner, International Reserves, External Debt Maturity, and the Reinforcement Effect for Financial Stability, March 2016.

No. 210 Hristov, N., The Ifo DSGE Model for the German Economy, February 2016.

No. 209 Weber, M., The short-run and long-run effects of decentralizing public employment services, January 2016.

No. 208 Felfe, C. and J. Saurer, Granting Birthright Citizenship – A Door Opener for Immigrant Children's Educational Participation and Success?, December 2015.

No. 207 Angerer, S., P. Lergetporer, D. Glätzle-Rützler and M. Sutter, How to measure time preferences in children – A comparison of two methods, October 2015.

No. 206 Kluge, J., Sectoral Diversification as Insurance against Economic Instability, September 2015.

No. 205 Kluge, J. and M. Weber, Decomposing the German East-West wage gap, September 2015.

No. 204 Marz, W. and J. Pfeiffer, Carbon Taxes, Oil Monopoly and Petrodollar Recycling, September 2015.

No. 203 Berg, T.O., Forecast Accuracy of a BVAR under Alternative Specifications of the Zero Lower Bound, August 2015.

No. 202 Henderson, M.B., P. Lergetporer, P.E. Peterson, K. Werner, M.R. West and L. Woessmann, Is Seeing Believing? How Americans and Germans Think about their Schools, August 2015.

No. 201 Reischmann, M., Creative Accounting and Electoral Motives: Evidence from OECD Countries, July 2015.

No. 200 Angerer, S., D. Glätzle-Rützler, P. Lergetporer and M. Sutter, Cooperation and discrimination within and across language borders: Evidence from children in a bilingual city, May 2015.

No. 199 Schulz, B., Wage Rigidity and Labor Market Dynamics with Sorting, May 2015.

No. 198 Jochimsen, B. and R. Lehmann, On the political economy of national tax revenue forecasts – Evidence from OECD countries, March 2015.

No. 197 Marz, W. and J. Pfeiffer, Resource Market Power and Levels of Knowledge in General Equilibrium, March 2015.

No. 196 Lehmann, R., Survey-based indicators vs. hard data: What improves export forecasts in Europe?, March 2015.

No. 195 Fabritz, N., ICT as an Enabler of Innovation: Evidence from German Microdata, January 2015.

No. 194 Kauder, B. and N. Potrafke, Just hire your spouse! Evidence from a political scandal in Bavaria, December 2014.

No. 193 Seiler, C., Mode Preferences in Business Surveys: Evidence from Germany, November 2014.

No. 192 Kleemann, M. and M. Wiegand, Are Real Effects of Credit Supply Overestimated? Bias from Firms' Current Situation and Future Expectations, November 2014.

No. 191 Kauder, B, Spatial Administrative Structure and Intra-Metropolitan Tax Competition, October 2014.

No. 190 Auer, W. and N. Danzer, Fixed-Term Employment and Fertility: Evidence from German Micro Data, October 2014.