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Industrial Relations and the Wage Differentials within Firms*

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Abstract

Increased wage inequality between skilled and unskilled workers is a stylized fact, which can be observed in many developed countries. Among the explanations advanced for this phenomenon is the increasing globalization, a skill-biased technical progress, restructuring of the firms, and last but not least, a decreasing importance of industrial relations institutions. In the paper, we investigate in a three-step procedure with German firms' data whether the latter determinant is influential. We control for the other relevant explanations and split industrial relations into three components – coverage of collective bargaining, existence of a works council, and union density – within a four-equation model. We find an insignificant influence of the union density. A works council compresses the wage differentials between skilled and unskilled blue-collar workers while coverage is effective in the opposite direction.

Zusammenfassung

In vielen Industrieländern lässt sich eine zunehmende Ungleichheit der Löhne zwischen qualifizierten und unqualifizierten Beschäftigten beobachten. Unter den wichtigsten Erklärungen für dieses Phänomen ist neben fortschreitender Globalisierung, qualifikationsverzerrendem technischen Fortschritt und der Reorganisation von Betrieben auch die rückläufige Bedeutung industrieller Beziehungen zu nennen. In diesem Beitrag wird in einem dreistufigen Verfahren mit Betriebsdaten aus Niedersachsen empirisch untersucht, ob eine schwache Ausprägung industrieller Beziehungen innerhalb von Unternehmen zur Vergrößerung der Lohnunterschiede beiträgt. Drei Komponenten dienen der Messung industrieller Beziehungen: Tarifbindung, Betriebsräte und gewerkschaftlicher Organisationsgrad. Unter Berücksichtigung der anderen Erklärungsansätze werden die einzelnen Einflüsse im Rahmen eines Vier-Gleichungsmodells geschätzt. Es zeigt sich, dass der gewerkschaftliche Organisationsgrad keinen Einfluss auf die innerbetriebliche Lohnungleichheit hat. Die Existenz von Betriebsräten verringert die Lohnspreizung und Tarifbindung bewirkt das Gegenteil.

JEL classification numbers: J31, J51

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1. Introduction

In the last years, the discussion on wage inequality has intensified in response to recent empirical trends. Especially in the United States and in the United Kingdom real wages have stagnated or declined for unskilled workers, while skilled workers have improved their position. The most commonly cited explanations for this change are the increasing globalization of the economy, skill-biased technical progress and organizational change. Furthermore, a declining influence of unions and changes in the institutional framework are mentioned. However, in Germany and other European countries empirical investigations on the aggregate level find a nearly stable wage structure.

We believe that in order to learn more about the actual wage differences we have to go beyond aggregate level studies and turn to the analysis of firms' data. Particular attention should be devoted to differences within establishments. Even if flexibility and wage dispersion appear to be weak on the macroeconomic level enormous differences may still prevail between and within establishments. Some firms are flexible and have adjusted to the necessities of globalized economies, while others are extremely inflexible. In this case, policy interventions, which affect all enterprises in the same way, are inefficient. The intention of this paper is to bring some light into this darkness. Our investigation focuses on the impact of industrial relations on firms' wage structure given that industrial relations are more important in Germany than in other countries.

The paper is organized as follows. In section 2, we discuss some theoretical arguments, in which way industrial relations may affect the firm's internal wage structures. Section 3 briefly reviews existing empirical evidence, followed by a presentation of our own analysis in section 4. We first provide some descriptive statistics and then expose results of a three-step multivariate analysis including corrected instrumental variables (IV) estimates, principal component analysis and determination of a wage differential function. In the final section, we summarize our results.

2. Theoretical framework

Industrial relations institutions are frequently discussed under the topic of „unionization" in the literature. One of the objectives of the unions is redistribution. Usually, they prefer a less dispersed wage structure across as well as within firms. Several explanations can be found for that line of reasoning (e.g. Blau and Kahn 1999, Freeman and Medoff 1984, Katz and Autor 1999, Lemieux 1998). Firstly, workers' solidarity requires a relatively uni-

form wage distribution. The consensus among workers will be jeopardized if wage differences between skilled and unskilled employees are too large. Secondly, unions are political institutions representing membership interests, where particular consideration is given to the median voter. Thus, unions focus on the median wage which usually falls below the average wage and support an adjustment of the former to the latter. Thirdly, as Agell and Lommerud (1992) have emphasized, given the potential arbitrariness in measuring individual productivity, risk-averse workers prefer a narrow wage distribution. Unions will take account of these preferences in their objective functions.

Unions can approach their goal of compressing pay differentials by establishing job categories for specific tasks and qualifications with a single wage for each category (Freeman and Medoff 1984). Subsequently, the wages of the groups at the lower end of the distribution are raised relatively to the other or the lowest wage group is disestablished altogether. Additionally, the unions may bargain for a hard core of wage increase („Sockel") in the yearly wage rounds, i. e. a uniform amount of money for all groups.

Often, the impact of unionization on the wage structure is considered to be connected with trade union density (e.g. Card 1996, Lewis 1986). Within the institutional setting of Germany, however, this may be misleading, since collective agreements are not exclusively applied to union members. Bargaining coverage (Tarifbindung) is the more appropriate phenomenon, which is given for all member firms of an employer's association and for enterprises signing a single employer contract. Looking at the relationship between coverage and wage differentials, we also have to take into account objectives and behavior of employers. In principle, coverage by collective bargaining may be used as an instrument to stabilize employment and the wage structure. Employers and employees are usually interested in stable contracts. Workers are risk-averse and firms favor stability because it simplifies planning and thus decision making under uncertainty. Notwithstanding, situations do exist, in which adjustments are necessary and more important than stability. Firms in particular need flexibility and seek to complement „Tarifbindung" (coverage) with measures that permit the necessary adjustments. One possibility is to implement a wide effective wage structure by a strong wage drift or by using the whole range of negotiated wage groups. Flexibility and adjustment follow by selective hiring and firing.

Decentralized wage bargaining allows an adjustment of the wage level and of the wage structure to the market requirements. Both, high wages and large wage differentials, may be incentives to enhance effort of the employees by gift exchange (Akerlof 1984). Higher wages correspond to higher uti-

lity of the workers. Large wage differentials between skilled and unskilled workers and within the firm's hierarchy indicate better chances to improve the worker's wage position by investment in human capital or by promotion. Whether firms choose the wage differential or the wage level option as a motivator depends on several reasons. Following incentive arguments the latter option is preferable, because effort is affected more directly. Whether enhanced effort leads to promotion is uncertain. Furthermore, especially in the case of teamwork, wide wage differentials may be seen as unfair. Then, those who are not promoted reduce their effort and intrigue against other workers with negative consequences for productivity (Dye 1984, p. 184). Therefore we expect that firms more often adjust by changing the wage level and avoid the disadvantages of the wage structure option. Only firms that are not covered by a collective bargaining agreement can adjust by changing the wage level. In a recession, these firms lay off unskilled workers, while the wage of skilled workers will be reduced. Insider power avoids dismissals of skilled workers. The same firms experience stronger and faster wage increases during an economic recovery. Furthermore, these establishments may adjust by training of unskilled workers if the productivity gap between skilled and unskilled workers exceeds the respective wage gap (Pischke 1998). As firms without „Tarifbindung" are on average more successful, have a higher productivity (Hübler / Jirjahn 2001, Table 6, line constant) and can fund training measures more easily, this behavior seems more likely.

Freeman and Medoff (1984) stress that a trade union is a vehicle for collective voice – that is, for providing the work force with a mean of communicating with management. But in Germany, works councils instead of the unions seem to express the collective voice. A works council offers the prospect of an improvement in the joint surplus of the enterprise via processes of information, exchange, consultation, and participation (Freeman, Lazear 1995). Sometimes, the council negotiates works agreements supplementing wages bargained at industry levels. Wage drift is systematically higher in works council regimes (Hübler / Jirjahn 2001, Table 5, line works council). The distributional conflict is a factor that will always interfere with the ability of the works councils to achieve the benefits of participation. Workers' share of the surplus increases with the absolute surplus, while profits decline relatively. Profits may also decline in absolute terms because knowledge and involvement constitute power.

Management's use of the works councils as a communicator to workers can set an incentive for effort on the part of workers. Consultations allow new solutions. Codetermination provides workers with more security and, therefore, encourages workers to consider the firm's objectives. Works councils also help to restrain influence activities. They can convince the employ-

ees that co-operation among the workers and with the management strengthens the employee's position and increases their earnings. This results in a higher effort, less shirking and less fluctuation, a lower degree of absenteeism and a higher investment in specific human capital. If works councils have also partial control over the management's decisions, we can expect that the latter will be improved. Altogether, the voice function of works councils can explain a positive correlation between the existence of such councils and the wage level. In addition, redistribution between employers and employees may result via rent sharing.

Works councils are engaged in activities to enhance the productivity and in rent seeking (Hübler / Jirjahn 2001). As high wage differentials give incentives to more effort they support a wide wage spread under incentive aspects. If the productivity of unskilled workers is not affected by the activities of works councils to the same extent as the productivity of their skilled colleagues wage differentials may also change. On the one hand, we should expect that works councils have more influence on unskilled workers than on skilled workers. The former have more confidence in their organization, while the latter usually work with high effort even without the support of a works council. A depressed wage distribution should follow. Although councils are not entitled to determine the wage level, their rights include the assignment to pay grouping. This affects the wage dispersion. The more workers are assigned to one or only few wage groups the lower the wage dispersion. On the other hand, works councils are more sensitive than unions to the positive incentive effects of a wide wage spread. If the wage spread increases productivity and enlarges the firm's surplus, it could imply a better net result for all.

A further indirect mechanism, which induces a negative relationship between industrial relations institutions and wage differentials, may be the pattern of variable pay schemes. The more variability a payment scheme permits the larger the corresponding wage differential. Incentives that pertain to individual performance, like piece rates, increase the dispersion of earnings within establishments and undermine conventional wage policy (Freeman 1982). The function of works councils differs a little bit from that of unions. One can argue that the works council can help the management to find the best scheme of payment for the firm. Piece rates should not suffer from managerial arbitrariness. Therefore, the employer and the works council have to find an agreement that determines the premia and piece rates. On the one hand, costs can be saved by these negotiations compared with separate agreements. In addition, on the other hand, workers confine the works council so that influence activities can be avoided. In a non-co-operative regime piece rates will generate extremely high ongoing costs of influence activities.

Summarizing the previous arguments – especially worker's solidarity, median voter interests, risk aversion of workers – the industrial relations institutions are expected to reduce the skilled-unskilled wage differential though there may be circumstances leading to other outcomes. The industrial relations are characterized by three variables indicating (1) the existence of coverage by collective agreements, (2) works councils and (3) trade union density at the establishment level. The indicators describe partially different and partially joint effects on the wage differential between skilled and unskilled workers. For the empirical analysis we can formulate the following expected industrial relations effects:

- Coverage by collective bargaining should be an instrument to stabilize employment and the wage structure. This is associated with standardization and favours narrow differentials. But as collective bargaining reduces the firm's possibility to adjust the wage level to specific market requirements firms may use variation in the wage dispersion as an instrument to necessary adjustment and a wide wage spread as an incentive to more effort.
- Works councils are like unions representative agents of the workforce and should have similar depressing effects on the skilled-unskilled wage differential. However, if works councils give superior weight to incentive arguments they may support wide differentials as well.
- The standard arguments speak principally in favour of a negative effect of unions on wage dispersion for the overall economy. However, trade union density at the establishment level is only a weak indicator of the power of the workforce in wage determination, since collective agreements are mostly negotiated at industry levels and the collective voice of the employees is expressed by the works council. Therefore, the influence may be negligible.

3. Previous empirical evidence

Over the past years, literature on the increasing wage inequality based on aggregated data has burgeoned and studies using individual data became fairly common. Neither studies with aggregated nor with individual data are satisfying. The former may mask opposite effects, which are compensated at the aggregated level. The latter can only partially detect effects working at the firm level. However, these should be important for the skilled-unskilled wage differential, since most determinants are firm specific. Investigations, which use firm's data and analyze the relationship between wage differentials and industrial relations, are almost completely missing.

Fortin and Lemieux (1997) present some evidence on the role of institutional changes on wage distribution in the United States. Deunionization primarily affects men's wages. Graphs illustrate the wage distribution among unionized and non-unionized workers and show that deunionizations have contributed to the erosion of the middle of the wage distribution. Freeman (1993) finds that deunionization explains a fifth of the increase in male wage inequality from the 1970s to the late 1980s, while DiNardo, Fortin and Lemieux (1996) estimate a percentage between 14 and 20 percent. Lucifora (1999) has conducted an international comparison of how labor market institutions affect wage inequality and low pay. Based on aggregated data from 20 OECD countries he finds a negative correlation between union density and the wage differential, measured by the log of the ratio of the top- to the floor-decile. Higher union density appears to be associated with lower wage dispersion, while no effect is detected for the coverage or the centralization of collective bargaining.

Blau and Kahn (1999) summarize the impact of labor market institutions on wage dispersion from a macroeconomic perspective. According to their result, the overall variance in pay is smaller in countries where unions are more prevalent. They find some general evidence that the degree of centralization of wage-setting institutions tends to be associated with lower wage inequality. Flanagan (1999) confirms this outcome, although he mentions that the negative cross-country relationship between the centralization of collective bargaining and wage dispersion weakened somewhat in the early 1990s.

Card's (1998) results from a longitudinal study with CPS data suggest that unions raise wages for workers with lower rather than higher levels of observed skills. In the same vein, based on a sample from NLS over the period 1980 – 1989, Vella and Verbeek (1998) show that individuals with characteristics typically associated with lower wages receive larger union premia. However, union wage gains may be overestimated, since unobserved heterogeneity, which positively contributes to the likelihood of union membership, is associated with higher wages.

Haskel (1999) investigates effects on changes in log relative wages of skilled and unskilled work in UK manufacturing. Using a panel of 80 industries over 1980 – 1989 he finds among others negative, but insignificant effects of an increase in union density on the wage differential. He argues that imprecision may be due to mismeasurement. Data are not available on the change in the relative unionization of the skilled and unskilled.

German studies using firm's data concentrate on the effects of industrial relations on firms' performance. Among others, their influence on the average wage level is investigated (FitzRoy, Kraft 1985, Addison, Schnabel,

Wagner 2001, Jirjahn, Klodt 1999). The latter confirm that firms with a works council pay significantly higher wages, while FitzRoy and Kraft do not find any significant influence. The effect of coverage by collective bargaining is not so obvious. Jirjahn, Klodt (1999) find insignificant negative effects. If the sample is split into firms with and without „Tarifbindung", the significant works council effect remains only in the latter. It is however interesting to note that the effect of coverage on the existence of piece rate payment is positive. In firms covered by collective bargaining the existence of a works council increases the probability of piece rate payment (Heywood, Hübler, Jirjahn 1998). Fitzenberger (1999) and Kraft (1994) have conducted studies with German industry data, which investigate the effects of unions on wage differentials. The latter does not find that active unions influence the ratio of skilled to unskilled worker's wage. The former has more differentiated results. But in the majority of the estimates the union effect is also insignificant, especially in the non-manufacturing sector.

Also research conducted by Gerlach, Hübler, Meyer (1999) does not support the hypothesis that industrial relations affect wage differentials. Their study uses firms' data from the state of Lower Saxony and a composite measure for industrial relations, which is determined as a factor of a principal component analysis.

In nucleus we know the following from the existing empirical studies:

- Deunionization has contributed to wage inequality in the overall economy.
- An increasing degree of centralization of wage setting has no effect on the wage inequality in the cross-country comparison.
- Unions raise wages for unskilled workers.
- Industry studies cannot find significant union effects on wage differentials.
- Firm level studies show that works councils have effects on the wage level, the payment scheme and the productivity. But the effects differ between firms with and without collective bargaining.

Up to now the influence of industrial relations institutions on the wage differential is an open question.

4. Empirical analysis

4.1 Data and descriptive results

Our empirical analysis is based on the „Hannover Panel" (Brand et al. 1998), which is a sample-survey of establishments designed as a panel study with four years of coverage (1994 – 1997). The population covered encompasses manufacturing establishments with at least five employees in the first wave, and which are located in the German federal state of Lower Saxony (Niedersachsen). The sample is stratified according to establishment size and industry. The data were collected in face to face interviews with firm owners or top managers. The questionnaires covered various aspects of firm structure, firm behavior and firm performance with an emphasis on issues relating to personnel. A total of 1025 establishments took part in the first wave of the Hannover Panel (1994). Due to panel mortality, the number of participating firms has diminished in the following years. In the last year, after four waves, 711 establishments still participated.

For the empirical analysis of the skilled-unskilled wage differential an indicator is needed that does not mix wage level and wage structure effects. If, for example, the wages of all employees in a firm are increasing with the same percentage due to the works council's acting, then both, the average wage and the standard deviation, also increase with the same percentage. In order to avoid this artificial effect the coefficient of variation or the relative wage span between the highest and the lowest wage per hour should be applied. The Hannover Panel includes information about the last item in the fourth wave, since respondents were asked:

> *Can you approximately tell us the difference in percent between the highest effective hourly wage rate of a skilled blue-collar worker and the lowest effective hourly wage rate of an unskilled blue-collar worker in your establishment?*

The respondents were asked to give a 'guesstimate'. However, during the data-collecting phase no interviewer reported difficulties concerning this question. 617 firms answered consistently.[1] The wage differential is on average 38.0 percent. Since according to aggregate statistics this differential is roughly one third, the reported values seem to be reasonable.[2] One could

[1] Nine firms without a production department were discarded from the analysis, since the question focused on the wage differential in the production.

[2] Based on the „Lohn- and Gehaltsstrukturerhebung 1995" qualified blue-collar workers [group 1a] earn 34.5/35.0 percent (female/male) more than unqualified workers [group 3] (Kaukewitsch 1998, 50). Nevertheless, many firms in our sample provide only rounded data. Figures like 5 percent, 10 percent and so on are overrepresented. From this fact one might conclude that our dependent variable is suspect and,

suppose that our measure of the wage span is not closely related to more common measures of wage differentials. We cannot answer this problem definitely, however, evidence from another data set gives us some insight.[3] The interesting question is now: Does the wage differential correspond to differences in industrial relations?

The first indicator characterizing industrial relations employed in our analysis is coverage. Collective agreements are usually negotiated at the industry level. The contracts are binding for unionized workers whose employer is either a member of an employers' organization or signed a single-employer contract. Additionally, experience has shown that in those cases where the employer is not forced by law to apply the negotiated conditions he will frequently do so voluntarily, because of threat effects, equity considerations or in order to save transaction costs. Therefore, we have four types of coverage:

1. establishments covered by multi-employer contracts, $N = 344$,
2. establishments covered by single-employer contracts, $N = 52$,
3. establishments voluntarily applying multi-employer contracts, $N = 123$,
4. establishments not covered and not applying collective contracts, $N = 98$.

In the following, we concentrate on firms of type one and four. These types are in fact contrasting and should be a suitable basis for an analysis of the impact of coverage, while the other two types are hybrid. This is straightforward for firms applying contracts voluntarily, but it may also be true for single-employer bargaining: On the one hand, they are covered by collective agreements. On the other hand, decentralized bargaining at the enterprise level allows having regard to the particular situation of the company, as is the case with non-coverage. However, the results presented later on are not only valid for the restricted sample (see Table 4, line [10] and [11]).

The other central element of industrial relations in Germany concerns the co-determination system. In firms with five or more employees a works council may be elected by the work force (Addison, Schnabel, Wagner 1997). Since this is exactly the minimum size for firms to be selected into our sample every establishment could have a works council. However, Table 1 shows

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therefore, the results are not reliable. However, we demonstrate in the next subsection that this guess is not plausible.

[3] Using the data from the Socio-Economic Panel (SOEP) we have calculated the correlation coefficient r between wage differentials of skilled and unskilled employees (Meister-Ungelernte) and wage dispersion over 16 years (1984 – 1999). The outcome is: r=0.766.

in the upper part that in only two thirds of the firms the employees make use of this opportunity. As an additional indicator of the industrial relations, the union density at establishment level is displayed in the table. The figures are similarly clustered as the wage differentials, since management has no exact information about the number of union members in the establishment. But we can say that density is rather low in firms without a works council and without coverage and rather high in the opposite cases.

Table 1

Industrial relations, firm size and skilled-unskilled wage differential within manufacturing establishments in Lower Saxony 1997[a], $N = 442$[b]

Type	Establishments covered by multi-employer contracts	Establishments with a works council	Share in the sample	Union density	Average number of employees	Wage differential	|t-test| on differences in wage differential
			percent	percent	*n*	percent	
A	No	–	22.2	12.2	75.1	35.1	
B	Yes	–	77.8	41.6	180.8	38.6	AB 0.99
C	–	No	35.4	4.0	40.7	33.0	
D	–	Yes	64.6	54.3	218.3	40.0	CD 2.15**
E	No	No	15.8	1.9	41.6	31.2	
F	Yes	No	19.6	5.7	40.1	34.5	EF 0.70
G	No	Yes	6.4	42.7	148.8	39.1	EG 1.01
H	Yes	Yes	58.3	55.3	225.8	40.1	EH 2.13**

*/**/*** denote significance at the 0.10 / 0.05 / 0.01 levels, respectively.
[a] Information concerning the works council is based on Wave 3, which was collected in 1996.
[b] Because of missing values concerning the items works council and union density the size of the sample is in some cases smaller.

Source: Hannover Panel, Wave 3 and 4.

The last two columns of Table 1 give information about the variation in the skilled-unskilled wage differential according to the existence or non-existence of the aforementioned institutions. In establishments covered by collective agreements or provided with a works council, the wage differential is higher than in their counterparts without such institutions. However, the difference is statistically significant in one case only (comparison of type C with D). At first sight, the basic hypothesis that industrial relations institutions reduce the skilled-unskilled wage differential seems not to be corroborated by the data.

In the lower part of Table 1, the establishments are grouped with respect to both institutions simultaneously. Type E firms have neither coverage nor a works council; type H firms, on the contrary, have both. The latter group

covers the bulk of the sample.[4] The other two types are characterized by a single institution, either coverage (F) or works council (G). Again, the data do not confirm the basic hypothesis that the industrial relations institutions dampen wage inequality. The wage differentials of groups F to H are higher than in the reference group E. The works council seems to have a greater impact on the differentials than the unions via collective agreements.

The results presented above, however, may be distorted by a firm size bias. One should expect that large firms have on average a very differentiated workplace structure, which requires both – at least some – low skilled workers on the one hand and very high skilled on the other hand. A wide wage differential should hence prevail in large firms. Small and middle-sized firms, by contrast, will often have only one category of workplaces, either skilled or unskilled, leading to a smaller difference between the highest and the lowest wage. Table 1 clearly shows a positive correlation between firm size and the appearance of industrial relations institutions and this is well documented in the literature (Addison, Schnabel, Wagner 1997). Therefore, the firm size may be the factual driving force of the observed differences in the wage differentials. Apparently, a multivariate analysis is necessary to control for that possibility.

4.2 Methods and results of the multivariate analysis

A multiple regression model can be used to study the impact of industrial relations on the skilled-unskilled wage differential with controls for other determinants of wage dispersion. These may be variables affecting the workplace structure and the marginal productivity of the employees working at the highest and lowest skilled position. Potentially important variables are grouped into the following conceptual areas: Globalization of the economy, skill-biased technical progress and restructuring of the enterprise (Snower 1999, Gerlach, Hübler, Meyer 1999). Global markets with an expansion of international trade lead countries with relatively abundant skilled labour towards greater specialization in skill-intensive goods. Therefore the wages for unskilled tend to a lower level combined with a wider wage differential. Technical progress is also skilled-biased. New technologies replace unskilled workers and ask for more skilled workers. For example, skilled workers use and can use computers much more than unskilled. This change in the demand for labour induces more wage inequality between skill groups. Also the influence of organizational change tends to

[4] For the underlying population, the share of firms with coverage and a works council is considerably lower, since we have an oversampling of large firms, in which the existence of industrial relations institutions is more likely.

increase earnings inequality. Lindbeck and Snower (1996) describe the restructuring of firms in the last decade as a transformation from a tayloristic to a holistic organization. This means a switch from task-orientation to customer-orientation. These new organizations require team-members with a broader range of skills. Multi-skilling and multi-tasking are necessary for job rotation, cooperation and communication. Again unskilled workers are displaced by skilled and a larger wage spread between these two groups of workers is an expected consequence.

For the purpose of empirical investigations, suitable indicators need to be developed for these theoretical constructs. Numerous variables exist, which may be included in regression models to describe these fields. The following list contains the theoretical constructs and the indicators employed in our investigation.

- *Industrial relations:*
  Coverage by multi-employer contracts (d – dummy variable), existence of a works council (d), union density at establishment level measured as percentage of union members.
- *Globalization of the establishment:*
  Percentage of sales exported, most important market (4 categories: 1, if 'regional', 2 if 'national', 3 if 'EU-market', 4 if 'world market'), co-operation with foreign firms (d), firm owns foreign establishments (d), firm is owned by a foreign enterprise (d).
- *Technical progress:*
  R&D expenditures as a percentage of sales, new patents (d), product innovation (d), process innovation (d), technical level of the machinery (4 categories: 1 if 'newest level', 2 if 'satisfactory', 3 if 'modernization is desired', 4 if 'modernization is necessary').
- *Restructuring of the enterprise:*
  Basic organizational changes, e.g. introduction of profit centers (d), closing of parts of the establishment (d), transfer of parts of the establishment to other company business units (d), foundation of parts of the establishment as separate business unit (d), integration of outside business units (d).
- *Additional controls:*
  Firm size, percentage of female employees, existence of training on-the-job financed by the firm, 4 industry dummies.[5]

[5] In the third wave of the panel, 14 industries are taken into account. However, some of them are only staffed with very few establishments. In a preliminary investigation, wage differentials with respect to all 14 industries were estimated with food industry as control group. Only four industries differed considerably in the impact from that of the control group. Therefore, we enlarged the reference sector and

The indicators used to measure globalization, technical progress and restructuring are far from being perfect. However, their connections with the theoretical items seem to be clear. The percentage of female employees and training on-the-job describe the workplace structure and the productivity. The larger the former the wider the expected differential at the lower end of the wage structure due to incentive arguments. The upper wage spread should rise with an increase of the training because not all employees participate to the same extent. Skilled workers with high wages have a better chance of further training than unskilled. The industry dummies are additional indicators of the workplace structure.

Estimates of a regression model with the variables listed above give no clear answer to our issue. The estimated coefficients for the three industrial relations variables are all insignificant, and most other regressors are insignificant, too.[6] Because of strong multicollinearity and simultaneity, the results are not reliable. We expect that especially firm size affects wage differentials directly and indirectly via industrial relations (IR). However, other firm characteristics are also highly correlated. Furthermore, interdependencies are supposed between the coverage of a firm, the existence of a works council and union density within the firm. In addition, simultaneity between IR variables and wage differentials cannot be excluded. Our major hypothesis is related to the effects of IR on wage spread. However, the inverse relationship makes sense, too. If few workers earn very much but the majority of employees has only low income the latter might try to reduce the wage gap by union membership or by choosing a works council. Firms might favour collective bargaining if wage differentials are too low due to strong insider power. For covered firms decentralized decisions are less important, the influence of insiders drops and therefore higher wage differentials may follow. If interdependencies are neglected both effects can compensate.

We attempt to solve these problems by a stepwise procedure. First, we correct the industrial relations indicators from the firm size impact. Next, we reduce the number of explanatory variables and thus the dimension of the design matrix. We conduct a principal component analysis. Finally, we estimate a regression model with factor scores obtained from the principal

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use dummies only for those industries with a t-value greater than one: Textiles / clothes, chemical industry, quarry industry / glass / ceramics, production of iron-metal goods.

[6] A regression with the wage differential as dependent variable and the above listed independent variables gives the following results with respect to the industrial relations variables (estimated coefficients and t-statistics in parentheses): coverage 2.11 (0.40); works council –5.49 (-0.90); union density 0.02 (0.25). Only five of the 26 regressors are statistically significant at conventional levels. The complete results are not presented in the tables, but may be obtained from the authors on request.

component analysis, corrected industrial relations' indicators, and some additional variables including firm size.

In the first step, the variables indicating coverage, existence of a works council and union density have to be adjusted for firm size effects. The method of correction is demonstrated for the coverage variable. At first, the reduced form of a probit model to determine the probability of coverage is estimated within a four-equation model[7]

$$(1) \qquad \text{prob}\ (coverage = 1)_i = \Phi\Big[\hat{\beta}_0 + \hat{\beta}_1 \cdot firm\ size_i + \hat{\beta}_2 \cdot (firm\ size_i)^2 + \sum_k \hat{\beta}_k \cdot x_{ik}\Big] = \Phi\ [\text{probit}_i]\ .$$

This is the first stage analogously to 2SLS in a linear simultaneous regression model and this means that also the interdependence between the IR-variables is considered. The difference to conventional models is the nonlinearity of (1). The covariates x_k incorporate the determinants of coverage (Bellmann, Schnabel, Kohaut 1999), the determinants of works councils (Addison, Schnabel, Wagner 1997), the determinants of union density (Klodt, Meyer 1998), and additional regressors of the wage differential equation estimated at the third step.[8] From this estimated equation, the probability of coverage is determined excluding the impact of firm size

$$(2) \qquad \text{prob}\ (coverage = 1)_i^{corr} = \Phi\Big[\text{probit}_i - \hat{\beta}_1 \cdot firm\ size_i - \hat{\beta}_2 \cdot (firm\ size_i)^2\Big]\ .$$

The same procedure is applied to the variable works council. A probit model with the same right hand side variables is estimated and then the probability that an establishment has a works council is calculated neglecting the firm size effect. Since union density is not a dummy variable, we estimate this equation by OLS instead of ML method for the probit model but with the same regressors as the base for the firm size correction.

In the second step, we reduce the numerous indicators listed above for globalization, technical progress and restructuring by factor analysis using the principal component method. The number of extracted factors can be determined by the number of factors with an eigenvalue greater than 1 following Kaiser and Dickman (1959). In our data set, five factors fulfil the

[7] These refer to the wage differential, coverage, union density, and works council function.

[8] A complete list is given in Appendix A, excluding the last four variables.

condition. This model explains 56 percent of the variance. Employing the factor scores in the regression model to explain the skilled-unskilled wage differential is statistically unsatisfactory. Only three of five factors show a significant impact on the differential. Additionally, it is difficult to interpret the extracted five factors in the light of the theoretical arguments discussed above.

Interpretation is much easier if the number of factors is restricted to two. Statistically, this restriction can be justified by the Scree test (Cattell 1966). According to this concept, factors should not be included in the analysis if their eigenvalues decrease slowly in comparison to factors of higher order. If we follow this approach, only 34 percent of the variance are explained. Table 2 presents the matrix of the rotated factor loadings.

Table 2

Rotated factor matrix based on indicators of globalization, technical progress and restructuring of the enterprise, following the varimax criterion, $N = 348$

Variable	Factor 1	Factor 2
Globalization of the establishment		
Percentage of sales exported	0.78999	0.02784
Most important market, 4 categories	0.81057	0.03266
Co-operation with foreign firms	0.60112	0.17785
Firm owns foreign establishments	0.59072	0.14378
Firm is owned by a foreign enterprise	0.48887	-0.02790
Technical progress		
R&D expenditures as a percentage of sales, 3 categories	0.69340	0.13561
New patents	0.62923	0.19724
Product innovation	0.49187	0.26786
Process innovation	0.04465	0.35044
Technical level of the machinery[a], 4 categories	0.15177	0.05617
Restructuring of the enterprise		
Basic organizational changes	0.17676	0.47131
Closing of parts of the establishment	-0.11385	0.69197
Transfer of establishment parts to other company business units	0.02133	0.37457
Foundation of parts of the establishment as separate business unit	-0.12463	0.73341
Integration of outside business units	-0.00193	0.10142

[a] Information is based on Wave 3, which was collected in 1996.

Source: Hannover Panel, Wave 3 and 4.

Usually, the first factor is a joint factor. According to Table 2, this factor integrates the two theoretical items globalization and technical progress. Six of ten variables of this joint group have loadings on the first factor above 0.5, a number that is often used as a boundary for interpretation of influence. Two other variables are near this critical value. The finding that globalization and technical progress are integrated into a joint factor corresponds with the difficulty to separate the influence of these items (Leamer 1996, p. 311). The second factor loads on variables characterizing the restructuring of the enterprise, especially closure or outsourcing of parts of the establishment.

The last step of our investigation focuses on how the adjusted indicators of industrial relations (step 1), the factor scores of the two extracted factors (step 2), and firm size affect the skilled-unskilled wage differential. This means we model this step analogously to the second stage of the 2SLS method. In other words, we use the results of the first stage as instruments in the second stage, since the 2SLS estimator is an IV estimator. Instrumental variables methods use only a portion of the variability in key variables to estimate the relationship of interest (Angrist / Krueger 2001). The results of these estimates are presented in Table 3 under the heading of model 1. The asymptotic estimation of the variance-covariance matrix V follows Hübler (1989, p. 289, (17.53) where the variance of the error term is determined by (17.52) and the error term follows p. 250 (15.7)). The roots of the main diagonal elements in V give us the standard errors of the coefficients $\hat{\beta}$. The asymptotic t-values, $\hat{\beta}/s_{\hat{\beta}}$, are presented in Table 3. We have listed the predetermined (exogenous) variables in Appendix A, which are the base of the instruments, the estimated probabilities.

To overcome the multicollinearity problem due to the numerous indicators of our three explanations for wage inequality the principal component analysis is used as the factors are orthogonal. Our solution of the simultaneity problem between IR variables and wage differentials is the IV estimator, analogously to the 2SLS estimator in linear models. But there arises a further collinearity, namely between firm size and the IV variables of IR because firm size is a relevant determinant of the IR functions. If we suppress firm size in the IR functions misspecification follows. However, if we estimate the complete IR functions and adjust the predictions of the IR variables by suppressing the firm size effect, the corrected predictions of IR are highly correlated with the correct prediction but uncorrelated with firm size in the wage differential equation. Now, the firm size variable combines the direct and the indirect effects via IR on wage differentials in the latter equation. In order to check for the relative importance of the several determinants the beta coefficients are displayed.

Table 3

Determinants of the skilled-unskilled wage differential, $N = 315$

Determinants	Model 1		Model 2		Model 3	
	Beta coefficient (| t-value |) [|robust[a] t-value|]					
Probability of coverage[b]	0.156**	(2.159)	0.220***	(3.102)	0.174**	(2.314)
	**	[2.394]	***	[2.832]	***	[2.847]
Probability of a works council[b]	-0.128	(1.347)	-0.242**	(2.549)	-0.195**	(1.983)
		[1.604]	**	[2.567]	**	[2.113]
Union density[b]	-0.048	(0.579)	0.077	(0.379)	0.093	(1.063)
		[0.742]		[0.911]		[1.029]
Factor 1[c]	0.160**	(2.225)	0.159**	(2.270)	0.158**	(2.263)
	**	[1.987]	**	[2.030]	**	[2.111]
Factor 2[d]	0.127**	(2.265)	0.103*	(1.879)	0.101*	(1.828)
	**	[1.987]	*	[1.741]	*	[1.623]
Firm size (number of employees)	0.198***	(3.197)	0.146**	(2.396)	0.129**	(2.108)
	***	[2.778]	**	[2.582]	*	[1.893]
Percentage of female employees	–		0.265***	(4.576)	0.332***	(5.236)
			***	[2.706]	***	[2.666])
Training on-the-job firm financed	–		0.148**	(2.506)	0.147**	(2.443)
			***	[2.582]	**	[2.515]
Industry dummies (4)	no		no		yes	
Adjusted R-squared	0.073		0.140		0.154	
F-test [$H_0 : \beta_1 = 0$, in $y = x_1'\beta_1 + u$]	5.12***		7.37***		5.74***	
F-test [$H_0 : \beta_2 = 0$ or $\beta_3 = 0$, in $y = x_1'\beta_1 + x_2'\beta_2 + (x_3'\beta_3) + u$]	–		12.92***		2.25*	
RESET using powers of the fitted values of y	1.15		5.44***		7.70***	
RESET using powers of the independent variables	1.26		0.85		0.73	

*/**/*** denote significance at the 0.10 / 0.05 / 0.01 levels, respectively.
[a] Heteroscedasticity-consistent (White 1980).
[b] The variable is estimated and adjusted by the firm size effects.
[c] Factor 1 indicates globalization and technical progress.
[d] Factor 2 indicates restructuring of the enterprise.

Source: Hannover Panel, Wave 3 and 4.

The regression results of model 1 clearly show that globalization / technical progress, restructuring and firm size[9] have a significant impact on the skilled-unskilled wage differential. The signs of the coefficients confirm the expectations. A more intense globalization and skill-biased technical pro-

[9] In the estimates of the first step, firm size squared is used as an additional regressor, since it is a significant explanatory variable of the works council equation. However, including this variable in the wage differential equation does not increase the explanatory power. The coefficient is insignificant and the other results are nearly unchanged.

gress, a greater relevance of restructuring or a greater firm size all result in a wider differential. Referring to the industrial relations indicators, the results are mixed. On the one hand, the coefficients of the works council and union density are negative, thus, confirming the hypothesis of the dampening impact of industrial relations. Yet, the low t-values indicate that the coefficients are not significantly different from zero. On the other hand, the result for the coverage variable is statistically significant, but the coefficient is positive. If we base our judgment concerning significance on the corrected t-values using heteroscedasticity-constistent (robust) standard errors the findings are the same. The adjusted coefficient of determination is rather low. From a theoretical point of view, this is not surprising, since the explanatory factors that were included in the regression are only rough indicators of the marginal productivity at the highest and lowest workplace of an establishment. However, from a statistical point of view the message of Ramsey's RESET is that the null hypothesis of a correct specification is not rejected.

In model 2 further indicators of the work place structure are added: the percentage of female employees and a dummy variable for the existence of further training on-the-job within the firm. Both tend to widen the differential as expected. If the former variable rises, the difference between skilled and unskilled wages widens at the lower end, while it is most likely that the latter determinant extends the differential of the better paid workers. Both coefficients are significant at conventional levels and should be included in the estimation according to the F-test, checking for the joint influence of the additional regressors ($H_0 : \beta_2 = 0$). A look at the results for the core variables of our investigation modifies the findings of the first model. The results regarding coverage are unchanged, i.e. coverage widens the differential significantly, and the union density is still without influence. However, the impact of the works council is now negative and statistically significant. If a firm has a works council, the differential is smaller compared to firms without this institution.

Since the first version of the RESET approach of model 2, which uses powers of the fitted values of the endogenous variable, rejects the hypothesis of a correct specification, model 3 is augmented by four industry dummies. The hypothesis that no industry effects exist ($H_0 : \beta_3 = 0$) has to be rejected. A look at Table 3, column 3 shows that the values of the estimated beta coefficients change only slightly and the essence of the estimation is still the same. Signs, significance and relative importance of the variables remain unchanged. If an establishment is covered by collective agreements, the skilled-unskilled wage differential is wider than in uncovered firms. The existence of a works council has an opposite effect and the size of union density is irrelevant for the differential. The comparison of the beta coeffi-

cients makes obvious that the coverage and the works council effects are stronger than that of most other determinants. Only the percentage of female workers is more important.

In the following we conduct some robustness checks of model 3. The results of that model are satisfactory referring to the statistical indicators, except for the first RESET. This points to omitted variables or non-linear relationships. Augmenting the equation by further available indicators of the workplace structure as for example a team dummy variable or by indicators of specific elements of the remuneration like profit sharing does not change the results substantially (see Table 4, line [1] and [2]). Since firm size is a crucial variable for the nexus between the wage differential and the industrial relations, model 3 is reestimated with different indicators, namely powers of the number of employees and discrete dummies for firm size classes (see Table 4, line [3] and [4]). But again, the main results persist.

If we use a Box-Cox transformation of the dependent variable of model 3 the statistical problem vanishes. In this case, also the first version of RESET does not reject the hypothesis of a correct specification. The results regarding signs, significance and relative importance of the variables are the same (see Table 4, line [5]). The only exception refers to the coefficient of the works council, which is no longer statistically significant ($|t\text{-value}| = 1.277$).

As the wage differential cannot be negative a log or logit representation of the dependent variable might be preferable. Then one has to adjust the values if the wage differentials are zero and 100 percent or more, respectively. Another procedure is to exclude those observations and to correct for a possible sample selection bias by an additional regressor (Heckman 1979). All these modifications do not change our major results (see Table 4, line [6] and [7]).

A further check is also related to the dependent variable. As the values of wage differentials are clustered around 5 percent, 10 percent and so on, we make an experiment to test whether our results are robust if more disaggregated values are available. We assume that the true values are uniformly distributed on an interval $[-5, +5]$ around the reported values. This means that the observed dependent variable (WD) is modified by the following disaggregated partially simulated wage differential:

$$WDS = \begin{cases} WD + 10Z - 5 & \text{if} \quad \text{I} = 0 \\ WD & \text{otherwise} ; \end{cases} \tag{3}$$

where $I = WD/5 - \text{int}(WD/5)$ with int (.) as integer and Z is an uniformly distributed random variable on the interval [0, 1]. If WDS instead of WD is used line [8], Table 4, follows. Only slight differences to the benchmark

Table 4

Robustness checks of Model 3

Type of check	Probability of coverage[a]	Probability of a works council[a]	Union density[a]
	coefficient (|t-value|) / [|robust[b] t-value|]		
[0] Model 3 / OLS	23.189*** [2.847]	-23.201** [2.113]	0.168 [1.029]
Additional explanatory variables			
[1] Team production, percentage of unskilled workers	25.604*** [3.078]	-25.920** [2.268]	0.241 [1.390]
[2] Profit sharing, payment above collectively agreed wage[c]	23.347** [2.285]	-19.380* [1.779]	0.181 [1.027]
Alternative firm size indicators			
[3] First to fourth power of firm size	23.148*** [2.857]	-23.918** [2.204]	0.137 [0.853]
[4] Three discrete firm size classes (less than 20, 20 to 249, 250 and more)	24.497*** [2.994]	-24.766** [2.203]	0.175 [1.076]
Modifications of the dependent variable and alternative estimation methods			
[5] Box-Cox transformation of the dependent variable[d]	2.363** (2.058)	-1.712 (1.277)	0.014 (0.760)
[6] Logit transformation of the adjusted dependent variable[e]	1.131** [2.230]	-1.090* [1.654]	0.008 [0.862]
[7] Log transformation, firms without wage differential are excluded (Heckman correction)	0.407** [2.026]	-0.612** [2.553]	0.002 [0.589]
[8] Partially simulated wage differentials	23.530*** [2.885]	-22.456** [2.046]	0.156 [0.955]
[9] Tobit-ML	22.263** [2.183]	-27.870*** [2.844]	0.065 [0.417]
Expansion of the sample and alternative assignment of firms			
[10] Firms voluntarily applying collective agreements included as covered	16.153* [1.820]	-19.119* [1.815]	0.284 [1.484]
[11] Firms voluntarily applying collective agreements included as noncovered	22.017*** [2.631]	-19.815** [1.981]	0.246 [1.270]
Modification of the variable union density			
[12] Partially simulated union density	23.034*** [2.832]	-23.420** [2.155]	0.176 [1.085]

*/**/*** denote significance at the 0.10 / 0.05 / 0.01 levels, respectively.
[a] The variable is estimated and adjusted by the firm size effects.
[b] Heteroscedasticity-consistent (White 1980).
[c] Firms voluntarily pay wages above those specified in the collective agreement.
[d] Standard t-values displayed, since robust standard errors are not available.
[e] If the wage differential is equal to zero it is set to 1; if the wage differential is greater or equal to 100 it is set to 99.

Source: Hannover Panel, Wave 3 and 4.

model in line [0] can be detected. We can also argue that the observed wage differentials are variables with measurement errors. But this only means that the measurement error of the dependent variable can be absorbed in the disturbances of the regression (Hübler 1989, 224). Therefore, no substantial problems follow from the imprecise measurement of the wage differentials.

Since the dependent variable is truncated at zero in some cases (4.1 percent), one may object that the employed estimating technique is not appropriate. However, if we reestimate model 3 with Tobit-ML instead of OLS the main conclusions are confirmed: The signs of the coefficient are unchanged, the value of the estimated coefficients and their significance are almost the same.

Two other modifications again confirm the robustness of our findings. At first, we reestimated model 3 for a larger sample including establishments not covered but applying multi-employer contracts voluntarily. If we classify them as covered firms the results in line [10], Table 4, follow. Since we do not precisely know, whether in these hybrid cases the specific regulations concerning the wage differential are applied, we can classify them as non-covered, alternatively. The results are presented in the next line [11]. In the first case, the t-values decrease, but the crucial variables coverage and works council are still significant at the 10 percent level. In the second case, the results are not changed substantially.

Finally, the influence of the imprecise measurement of union density is investigated. We follow the same approach as for wage differentials. The observed union density variable is adjusted analogously to (3). Results can be found in line [12], Table 4. Again, the robustness of our findings is confirmed. Altogether, we can interpret the comparison of the results in Table 4 as a kind of extreme bounds analysis suggested by Leamer and Leonard (1983). All these tests document the insensitivity of our core results in Table 3.

5. Summary

A variety of theoretical approaches predicts that industrial relations institutions tend to induce a compressed wage distribution within firms. However, previous empirical evidence is mixed and thus far no study has singled out the precise mechanism by which the skilled-unskilled wage differential is affected. According to our results it is important to distinguish between the different elements of industrial relations, since union density, works councils and coverage of collective bargaining have dissimilar impacts. The most remarkable results are the subsequent:

(1) We cannot detect any influence of union density on the internal wage structure between skilled and unskilled workers. This seems to be reasonable for the institutional setting of Germany where union representation and activity at the establishment level are weak.

(2) The outcome concerning the impact of the works council on the wage differential conforms to our basic hypothesis. The councils have codetermination rights and may contribute to upgrading of low qualified workers.

(3) Coverage by collective bargaining leads to a widening of the wage structure between skilled and unskilled workers. This result is surprising and defies the demand for a completely decentralized bargaining system. It is concordant with Fitzenberger and Franz' considerations (1999) who argue against decentralization. Instead, they favour collective bargaining combined with more flexibility. Insider power is stronger within non-covered establishments and there is a tendency to diminished wage spread.

(4) Several robustness checks demonstrate that our major results are stable.

At odds to theoretical expectations the works council is more influential in compressing the wage differentials within firms than are unions. Commonly, it will be argued that the latter are more interested in redistribution than the former. Our finding gives proof to the opposite. Apparently, for works councils redistribution is more important than a high wage level for all workers. For a complete picture of the impact of the industrial relations institutions on earnings inequality one must bear in mind that most firms with a works council have coverage at the same time and vice versa. For that reason, the two effects – one negative, the other positive – more or less cancel each other out. The overall effect of the industrial relations institutions on the skilled-unskilled wage differential within firms is, therefore, weak.

Obviously, this result coincides with an interpretation given recently by Teulings (1998). He points out that the wide wage dispersion, as for instance observed in the US, results from different payments to the same qualifications in different firms. Unfortunately, our data set does not allow testing this hypothesis directly.

Appendix A

List of Predetermined Variables of Equation (1) and (Estimated) Jointly Dependent Variables of Table 3, $N = 315$

Variable	Mean	Standard deviation
Firm size (number of employees)	129.13	170.97
Firm size squared	45813.41	138454.50
Percentage of female workers	27.80	23.51
Percentage of white collar workers	26.78	17.24
Percentage of part time workers	6.45	9.65
Percentage of shift workers	15.65	23.63
Percentage of apprentices, temporary workers, owners	10.78	12.11
Percentage of workers with variable pay	20.36	33.99
Percentage of sales exported	14.48	22.68
Technical level of the machinery, 4 categories	1.99	0.84
Profit situation, 4 categories	2.71	0.88
Branch plant (1, if firm is a branch plant)	0.10	0.30
Sole-proprietorship (1, if firm is owned by a sole proprietor)	0.05	0.21
Firm's age (1, if founded before 1960)	0.68	0.47
Craft establishment (1, if firm is member of a craft guild)	0.81	0.40
Teamwork (1, if teams exist)	0.38	0.49
Profit sharing schemes for managers (1, if present	0.48	0.50
Profit sharing schemes for employees (1, if present)	0.14	0.35
Training on-the-job financed by the firm (1, if present)	0.58	0.49
Industry dummy textiles / clothes	0.06	0.23
Industry dummy chemical industry	0.08	0.27
Industry dummy quarry industry / glass / ceramics	0.11	0.32
Industry dummy production of iron-metal goods	0.13	0.34
Probability of coverage by collective bargaining[a]	0.69	0.23
Probability that the firm has a works council[a]	0.44	0.26
Trade union density[a]	30.83	17.40
Skilled-unskilled wage differential in percent	37.04	31.29

[a] The variable is estimated and adjusted by the firm size effects.
Source: Hannover Panel, Wave 3 and 4.

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