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Internal Wage Dispersion and Firm Performance: White-Collar Evidence

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Abstract

Purpose – This paper investigates the net relationship between internal wage dispersion and firm performance.
Design/methodology/approach – An empirical investigation of the relationship between internal wage dispersion and firm performance is performed using linked employer—employee data for Norwegian firms from 1986 to 1997.
Findings – Contrary to findings in previous empirical work of a positive relationship between internal wage dispersion and firm performance, this analysis finds no such evidence in Norwegian firms, even though internal wage dispersion has increased.
Originality/value – This paper contributes to the relatively sparse empirical literature on internal wage dispersion and firm performance. Further, the analysis provides a new econometric specification for estimating internal wage dispersion that explicitly takes into account the hierarchical organization of firms. In contrast to previous work, the analysis also distinguishes between dispersion in both the fixed and variable portions of wages.

Keywords Wages, Bonuses, Wage dispersion, Firm performance, White-collar workers, Firm hierarchies.

Paper type Research paper.

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1. Introduction

How should a firm organize its internal pay structure so that it is optimal with respect to the overall performance of the firm? Further, should the firm compress the pay structure or should it pay different wages to each worker? Neither the theoretical nor empirical evidence is unambiguous on these issues. Theoretically, there are two strands of literature with opposing predictions. One strand of literature focuses on incentives and establishes a positive link between wage dispersion and firm performance: that is, workers will put forward more effort if there is more money to be earned. One example is tournament theory as proposed by Lazear and Rosen (1981). This theory is based on a compensation structure whereby workers are compensated on the basis of their relative performance. If workers differ in terms of their ability or level of effort, internal wage dispersion will increase. In tournaments, the best worker wins a prize, usually some form of promotion. In monetary terms, the prize is an increase in the wage. Hence, the relevant dispersion measure according to this theory is the wage dispersion between different hierarchical levels. The larger the monetary prize—that is, the wage spread between the possible future job and the current job—the greater the effort workers will put forward. This increased effort should also be beneficial for the firm, and hence reflected in firm performance.[1]

The second strand of literature focuses on equity and fairness. For example, Akerlof and Yellen (1988) suggest that effort may be a function of the variance in wages. The less variance a firm has in its compensation structure, the more harmonious labor relations will be: this has a positive effect on firm output. In Akerlof and Yellen (1990), they present the fair wage–effort hypothesis that states that if a worker's wage falls short of his or her conception of a fair wage, he or she will withdraw effort.[2] An understanding of what workers perceive as a fair wage is important since this has implications on how wage dispersion is measured. "Workers with low skill do not consider it fair to receive the identical wages as workers who are obviously more skilled." (Akerlof and Yellen, 1988, p. 48) "[I]t is important for supervisors' authority and morale that they be paid more than subordinates" (Bewley, 1999, p. 75). This implies that wage dispersion measures should be measured among workers that are homogenous in terms of their ability or effort level, and that wage dispersion measures should be measured within a given hierarchical level.[3]

The empirical literature on internal wage dispersion and firm performance is relatively sparse. One of the first papers to study the relationship between internal wage dispersion and firm performance is Winter-Ebmer and Zweimüller (1999), using data on 130 Austrian firms over the period 1975 to 1991. One drawback with this data is that it does not include any explicit firm performance measure. Instead, the authors are obliged to use standardized wages as a proxy for productivity. For white-collar workers, they find an inverse U-shaped relationship between wage inequality and earnings. For blue-collar workers, they find the same positive relationship. However, the negative portion of the inverse U shape only begins at very high measures of inequality. Moreover, although the data includes both white- and blue-collar workers, the authors analyze the two groups of workers separately.

In a series of papers Lallemand, Plasman, and Rycx (2003, 2004a,b) use Belgian data from 1995. They find a significant and positive relationship between measures of wage dispersion and firm performance. This holds for different measures of dispersion and performance, and when addressing the endogeneity problem by instrumenting the intrafirm wage dispersion with income taxes. The authors are, however, unable to control for unobserved worker and/or firm characteristics since they do not have access to panel data.

A positive relationship between wage dispersion and firm performance is also found by Heyman (2005), who test several predictions of the tournament model using Swedish white-collar data for the years 1991 and 1995. His results are robust with respect to different dispersion and performance measures and when instrumenting the dispersion measures by lagged values. Another Swedish study, Hibbs Jr and Locking (2000), employs the work of Akerlof and Yellen (1988, 1990) and Levine (1991) as their point of departure. Estimating production functions for the period 1964-1993 they find no results in favor of the "fairness, morale, and cohesiveness" theories; that is, they find no effect of wage leveling within workplaces and industries on productivity.

Using Danish data, Eriksson (1999) tests several predictions from tournament theory using a data set of some 2,600 executives in 210 firms during a four year period. Most of his findings are in line with tournament predictions. Bingley and Eriksson (2001) used institutional differences in the Danish income tax system as an instrument. Their results, based on 6,501 medium- to large-sized private sector firms during 1992 to 1995, show that pay spread and skewness are positively related to firm productivity in an inverse U-shaped relationship. In line with Winter-Ebmer and Zweimüller (1999), this effect is again stronger for white-collar workers than blue-collar workers.

A recent paper by Grund and Westergaard-Nielsen (2004) argues, in contrast to previous work, that it is the dispersion of wage increases, rather than the dispersion in wage levels, that is important for creating monetary incentives in an organization. That is, the greater the dispersion of wage increases, the greater the monetary incentives. Using Danish linked employer-employee data for the period 1992 to 1997 to test their argument, they find that the greater dispersion of within wage growth is associated with low firm performance.[4] Their results are mainly driven by white-collar workers.

All of the papers considering the dispersion in wage levels have found a positive relationship between internal wage dispersion and firm performance, either as a linear or inverse U-shape function. Several of these studies have found stronger effects for white-collar workers than blue-collar workers. To the author's best knowledge, there is only one existing study (Leonard, 1990) that finds *no* significant evidence of a relationship between the variance of managerial pay within a firm, and the firms' performance (as measured by the return on equity). The results in this paper are in line with Leonard who used data on 439 large US corporations between 1981 and 1985.

2. Wage dispersion measures

One of the main contributions of this paper is to analyze separately the dispersion of the fixed and variable parts of wages. I start by suggesting measures for the fixed part. The first thing that must be decided is whether one is interested in wage dispersion between different groups of workers (e.g., blue-/white-collar workers) or within a specific group of workers. The most relevant measure in our setting is to look within a specific group (white-collar workers) since the wage spread incentive is most effective among homogenous workers with the same job design.[5] One must then decide whether to employ an unconditional or conditional measure. By unconditional measure, I mean spread measures that are computed on the wage data without any adjustments for different characteristics of the workforce and/or the firm. Conditional measures, on the other hand, are measures where observable characteristics such as education, experience, and gender are controlled for. The unconditional measure I use is the Coefficient of Variation (CV), defined as the standard deviation divided by the mean. The CV is computed within each firm for each year.

In many cases, it may seem more relevant to use a conditional dispersion measure by taking the composition of the workforce into account. This is because workers in a typical firm are heterogeneous along both observable and unobservable dimensions. Winter-Ebmer and Zweimüller (1999) suggested a conditional measure based on the regression

$$\log W_{ijt} = \alpha_{jt} + \boldsymbol{\alpha}_{jt}\mathbf{Z}_{ijt} + \varepsilon_{ijt} \qquad (1)$$

where $\log W_{ijt}$ is the log wage for worker *i* in firm *j* at time *t*. The vector $\mathbf{Z}_{ijt}$ contains controls for the individual observable characteristics of workers. The conditional measure is defined as the standard error of the regression; that is, the standard error of the residuals. Several of the empirical studies cited earlier have followed this approach. Equation (1) is estimated for each firm in each year. Hence, every parameter estimated is firm specific. Importantly, the parameter is allowed to vary not only between firms, but also within firms over time. Thus, the method allows e.g. (at least potentially) as many different returns to education as there are firm-year observations. If one believes in an equilibrium return to education in the economy, this is overly flexible. Their method also requires relatively many observations per firm to obtain reasonable and stable estimation results. Rather than the method described, I take two different approaches.

The idea behind the first approach is given by the equation

$$\log W_{ijt} = \alpha_0 + \boldsymbol{\alpha}\mathbf{Z}_{ijt} + v_j + \varepsilon_{ijt} \qquad (2)$$

where the main difference to Equation (1) is that the parameter vector $\boldsymbol{\alpha}$ does not have the subscript *jt*. That is, I do not allow the parameters to vary within or between firms over time. I do allow, however, firm-specific effects to enter through the fixed effect variable v_j. The **Z**-vector includes controls for tenure, years of education, age, age squared and year dummies. I calculate the dispersion measure as the standard deviation of the idiosyncratic error term ε_{ijt} in each firm in each year.

In the second approach, I use two established facts concerning wages and the hierarchical organization of firms. First, wages vary within a given hierarchical level; second, wages are strongly attached to these levels (Baker, Gibbs and Holmstrom, 1994; Grund, 2005). I capture this by introducing two different wage dispersion measures: one that captures the wage dispersion *within* hierarchical levels and a second that captures the wage dispersion *between* levels. Both of these measures are assumed to be firm specific. To my best knowledge, this is the first paper to control for hierarchical levels when examining the relationship between internal wage dispersion and firm performance.

One way to capture these dispersion measures is to use the Theil Index (an unconditional measure).[6] Let $\mathbf{w} = (w_1, \ldots, w_n)$ be the vector with wages in a firm with *n* workers. The Theil Index (*T*) is then defined as

$$T(\mathbf{w}; n) = \frac{1}{n}\sum_{i=1}^{n} \frac{w_i}{\bar{w}} \log \frac{w_i}{\bar{w}} \qquad (3)$$

where $\bar{w}$ is equal to $\sum_i w_i / n \quad (i = 1, \ldots, n)$. An advantage of the Theil Index is that it is additively decomposable, see Theil (1967) and Shorrocks (1980). More specifically, it can be decomposed into a within-group and a between-group component, or in our setting, a within-hierarchical level and a between-hierarchical level. For simplicity, denote these decompositions as Intra-Theil and Inter-Theil. Now partition the workers in a firm into *R* (disjoint) hierarchical levels where the hierarchical level *r* consists of $n_r\ (\geq 1)$ workers with wage distribution vector $\mathbf{w}^r = (w_1^r, \ldots, w_{n_r}^r)$ and mean wage $\bar{w}_r$.

$$T(\mathbf{w};n) = T(\mathbf{w}^1,\ldots,\mathbf{w}^R;n) = \underbrace{\sum_r \frac{n_r \bar{w}_r}{n\bar{w}} T(\mathbf{w}^r;n_r)}_{\text{Intra-Theil}} + \underbrace{\frac{1}{n}\sum_r n_r \frac{\bar{w}_r}{\bar{w}} \log \frac{\bar{w}_r}{\bar{w}}}_{\text{Inter-Theil}}. \quad (4)$$

Unfortunately, the Theil Index does not control for any characteristics of workers and/or firms. To obtain a conditional measure, I suggest the following econometric specification:

$$\log W_{ijt} = \alpha_0 + \boldsymbol{\alpha}\mathbf{Z}_{ijt} + v_{jr} + \varepsilon_{ijt} \quad (5)$$

where v_{jr} is a *firm-level-specific* effect (*r* denotes the hierarchical level). I use the standard deviation (computed for each firm in each year) of the idiosyncratic error term ε_{ijt} as a measure of wage dispersion within the hierarchical level. To obtain a measure of wage dispersion between the levels, I take the difference between the firm level-specific effect at the highest and lowest hierarchical level and divide by the number of levels from top to bottom in a given firm for a particular year, i.e., the average slope.

I denote variable pay as 'bonus' since I cannot distinguish between the different forms of variable pay in the data. As a dispersion measure I use the standard deviation of bonuses within each firm for each year.

3. Data

To create the sample, I use data from three different sources. The information on workers is from: (1) NHO (Næringslivets Hovedorganisasjon or Confederation of Norwegian Enterprise), Norway's main employer association; and (2) the governmental administrative registers (NRD) prepared for research by Statistics Norway. The information on establishments[7] (firms) comes from the Norwegian Manufacturing Statistics (NMS)[8] collected by Statistics Norway. The NHO data contains information on white-collar workers (linked to their employer) and covers, on average, 97,000 white-collar workers per year across different industries (although biased towards manufacturing) during the years 1980 to 1997.[9] CEOs (and, in large firms, vice CEOs) are not included in the data. The average number of plants is 5,000 and the average number of firms is 2,700 per year. I am able to merge the NHO data with the main register data, NRD, which is a linked employer–employee data set covering the years 1986 to 2002. These data contain a rich set of information for the entire Norwegian population aged 16 to 74 years. For more information on the NHO data and the merger with the NRD data, see Hunnes, Møen, and Salvanes (2007). Since the individuals are linked to the plants at which they work, I can merge plant information from the NMS to the workers. The NMS data covers the years 1966 to 2002.

In this paper, I employ the years 1986 to 1997.[10] I examine only full-time workers (defined as at least 30 working hours per week) and workers with a monthly wage of at least NOK 2,000 as measured in 1980 kroner. For firms to be included in the sample, they must employ at least five white-collar workers. Further, I remove observations where at least one variable is missing. I also remove firms with log gross production values per employee below the 1st percentile or above the 99th percentile. In a few cases, I also correct the shares that enter the **E**-vector in Equation (6) (a few observations have shares that are larger than would be observed in the real world; e.g., where the share of white-collar workers in the firm is greater than the firm size). The firm size is the average of the firm size in the NRD and the firm size variable in the NMS. Since the data used in this paper is from several different data sets, it is the union of these information sets that constitute the final sample (given the aforementioned cleaning and adjustment procedures). The wage data and firm data are deflated and measured in 1997 NOK.

After cleaning and imposing restrictions on the data, the final sample consists of 10,143 observations on firms for the whole sample period, or 1,723 different firms. Some 260 (15.09%) of these firms are present for the entire time span. In terms of workers, I use observations on 420,426 workers; that is, on average 35,035 workers per year in estimating the dispersion measures. Table 1 presents descriptive statistics on selected variables in the sample and for the entire NHO data set.

[Table 1 about here]

With respect to the hierarchical information (which is only present in the NHO data), firms assign each worker to an occupational group and a level within the occupational group. The groups are labeled A–F: Group A is technical white-collar workers; Group B is foremen; Group C is administration; Group D is shops; and Group E is storage. Group F is a miscellaneous group consisting of workers who do not fit in any of these categories. The hierarchical level is given by a number where zero represents the top level. The number of levels defined varies by group and ranges from 1 (F) to 7 (A). These codes are made by the NHO for the purpose of wage bargaining and as such are similar across firms and industries. In total, there are 22 combinations of groups and levels. To create a single hierarchy in a firm, I aggregate the 22 different combinations into seven different hierarchical levels, where 7 is the highest level.[11]

An important variable to describe is the bonus dummy used extensively throughout the analysis. This dummy takes a value of one if the firm in a given year pays a bonus to one or several of its workers and zero otherwise.[12] It is, however, not obvious how to interpret the dummy when it is set to zero.

One interpretation is that the firm did not have a bonus scheme that year. The other interpretation is that the firm had a bonus scheme, but workers were unable to cross the threshold releasing the bonus payment. In the latter, it is still the case that the increased effort of the workers (most probably) will have an effect on productivity; i.e., there is still a positive effect between bonuses and productivity.

Of the 1,723 different firms in the sample employed in the analysis, 356 pay bonuses for at least one year. When a firm paid a bonus, about 50% of the white-collar workers in a firm received the payment. Fifty-eight of the 356 firms always paid bonuses to all white-collar workers in the firm.

[Table 2 about here]

Table 2 shows how often firms switch between paying and not paying bonus from one year to another. I call this a change in "bonus regime states"; i.e., whether the firm has a bonus scheme or not. From the table, we can see that 87 firms pay a bonus in every year we observe the firm, and 1,367 firms do not pay a bonus in any observed year. Further, 91 firms that we observe paying a bonus in the first year of observation terminate their bonus payment during the years analyzed. Seventy-seven firms introduced bonus payments and do not terminate the bonus scheme thereafter. Sixty-nine firms start without a bonus scheme, introduce one, and then terminate the program. Eight firms start with a bonus scheme, terminate it, and then reintroduce it. Therefore, the majority of firms (1,699 firms) are quite stable regarding whether they use a bonus scheme. Of the 356 firms who paid a bonus for at least one year, only 24 firms have three or more changes in state; i.e., 332 firms (93%) are quite stable.

Recall that the dummy variable is one if at least one worker in a particular firm received a bonus payment in a given year. The average firm size in terms of the number of white-collar workers is about 40, and it seems quite unlikely that none of the workers in a typical firm were able to release the bonus in the presence of a bonus scheme. Hence, when the dummy is set to zero—that is, none of the workers received a bonus—it seems reasonable to assume that the firm does not have a bonus scheme as part of its reward system.

As a robustness check of the variable, I will set the dummy equal to one the first year I observe the firm paying a bonus and for the rest of the period. The idea is that I interpret the year when the firm first pays a bonus as the year of introduction of the bonus scheme, and I do not allow the firm to terminate the scheme. In this case, if the firm does not pay bonus I assume that the firm still has a bonus scheme, but workers were unable to release the bonus.

4. Descriptive analysis

The fixed part of the wage

From 1986 to 1997 there has been a small increase (approximately 10%) in log monthly wage—this holds for the mean and the 10th and the 90th percentiles. There was a small decrease in the late 1980s because of a wage freeze comprising 5% nominal increases in 1988 and 1989 (see Hunnes, Møen and Salvanes, 2007). Hunnes (2007), employing the same data set, shows that mean wage increases with the hierarchical level and that there is considerable overlap between the wage levels on the different hierarchical levels. This is also found in other studies; e.g., Baker, Gibbs, and Holmstrom (1994) and Grund (2005).

An interesting question in the present setting is how internal wage dispersion evolved over the time period analyzed. Figure 1 shows the mean of the firm standard deviation of the idiosyncratic error term ε_{ijt} as given in Equation (2). There has been a steady increase in internal wage dispersion starting around 1990/1991, with a relatively large increase from 1995 to 1996. Given this dispersion measure, there has been approximately a 20% increase in wage dispersion between 1986 and 1997. This supports the findings in Barth, Bratsberg, Hægeland, and Raaum (2005a, b) that between 1997 and 2003 the within-dispersion in Norwegian firms increased. They link this increased dispersion with more firms implementing incentive schemes. Their overall conclusion is that even if within-dispersion has increased as a result of more firms employing incentive schemes, labor market institutions in Norway are still very strong and keep overall wage differences relatively small compared to many other countries.

[Figure 1 about here]

The variable part of the wage

On average during 1986 to 1997, about 10% of firms pay bonuses in a given year with an increasing factor after 1993. Looking at the ratio between the sum of bonuses and total wages, the variable part of the wage is about 0.5%. But if the same calculations are repeated when we restrict the ratio to workers who have received a bonus, it is about 10%. That is, on average the variable part of a worker's wage given he or she has received a bonus, is about one-tenth of the monthly total pay. What about the dispersion in bonuses? Figure 2 reveals that there has been a large increase (about 130%) in the standard deviation in bonuses (mean of all firms) since 1993. Hence, the dispersion in bonuses has simultaneously increased with bonus usage.

[Figure 2 about here]

Figure 3 shows that there is strong convex relationship between bonuses and the hierarchical level.[13] The average bonus on level 7 (the top level) is about eight times higher than the average bonus on level 1. The same number using monthly wages is about 3. In other words, there is larger difference between the top and bottom in the organizational structure with the variable part of the wage than in the fixed part of the wage. Another interesting question is how the bonuses on different levels have evolved over the years 1986 to 1997. The most interesting observation from Figure 4 is the very large increase in bonus payments for the top level (level 7) of firms. The increase is very high from 1993 and onwards.[14] This adds to the previous comment on the use of and dispersion in bonus payments: after 1993 the use of bonus payments increased, the dispersion in bonuses increased, and top management in firms experienced a very high increase in the size of bonuses.[15]

[Figure 3 about here]

[Figure 4 about here]

5. Empirical strategy

Drawing on the theoretical and empirical background, it is clear that the empirical predictions from the different theories relating internal wage dispersion and firm performance move in different directions. In this paper, I restrict the analysis and follow the methodologies of most previous work in this area to see whether there are *some effects* of wage dispersion on firm performance.

To study the relationship between internal wage dispersion and firm performance I use the econometric specification

$$\log Y_{jt} = \beta_0 + \beta_1 bonus + \gamma f(disp_{jt}) + \phi \mathbf{I}_{jt} + \boldsymbol{\lambda} \mathbf{E}_{jt} + v_j + \varepsilon_{jt} \qquad (6)$$

$\log Y_{jt}$ is gross production value per employee at market prices. *bonus* is a dummy taking a value of one if the firm has paid a bonus in a given year and zero otherwise (see the discussion of this variable in the data section). The rationale for including this dummy is to assess whether the firms who use bonuses as part of their payment systems are more productive. In other words, what is the effect of a bonus payment scheme on productivity. $f(disp_{jt})$ is a function of the different dispersion measures in both linear and nonlinear terms and for both the fixed and variable parts of the wage. $\mathbf{I}_{jt}$ is a vector with the inputs log capital[16] per employee, log material costs per employee and log firm size as measured by the number of employees. The vector $\mathbf{E}_{jt}$ is the aggregate characteristics of the workforce: (1) the share of workers with more than 12 years of education; (2) the share of workers with more than 10 years of tenure; (3) the share of workers who are younger than 25 years; (4) the share of workers who are older than 50 years; (5) the share of workers who are females; and (6) the share of white-collar workers. I also include year dummies and a fixed firm effect v_j. The specification (6) can be interpreted as an (augmented) production function.

Identification

Before we start to look at the estimation results from the empirical specification given in Equation (6), we should notice two potential endogeneity problems. First, if we do not find a statistically significant relationship between productivity and wage dispersion, it could be because all firms are using the incentive schemes optimally. Observed variation in the use of incentive schemes, cross-sectionally and over time, will then only reflect firm heterogeneity. This will be unrelated to productivity because there is no scope for improved performance for any firm in this case. This is, however, only a theoretical possibility. Given that the optimal use of incentive schemes is highly controversial among both academics and practitioners, it is likely that variation in the use of incentive schemes both within and across firms has a strong element of experimentation. When a new management trend arises, some believers are eager to try it out while others are more skeptical and wait for experience to accumulate.

The second potential endogeneity problem is selection. If the type of experimentation described is completely random, it will be unrelated to firm productivity, and the OLS estimator can be given a causal interpretation. Firms that chose to try out incentive schemes may have, however, common unobservable characteristics that are systematically related to productivity. This is captured in the firm-specific error component, v_j, in Equation (6). One example would be the quality of managers where we would expect good managers to quickly implement new technologies and work practices. The firm-specific productivity effect, v_j, will then be positively correlated with the use of incentive schemes, and this will cause a positive bias in the OLS estimates. A fixed-effects estimator can correct this bias. The firms that switch wage policy regime within our sample period assure identification. However, there may also be correlation between the time-varying part of the error term, ε_{jt}, and the incentive scheme variables. A positive productivity shock, $\varepsilon_{jt} > 0$, may give rise to extraordinary profits that are shared with employees via bonus payments and in such a way that the internal wage dispersion increases. Therefore, if we find a positive effect, even in a fixed-effects model, it may be driven by inverse causality. This can only be resolved with instrumental variable techniques. Unfortunately, while convincing instruments are unavailable, I argue that this is not detrimental to the conclusions of my analysis.

6. Results

Unconditional measures

Column (1) of Table 3 shows the results using OLS on the econometric specification (6).[17]

When using the OLS estimator, I set the value of v_j to zero and include eight industry dummies. The bonus dummy is significant and positive, implying that firms that have bonuses have higher productivity than firms without bonus payments as part of their wage policy. The coefficient is 0.047 implying that firms with a bonus scheme are about 4.7% more productive than other firms. The estimated parameters for the dispersion of the variable part of the wage appear to indicate a U-shaped relationship. This means that up to a certain point, an increase in dispersion in the variable wage portion is negatively associated with firm performance, thereupon the relationship becomes positive. However, even though the parameters are statistically significant, their size, and hence their impact on firm performance, appears to be very small. The result for dispersion in the fixed part of the wage shows that only the linear part statistically significant. Its estimated value is 3, and at sample means this gives an elasticity of .069. A 10% increase in wage dispersion increases firm productivity with .69%.

In order to control for unobserved heterogeneity among firms, I allow for fixed effects in the error term. The estimation result is presented in column (2) of Table 3. The bonus dummy variable remains positive. However, it is now only about 1/3 of its size in the pooled OLS estimation. The dispersion measures for the variable part of the wage are no longer significant, their signs have shifted, and their effects on productivity are smaller when compared to the pooled OLS estimation. The dispersion measures for the fixed part of the wage are reduced when compared to the pooled OLS estimation and they are not statistically significant.

[Table 3 about here]

Controlling for hierarchy: the Theil Index

Table 4 shows the regression results where I have used the Theil index to measure dispersion in the fixed part of the wage as defined in Equations (3) and (4). Models (1) and (2) are estimated using pooled OLS, while models (3) and (4) are estimated using fixed effects. In model (1), where I have not decomposed the Theil index, all of the dispersion measures are statistically significant and the Theil index indicate an inverse U shape between dispersion and firm performance. In the fixed-effects model of this specification, model (3), only the squared term of the Theil index is statistically significant and its sign is negative. In model (2), I have decomposed the Theil index into its inter- and intraparts; see Equation (4). The estimation results show that it is the dispersion *between* the hierarchical levels that is (statistically) significant. This also drives the significance of the Theil index in model (1). This result is compatible with tournament theory where it is the wage spread between the hierarchical levels that creates incentive. The values of the estimate for the Inter-Theil is 1.324 for the linear part and -8.087 for the nonlinear part, hence, the shape is an inverse U. Controlling for firm fixed effects removes statistical significance, implying that the relationship is driven by the differences between firms. In both models (3) and (4), the bonus dummy is on the verge of being significant (*p*-values of .106 and .101).

[Table 4 about here]

Conditional measures

In Table 5, I present the estimation results using the conditional measures defined in the section on dispersion measures. We start by looking at columns (1)–(3); i.e., the estimation results applying pooled OLS. Again, the bonus dummy is positive and significant. The dispersion in bonus payment is also significant. The effect of the bonus dummy and the dispersion in the bonus payment on productivity is about the same as when applying the unconditional measure. Turning to the fixed part of the wage, I employ three different approaches. The first, column (1), is the conditional measure as defined in Equation (1), that is, the conditional measure used in several previous empirical studies in the literature. In column (2), I use the specification given by Equation (2) where the dispersion measure is defined as the standard deviation of the idiosyncratic error term. Model (3) in Table 5 is the specification where I use one dispersion measure for the fixed part of the wage within hierarchical levels and one conditional measure for the dispersion between the hierarchical levels, see Equation (5). As in the case with unconditional measures, the parameters for the dispersion in the fixed part of the wage are not statistically significant. Applying fixed effect models does not add any new insights, see models (4), (5), and (6) in the table.[18] Hence, neither within dispersion or dispersion between the hierarchical levels appear to have any effect on firm productivity.

[Table 5 about here]

Throughout the interpretation of the estimation results, I have assumed a causal relationship exists. However, as discussed in the section on identification, reverse causality is a potential concern. In the working paper version of this article (Hunnes, 2006), I have attempted to resolve this issue using union density as an instrument for the bonus dummy. The IV estimation did not produce statistically significant results, but it is not obvious that union density is a valid instrument. The rationale for the use of union density is that strong unions typically oppose the use of bonuses. Landsorganisasjonen i Norge or LO (Norwegian Trade Union Confederation) as the main blue collar union in Norway has, for example, stated that it is necessary to "halt the unhealthy development of pay increases, options, and bonus arrangements to top leaders" in order to "ensure the members a part of the creation of values in the form of purchasing power and social improvements, and to give this a good distribution profile."[19] [20] This suggests that union density will be correlated with the use of bonuses, but strong unions may also directly affect productivity. This invalidates union density as an instrument. I have also tried to use lagged values of the bonus variable as an instrument, though still without producing significant estimates. Given that the bonus variable is a dummy variable with high persistence, using lagged values as instruments is also unattractive. Lack of a good instrument is, however, not detrimental. My results suggest that the effect of incentive pay on firm performance is very modest. Potential reverse causality bias would then yield bias in the opposite direction.

Robustness checks

To check for robustness in the unconditional measure for the fixed part of the wage, that is, the use of the Coefficient of Variation (CV), I have used ratios of different percentiles (99/50, 95/05, 90/10, 90/50 and 50/10). The rationale for using these different ratios of percentiles is to assess whether the effects differ across different parts of the wage distribution. All of the unconditional measures are computed within each firm for each year. The results using these different measures do not add any new insights.[21]

For the dependent variable, I have also specified profit per employee, instead of log gross production value per employee. As a proxy for profit, I employ value-added at market prices less total wage costs. For the specification in Equation (6), this implies dropping capital and material costs from the **I**-vector and changing the dependent variable. The results from these estimations are not reported since they do not add any new significant information that would alter the above findings. The bonus dummy, however, is not significant in as many of the cases as when log gross production value per employee is the dependent variable.

As an alternative to using different dispersion measures, I have also tried to consider only dispersion measures for the top levels of the firm hierarchy. The results do not add any significant new insights. Neither does examination of the different occupational groups separately.

As an extension, I have run a version of the specification given in Equation (6) where I have described the use of bonuses in the firms along four dimensions. First, whether a firm has a bonus as part of its wage policy. Second, the coverage of the bonus scheme, defined as the fraction of white-collar workers who received a bonus. Third, the intensity of bonus payment defined as the total bonuses paid in a firm as a fraction of the total wages for white-collar workers. Fourth, the dispersion in bonus payment measured (as earlier) as the standard deviation of bonuses. However, the results from these estimations are too unstable to provide any strong conclusions and are therefore not reported.

In the description of the bonus variable in the data section, I outlined a robustness check for the variable. The results show that a qualitative interpretation of the estimated coefficient remains. Nevertheless, the size of the coefficient is quantitatively smaller and no longer statistically significant.

7. Summary and conclusion

Contemplating wage structure, Lazear and Shaw (2005) argue that: "[t]he ultimate question is whether wage policy specifically and labor policy in general has an effect on productivity." A wage policy can be described along many dimensions, one of which is wage dispersion. In this paper, I have considered the relationship between internal wage dispersion and firm productivity. With respect to the wage dispersion measures, I have examined both conditional and unconditional measures where the main difference between the two has been whether to include controls for worker heterogeneity. When estimating the conditional measures, I have suggested two new approaches where one explicitly takes into account the hierarchical organization of firms by using wage dispersion measures for both dispersion within and between hierarchical levels. Further, I have distinguished between wage dispersion in both the fixed and variable parts of the wage. To perform the study, I used a data set that is very well suited for the research question and covers white-collar workers in Norway during the period 1986 to 1997.

The main findings for the fixed part of the wage are: (1) internal wage dispersion, after controlling for worker heterogeneity, has increased during the time period analyzed; and (2) there is no significant link between wage dispersion and how well the firm performs. For the variable part of the wage, I have showed that: (1) both the use and the size of bonuses appears to have increased somewhat from 1993 onwards; (2) the mean firm standard deviation in bonus payments has increased significantly from 1993; (3) the size of the bonus is convexly related to the firm's hierarchical levels; (4) growth in the size of bonus payments has been especially strong for the top worker level in firms; and (5) the relationship between bonus payment and firm performance is not very robust.

Conclusion: The descriptive evidence in my study shows that there are some changes in firm wage policies in the period analyzed. However, the empirical analysis shows that it is difficult to detect the effects of these changes on firm performance.

Notes

[1] One adverse implication of the increased competition may be that workers seek to sabotage each other's work instead of working together if they compete for the same promotion. The incentive to sabotage coworkers arises from the use of relative performance evaluation (which lies at the core of tournament theory). See Lazear (1989, 1995) for a discussion of this problem.

[2] In Akerlof and Yellen's framework a fair wage system is defined as "one with pay differentials which are more compressed than productivity differentials."

[3] There are other papers that also argue for a compressed wage structure. See Levine (1991) on cohesiveness, and Milgrom (1988) and Milgrom and Roberts (1988, 1990) on influence activities. Also note that an explicit monetary incentive scheme aimed at increasing the productivity of workers can have an adverse side effect by crowding out the internal motivation of workers (Frey, 1997; Frey and Jegen, 2001). This adverse effect goes in the opposite direction of the incentive scheme. However, there are different opinions among economists on how important the crowding out effect is; see, e.g., Fehr and Falk (2002), Prendergast (1999) and Gibbons (1998).

[4] While they find a U-shaped relationship between wage increase dispersion and firm performance, the vast majority of firms are on the decreasing part of the U-shaped curve. This, the authors claim, means that "fairness considerations are found to be more important than competition effects in general." They also control for wage dispersion measures in levels, but while the coefficients are statistically significant using OLS, they are not significant when fixed effects are introduced.

[5] The analysis is restricted to only white-collar workers, on the basis that workers at higher levels in the firm's hierarchy are more valuable to the organization. As Leonard (1990, p. 18-S) puts it: "Position in the corporate hierarchy is one of the strongest determinants of pay. In a number of economic models, this link is attributed to the greater sensitivity of corporate success to the acts of higher-level executives than to those of lower-level executives. Executives with a wider span of control are expected to have greater marginal revenue products."

[6] Grund (2005) uses the same approach for looking at wage dispersion within and between hierarchical levels.

[7] I use firm(s) when referring to the employer unit, even though the information gathered concerns establishments.

[8] The fact that I am using firm-level data from the NMS implies that only the manufacturing sector of the economy is included.

[9] Data for 1987 is missing from the dataset. However, because the data files for each year contain the lagged values, I was able to reconstruct 1987 using the lagged values in the 1988 file. This is, of course, not a perfect reconstruction since I do not have information on workers who left the data set in 1987 and were not present in the 1988 file.

[10] The reason is that I want to use some information that is contained only in the main register of data. Hence, the time period is bounded by the NRD data (lower bound) and the NHO data (upper bound).

[11] To assist with the aggregation, I have carefully utilized the NHO's descriptions of the different occupational groups. Nonetheless, harmonization across occupational groups is still difficult. One problem lies in the fact that some levels are overlapping with respect to responsibility. Another problem arises because the levels defined within each group do not necessarily align. For more information on this process, see Hunnes, Møen and Salvanes (2007). Following the aggregation, the distribution of the workers on the different hierarchical levels is approximately: level 1 (bottom): 9%, level 2: 16%, level 3: 32%, level 4: 25%, level 5: 6%, level 6: 11%, and level 7 (highest): 2%.

[12] In the data set with the worker as the unit, the variable is given as the average bonus per month during the last 12 months prior to 1 September.

[13] In producing Figures 3 and 4 I have disregarded occupational group F. Group F is a miscellaneous group with workers who do not fit into any of the 21 other groups. Among those included in F group are sales people whose wage is largely commissioned based: if included, they would distort the representativeness of workers.

[14] In this respect, note that after a downturn in the economy beginning in the late 1980s, the economy started to recover after about 1993.

[15] Using data from 1997 to 2005 (Lunde and Grini, 2007) confirm that these trends continued after the end of this study's sample period.

[16] I am grateful to Ragnhild Balsvik who gave me access to the capital data used in Balsvik and Haller (2006).

[17] To make the tables smaller and more readable, I only report the estimates of the parameter β_1 and the parameter vector γ from Equation (6). Hence, while the following control variables are included in the regressions, they are not reported: log capital per employee; log material costs per employee; log firm size measured by number of employees; the share of workers with more than 12 years of education; the share of workers with more than 10 years of tenure; the share of workers who are younger than 25 years; the share of workers who are older than 50 years; the share of workers who are female; the share of white-collar workers; and 11 year dummies. In the pooled OLS, I also use eight industry dummies. In the 12 estimations reported in the paper, the following variables are always significant at 10% or smaller significance level: log firm size measured as number of employees; share of workers with more than 12 years of education; the share of workers who are older than 50 years; the share of females; log material costs per employee; the year dummies for 1995, 1996 and 1997; and the industry dummies. The variables for the share of workers with more than 10 years of tenure, the share of white-collar workers, and the year dummies for 1988 to 1993 are not significant in any of the models. The remaining variables differ with respect to statistical significance.

[18] The dummy variable for the bonus payment is barely insignificant (its *p*-value is .101) in models (4) and (5).

[19] LO (2005, p.9)

[20] Previous studies also show that firms with a higher degree of unionization have smaller wage dispersion than firms with at lower degree of unionization. "[…], the available evidence for both the USA and Britain indicates that trade unions significantly reduce wage dispersion. Freeman (1980a, 1982) and Hirsch (1982) show that US unions reduce intra-industry wage dispersion, inter-firm and intra-firm wage dispersion, and wage dispersion across certain labour markets. Gosling and Machin (1993) show that trade unions in Britain also reduce wage dispersion within the union sector: they show that both the interestablishment and intraestablishment wage distributions for manual workers are narrower in plants with recognised unions." (Booth, 1995, p. 179).

[21] The results are available in the working paper version of this paper; Hunnes (2006).

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Figure 1: Internal wage dispersion (for the fixed part of the wage) measured as the standard deviation of the idiosyncratic error term from Equation (2) (mean over firms).

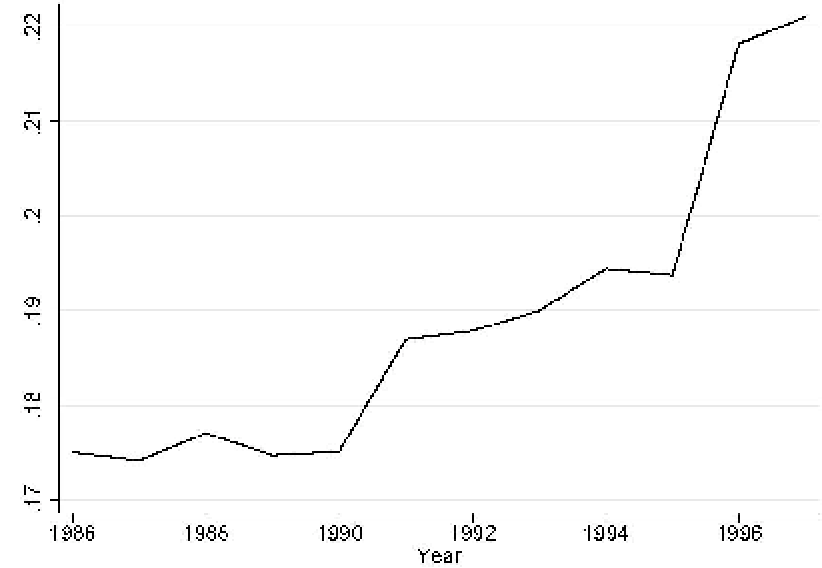

Figure 2: The standard deviation of bonuses (average of all firms).

Figure 3: Bonus by level (average of all workers).

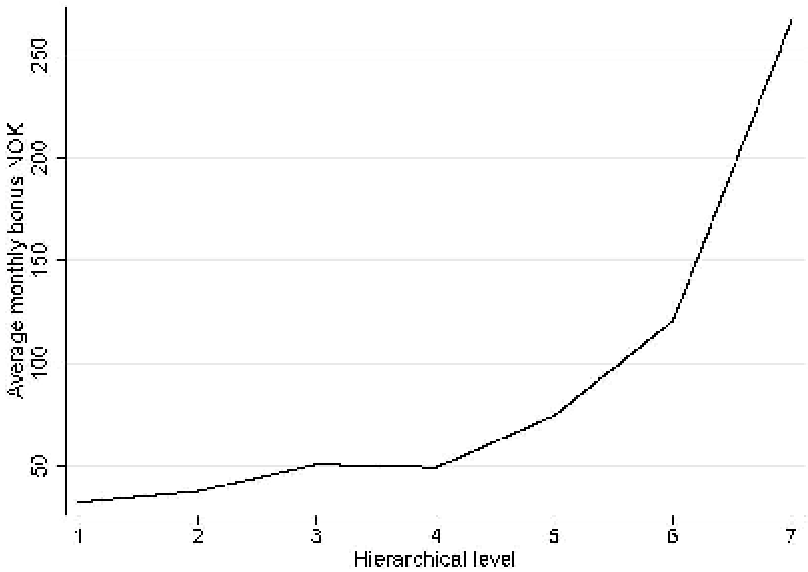

Figure 4: Bonus by level and year (average of all workers).

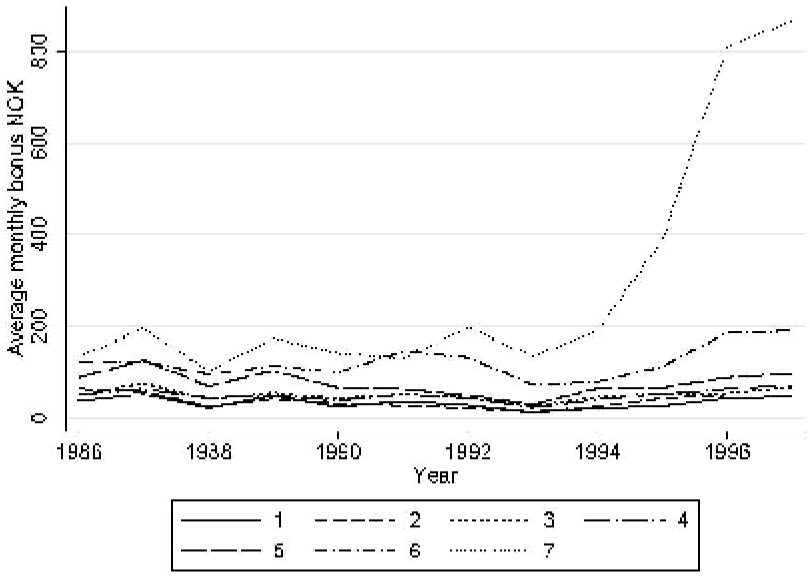

Table 1: Summary statistics (average of firm-year observations)

	Sample		NHO data set	
Variable	Mean	Std. Dev.	Mean	Std.Dev.
Log gross production value[a]	6.930	0.572	[e]	[e]
Profit[a]	138.160	217.842	[e]	[e]
Log capital[a]	6.804	0.900	[e]	[e]
Log material costs[a]	6.443	0.789	[e]	[e]
Log firm size	4.439	0.977	[e]	[e]
More than 12 years of education[b]	0.110	0.113	0.147	0.172
More than 10 years tenure[b]	0.206	0.229	0.194	0.232
Age less than 25 years[b]	0.102	0.083	0.100	0.101
Age more than 50 years[b]	0.239	0.117	0.219	0.134
Females[b]	0.205	0.172	0.226	0.194
White-collar[b]	0.277	0.171	0.448	0.286
White-collar with bonus[c]	0.063	0.222	0.067	0.214
Mean log wage[d]	9.920	0.123	9.897	0.160
Log wage 90th percentile[d]	10.237	0.176	10.206	0.218
Log wage 10th percentile[d]	9.646	0.142	9.627	0.172
Log wage 5th percentile[d]	9.596	0.148	9.584	0.175
Log wage 50th percentile[d]	9.898	0.133	9.878	0.171
Log wage 95th percentile[d]	10.316	0.197	10.279	0.239
Coefficient of variation (CV)[d]	0.023	0.006	0.023	0.007
Ratio of 90/10 percentile[d]	1.061	0.019	1.060	0.022
Ratio of 95/5 percentile[d]	1.075	0.023	1.073	0.026
Ratio of 90/50 percentile[d]	1.034	0.014	1.033	0.015
Ratio of 50/10 percentile[d]	1.026	0.013	1.026	0.016
σ bonuses[d]	126.362	895.911	280.233	1156.877
Bonuses as % of total wages[d]	0.005	0.022	0.009	0.035
N	10143		30323	

[a] Per worker in the firm
[b] Share of workforce (blue and white-collar workers)
[c] Share of white-collar workers
[d] White-collar workers
[e] Numbers not available. The numbers for log gross production value, profit, log capital, log material costs and log firm size is taken from the manufacturing statistics. As noted in Section 3, the NHO data set covers sectors additional to the manufacturing sector, but for these sectors there is no firm information available.

Table 2: Number of bonus regime changes.

	Number of bonus regime changes							
	0	1	2	3	4	5	6	
Firms pay bonus in first year observed	87	91	8	8	0	0	0	194
Firms does not pay bonus in first year observed	1,367	77	69	12	2	1	1	1,529
	1,454	168	77	20	2	1	1	1,723

Table 3: Unconditional measures.

	Pooled OLS	Fixed effect
	(1)	(2)
Bonus	.047**	.013*
	(.022)	(.008)
σ bonus	-.00002**	5.10e-06
	(6.88e-06)	(3.63e-06)
σ^2 bonus	5.02e-10***	-9.84e-11
	(1.53e-10)	(8.17e-11)
Disp	2.993*	1.862
	(1.647)	(1.307)
$Disp^2$	-27.570	-23.653
	(29.967)	(24.329)
N	10143	10143
R^2 (within for FE model)	.87	.73

Note—The dependent variable is log gross production value per employee at market prices. Control variables included in the regressions (but not reported) are: log capital per employee; log material costs per employee; log firm size measured as the number of employees; share of workers with more than 12 years of education; the share of workers with more than 10 years of tenure; the share of workers who are younger than 25 years; the share of workers who are older than 50 years; the share of female workers; the share of white-collar workers; and 11 year dummies. In the pooled OLS, I also use eight industry dummies. Huber–White robust standard errors allowing for the clustering of errors are in parentheses. ***/**/* indicate significance at the 1, 5, and 10 % level.

Table 4: Theil index results.

	Pooled OLS		Fixed effects	
	(1)	(2)	(3)	(4)
Bonus	.046**	.047**	.013	.013
	(.021)	(.021)	(.008)	(.008)
σ	-.00002***	-.00002***	5.36e-06	5.00e-06
	(6.31e-06)	(6.19e-06)	(3.51e-06)	(3.57e-06)
σ^2	4.91e-10***	5.00e-10***	-1.03e-10	-9.58e-11
	(1.42e-10)	(1.38e-10)	(7.99e-11)	(8.09e-11)
Theil index	1.266**		.504	
	(.534)		(.390)	
Theil index^2	-6.468**		-3.413*	
	(2.964)		(1.966)	
Inter-Theil		1.324**		.450
		(.567)		(.370)
Inter-Theil^2		-8.087*		-3.206
		(4.661)		(3.278)
Intra-Theil		.537		.181
		(.901)		(.621)
Intra-Theil^2		-3.853		-2.463
		(5.715)		(3.518)
N	10143	10143	10143	10143
R^2 (within for FE model)	.87	.87	.73	.73

Note—The dependent variable is log gross production value per employee at market prices. Control variables included in the regressions (but not reported) are: log capital per employee; log material costs per employee; log firm size measured as the number of employees; share of workers with more than 12 years of education; the share of workers with more than 10 years of tenure; the share of workers who are younger than 25 years; the share of workers who are older than 50 years; the share of female workers; the share of white-collar workers; and 11 year dummies. In the pooled OLS, I also use eight industry dummies. Huber–White robust standard errors allowing for the clustering of errors are in parentheses. ***/**/* indicate significance at the 1, 5, and 10 % level.

Table 5: Conditional measures.

	Pooled OLS			Fixed effects		
	(1)	(2)	(3)	(4)	(5)	(6)
Bonus	.044**	.045**	.046**	.013	.013	.013*
	(.021)	(.021)	(.021)	(.008)	(.008)	(.008)
σ bonus	-1.00e-05**	-.00002***	-.00002***	6.13e-06*	5.68e-06	4.93e-06
	(5.85e-06)	(3.51e-06)	(5.78e-06)	(3.40e-06)	(3.51e-06)	(3.48e-06)
σ^2 bonus	4.33e-10***	4.73e-10***	5.17e-10***	-1.06e-10	-1.14e-10	-1.05e-10
	(1.32e-10)	(1.30e-10)	(1.36e-10)	(7.85e-11)	(8.07e-11)	(7.87e-11)
σ_{rmse} from Eq. (1)	.035			-.094		
	(.107)			(.087)		
σ^2_{rmse} from Eq. (1)	-.339			.020		
	(.349)			(.236)		
$\sigma_{\varepsilon_{ijt}}$ from Eq. (2)		.297			.030	
		(.182)			(.161)	
$\sigma^2_{\varepsilon_{ijt}}$ from Eq. (2)		-.466			-.120	
		(.322)			(.312)	
$\sigma_{\varepsilon_{ijt}}$ from Eq. (5)			.095			-.055
			(.195)			(.170)
$\sigma^2_{\varepsilon_{ijt}}$ from Eq. (5)			.088			.134
			(.610)			(.519)
Slope firm-level-specific effect			.182			-.256
			(.199)			(.172)
Slope^2 firm-level-specific effect			-.654			.565
			(.679)			(.608)
N	10143	10143	10143	10143	10143	10143
R^2 (within for FE models)	.87	.87	.87	.73	.73	.73

Note—The dependent variable is log gross production value per employee at market prices. Control variables included in the regressions (but not reported) are: log capital per employee; log material costs per employee; log firm size measured as the number of employees; share of workers with more than 12 years of education; the share of workers with more than 10 years of tenure; the share of workers who are younger than 25 years; the share of workers who are older than 50 years; the share of female workers; the share of white-collar workers; and 11 year dummies. In the pooled OLS, I also use eight industry dummies. Huber–White robust standard errors allowing for the clustering of errors are in parentheses. ***/**/* indicate significance at the 1, 5, and 10 % level.