Internal Wage Dispersion and Firm Performance: White-Collar Evidence*

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Abstract

Is internal wage dispersion good for firm productivity, or do internal wage differences break the conception of fairness and cause counterproductive behavior among workers? Contrary to previous empirical work that has found a positive relationship between internal wage dispersion and firm performance, this paper shows that such a relationship is not present using a unique linked employer–employee data set for white-collar workers in Norway over the period from 1986 to 1997. In the analysis, several different wage dispersion measures are used, of which two explicitly control for wage dispersion within and between levels in the firm's hierarchical organization. The analysis also distinguishes between dispersion in the fixed and variable parts of wages.

Keywords: Wages, bonuses, wage dispersion, firm performance, white-collar workers, firm hierarchies.

JEL classification: M52, J3

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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? Should the pay structure be compressed, or should it pay different wages to each worker? Neither the theoretical nor empirical evidence is unambiguous. Theoretically, there are two strands of literature with opposing predictions. One stand of this literature focuses on incentives and establishes a positive link between wage dispersion and firm performance: workers will put forward more effort if there is more money earned. An example of this is tournament theory as put forward by Lazear and Rosen (1981). The second strand of literature focuses on equity and fairness; e.g., the fair wage-effort hypothesis of Akerlof and Yellen (1990). In this, if the wage dispersion among similar type of workers gets too large, it leads to counterproductive behavior among workers.[1]

In this paper, I investigate the net relationship between internal wage dispersion and firm performance using Norwegian data from 1986 to 1997. The analysis is restricted to examine only white-collar workers using the argument that workers at higher levels in the firm hierarchy are more valuable to the organization.[2]

The paper contributes to the existing literature in two ways. First, I suggest a new econometric specification for estimating the internal wage dispersion that explicitly takes into account the hierarchical organization of firms. It is well documented that wages are closely tied to the hierarchical level to which workers are attached; see, e.g., Baker, Gibbs, and Holmstrom (1994). Tournament theory stresses that it is the wage spread between hierarchical levels that creates incentives in organizations. By distinguishing between wage dispersion between and within hierarchical levels, I am able to investigate whether the effects differ. Second, we know that many workers' pay includes both a fixed and a variable component. The variable pay may be an explicit performance based pay, or just some extra payment that the workers receive because the firm is doing well. In this manner, dispersion in fixed and variable pay may

[1] One version of this is discussed by Lazear (1989, 1995) within the tournament theory framework. See Section 2.

[2] As Leonard (1990) 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."

have different effects on performance. In this paper, I denote the variable pay as a 'bonus' since I cannot distinguish between the different forms of variable pay in the data.

The main findings are as follows: (1) internal wage dispersion, controlled for worker heterogeneity, has increased during the time period analyzed; (2) there is no significant link between dispersion in the fixed part of the wage and how well the firm performs; (3) even though there is a statistically significant relationship between dispersion in bonus payments and firm performance, its economic significance is very small; and (4) there is a positive and significant relationship between firm productivity and whether the firm has a bonus payment as part of their wage policy. However, when controlling for endogeneity using the degree of unionization as an instrument, this relationship does not hold.

The paper proceeds as follows. In the next section, I look at the theoretical arguments describing the relationship between internal wage dispersion and firm performance. I also give an overview of previous empirical studies. Different wage dispersion measures are presented in Section 3, and in Section 4 I describe the data and perform some descriptive analysis. The main contribution in this study is to analyze the link between internal wage dispersion and productivity. In Section 5, I discuss the econometric specification and identification and report the results. Section 6 summarizes and concludes the paper.

2 Theoretical and empirical background

2.1 Theory

One of the central predictions from tournament theory is a positive relationship between internal wage dispersion and firm performance (Lazear and Rosen, 1981). This theory is based on a compensation structure whereby workers are compensated relative to each other. More specifically, the best worker wins a prize, usually some form of promotion. In monetary terms, the prize is an increase in the wage. The larger the monetary prize, that is, the wage spread between the possible future job and the current job, the larger the effort workers will put forward. This increased effort should also be beneficial for the firm, and should be reflected in firm performance. 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. Lazear (1989, 1995) looks at this problem using two types of workers "hawks" and "doves" where hawks have an absolute advantage in attacking coworkers. The incentive to sabotage coworkers arises from the use of relative performance evaluation (which lies at the core of tournament theory). This implies that the worker who wins the tournament is not necessarily the best worker in an absolute sense, only relative to his or her coworkers. To win the tournament, a worker is not only dependent upon his own success, but also on the failure of coworkers. Lazear shows that the optimal solution to this adverse implication is to implement some degree of wage compression among groups of similar workers. Lazear also shows that hawks will be overrepresented in the higher levels of the firm hierarchy.

Three theories that provide different predictions to tournament theory are those based on fairness considerations, cohesiveness and intrinsic motivation. 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, and this will have a positive effect on firm output. In Akerlof and Yellen (1990) they present the fair wage-effort hypothesis which states that if a worker's wage falls short of his conception of a fair wage, he will withdraw effort.[3] Building on the notion of cohesiveness, defined as the propensity to obey group norms because approval of the group is valued, Levine (1991) presents a framework where reducing wage dispersion in participatory firms can increase productivity through an increase in cohesiveness. Finally, from the psychological literature we have the notion of intrinsic motivation (see, e.g., Frey, 1997 and Frey and Jegen, 2001); that is, there are aspects of the job (tasks) itself that create motivation to put forward some effort. An important aspect of the notion of intrinsic motivation is the crowding out effect. If the external motivation (in our case, monetary incentives) is too high, it may tend to crowd out the intrinsic motivation.[4]

[3]Bewley (2004) reviews field studies, experiments and psychological evidence on fairness and concludes: "Perhaps the outstanding conclusion to be drawn from the works discussed is the importance of fairness to labor performance." Further, "A sense of fairness is probably the most important determinant of good company morale. Other important factors are close ties among coworkers and the significance attached to the firm's output."

[4]There are different opinions among economists on how important the crowding out effect is; see, e.g., Fehr and Falk (2002).

2.2 Empirical studies

The empirical literature on internal wage dispersion and firm performance is relatively sparse.[5] To perform such analysis, one requires linked employer–employee data including a wage dispersion measure and a measure of firm performance. Such data sets have only become available in recent years. Another problem is endogeneity since it can be difficult to establish the direction of causality. For example, assume we observe a firm with high performance, which also has a high degree of internal wage dispersion. One explanation would be that the firm is performing well because the wage dispersion creates incentives. Another explanation is that the firm is performing well and share rents with its workforce in such a way that it increases wage dispersion. If we do not control for endogeneity, our estimates of the relationship in question will be biased. Previous studies have taken two different directions on how to address the problem of endogeneity. One is to ignore it; the other is to use instrumental variable (IV) techniques. IV estimation, however, places further demands on the data since we need a valid instrument. See Section 5.1.1 for a discussion of identification.

One of the first papers to study the relationship between internal wage dispersion and firm performance is Winter-Ebmer and Zweimüller (1999) using data from Austria in the period 1975–1991. Their sample consists of 130 firms. A drawback with their data is that it does not include any explicit firm performance measure. Instead, the authors are forced to use standardized wages as a proxy for productivity. For white-collar workers, they find that more wage inequality is associated with higher earnings. However, if this inequality increases too far, it will work in the other direction. In other words, they find an inverse U-shaped relationship. For blue-collar workers, they find the same positive relationship, but the negative part of the inverse U-shape, however, kicks in at only very high values of the measure of inequality. 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 result holds for different measures of dispersion and performance,

[5]For a useful survey of different studies, see Appendix I in Lallemand, Plasman, and Rycx (2003).

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 concluded 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 study from Sweden (Hibbs Jr and Locking, 2000) uses the work of Akerlof and Yellen (1988, 1990) and Levine (1991) as a 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)—a seminal paper on empirical testing of the tournament model—tests several predictions from tournament theory using a rich data set of some 2,600 executives in 210 firms during a 4-year period. Most of his findings are in line with tournament predictions. Eriksson, together with Bingley, (Bingley and Eriksson, 2001) was one of the first papers to address the simultaneity problem between pay and firm performance. They 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 1992–1995, 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 stronger for white-collar workers than blue-collar workers.

A recent paper by Grund and Westergaard-Nielsen (2004) argues, and in contrast to previous work, that it is the dispersion of wage increases, rather than dispersion in wage levels, that is important for creating monetary incentives in an organization. The larger the dispersion of wage increases, the greater the monetary incentives. Using Danish linked employer-employee data for the period 1992–1997 to test their argument, they find that a large dispersion of within wage growth is associated with low firm performance.[6] Their results are mainly driven

[6] They actually find a U-shaped relationship between wage increase dispersion and firm performance, but the vast majority of firms are on the decreasing part of the U-shaped curve. This, the authors claim, means

by white-collar workers.

All of the papers looking at dispersion in wage levels have found a positive relationship between internal wage dispersion and firm performance, either linear or as an inverse U-shape function. Several of the papers have found stronger effects for white-collar workers than blue-collar workers. To the author's best knowledge, there is only one previous study (Leonard, 1990) that finds *no* significant evidence of a relationship between the variance of managerial pay within a firm, and the firms' performance (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.

3 Wage dispersion measures

3.1 The fixed part of the wage

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 one must decide 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 incentive of a wage spread is most effective among homogenous workers with the same job design. Next, one must decide which measure to use. One can use an unconditional measure or a conditional measure. By unconditional measures, I mean spread measures that are computed on the wage data without any adjustments for different characteristics of the work force and/or the firm. Conditional measures, on the other hand, are measures where I control for observable characteristics such as education, experience and gender.

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.

3.1.1 Unconditional measures

The first unconditional measure I use is the Coefficient of Variation (CV), which is defined as the standard deviation divided by the mean. The other five are ratios of different percentiles (99/50, 95/05, 90/10, 90/50 and 50/10). The rational for using all of 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 each year.

3.1.2 Conditional measures

In many cases, it may seem more relevant to use a conditional dispersion measure by taking the composition of the workforce into account. The 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

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

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 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 studies cited in Section 2 follow this approach. Equation (1) is estimated for each firm in each year. Hence, every parameter estimated is firm-specific, and they are allowed to vary not only between firms, but also within firms over time. Thus, the method e.g. allows (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. Instead of the method described, I take two different approaches.

The idea behind the first approach is given by the equation

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

where the main difference from 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 $\mathbf{Z}$-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.

3.1.3 Controlling for hierarchy

In the second approach, I use two established facts concerning wages and the hierarchical organizations in firms. First, wages vary within a given hierarchical level; second, wages are strongly attached to these levels.[7] I capture this by introducing two different wage dispersion measures: one that captures the wage dispersion *within* hierarchical levels and a second which captures the wage dispersion *between* levels. Both of these measures are assumed to be firm-specific. To my 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 two dispersion measures is to use the Theil Index (an unconditional measure). 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

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

where $\bar{w}$ is equal to $\sum_i w_i/n$ $(i = 1, \ldots, n)$. 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 Intra-

[7] One explanation for why wages are strongly attached (often in a convex fashion) to the levels is that workers higher up in the firm hierarchy are more productive since their decisions and actions have implications for workers on lower levels: this should be reflected in their wages. A second explanation is sequential tournaments (Rosen, 1986). The vast majority of promotions carry some extra payment to the promoted worker. But additionally, there is the option value of future promotions. As the worker moves up the hierarchy the option value gets smaller as the number of future potential promotions gets smaller. To compensate for the smaller option value, the direct monetary promotion premium must increase, hence the wage increases at a steeper rate when moving up the hierarchy. This implies that the promotion premium to, say, the CEO should be very large.

Theil and Inter-Theil. Partition the workers in a firm into R (disjoint) hierarchical levels where the hierarchical level r consists of n_r (≥ 1) workers with wage distribution vector $\mathbf{w}^r = (w_1^r, \ldots, w_{n_r}^r)$ and mean wage $\bar{w}_r$.

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

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

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

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 hierarchical level and the lowest hierarchical level and divide by the number of levels from top to bottom in a given firm in a given year. In other words, I use the average slope of the line in the (level, firm-level-specific effect)—plan. As shown in Figure 2, the wage-level relationship is not very convex: a linear approximation should be adequate.

3.2 The variable part of the wage

As a dispersion measure for the variable part of the wage, that is, the bonus part, I use the standard deviation of the bonuses within each firm in each year.

4 Data and descriptive analysis

4.1 Data

To create the sample, I use data from three different sources. The information on workers comes from (1) the main employers' association in Norway, NHO (the Confederation of Norwegian Enterprise) and (2) from the governmental administrative registers (NRD) prepared for research by Statistics Norway. The information on establishments[8] (firms) comes from the Norwegian Manufacturing Statistics (NMS)[9] collected by Statistics Norway. The NHO data contain information on white-collar workers (linked to their employer) and cover, on average, 97,000 white-collar workers per year across different industries (although biased towards manufacturing) during the years 1980–1997.[10] CEOs (and in large firms, vice CEOs) are, in principle, not included. 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 1986–2002. These data contain a rich set of information for the entire Norwegian population aged 16–74. For more information on the NHO data and the merger with the NRD data, see Hunnes, Møen, and Salvanes (2005). Since the individuals are linked to the plants at which they are working, I can merge plant information from the NMS to the workers. The NMS data covers the years 1966–2002.

In this paper, I use the years 1986–1997.[11] 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 one or several of the variables are missing. I also remove firms with log gross production value per employee below

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

[9] The fact that I am using firm data from the NMS implies that I only include the manufacturing sector of the economy.

[10] The year 1987 is missing from the data files. However, the data files for each year contain lagged values. Hence, 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 who were not present in the 1988 file.

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

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 larger than the firm size). The firm size is the average of the firm size in the NRD and the firm size variable in the MNS. Since the data used in this paper is from several different data sets, it is the union of these information sets that constitutes 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 period, or 1,723 different firms. Some 260 (15.09%) of these firms are present 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.

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 the other categories. 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 wage bargaining purposes, and as such they are similar across firms and industries. In total there are 22 combinations of groups and levels. To create a single hierarchy in a firm, we aggregate the 22 different combinations into seven different hierarchical levels where 7 is the highest level. For more information on this process, see Hunnes, Møen and Salvanes (2005).

4.2 Descriptive analysis

4.2.1 The fixed part of the wage

Table 1 presents descriptive statistics on selected variables in the sample and Figure 1 shows the development of log monthly wages (excluding bonuses) during the sample period.[12] From the figure, we see that there has been a small increase in the wage during the time period—this holds for the mean, the 10th and the 90th percentile. 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, 2005). Figure 2 shows the average of the log monthly salary by hierarchical level. The vertical line gives the distance between the 5th and 95th percentile. From the figure it is clear that the mean wage increases with the hierarchical levels, although the mean wage on levels 2 and 3 and levels 5 and 6 is not that different. Furthermore, 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 3 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. This supports the findings in Barth, Bratsberg, Hægeland, and Raaum (2005a,b) who show 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 the 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 when compared to many other countries.

[12]The monthly wage is given in the NHO data.

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

Variable	Mean	Std. Dev.	Min.	Max.
log gross production value[a]	6.93	0.572	5.32	8.824
profit[a]	138.16	217.842	-1857.726	1977.152
log capital[a]	6.804	0.9	1.265	11.058
log material costs[a]	6.443	0.789	-4.497	8.862
log firm size	4.439	0.977	1.705	7.826
more than 12 years of education[b]	0.11	0.113	0	1
more than 10 years of tenure[b]	0.206	0.229	0	1
age less than 25 years[b]	0.102	0.083	0	0.796
age less more than 50 years[b]	0.239	0.117	0	0.846
females[b]	0.205	0.172	0	0.974
white collar[b]	0.277	0.171	0.006	1
white collar with bonus[c]	0.063	0.222	0	1
mean log wage[d]	9.92	0.123	8.993	10.388
log wage 90th percentile[d]	10.237	0.176	9.336	11.15
log wage 10th percentile[d]	9.646	0.142	8.434	10.192
log wage 5th percentile[d]	9.596	0.148	8.434	10.192
log wage 50th percentile[d]	9.898	0.133	8.984	10.667
log wage 95th percentile[d]	10.316	0.197	9.336	11.239
coefficient of variation (CV)[d]	0.023	0.006	0.003	0.088
ratio 90/10 percentile[d]	1.061	0.019	1.005	1.222
ratio 95/5 percentile[d]	1.075	0.023	1.006	1.222
ratio 90/50 percentile[d]	1.034	0.014	1	1.125
ratio 50/10 percentile	1.026	0.013	1	1.149
σ bonuses[d]	126.362	895.911	0	46602.805
bonuses % of total wages[d]	0.005	0.022	0	0.536
N		10143		

[a] per worker
[b] share of workforce
[c] share of white collar workers
[d] white collar workers

Figure 1: Mean firm log monthly wage (excluding bonuses).

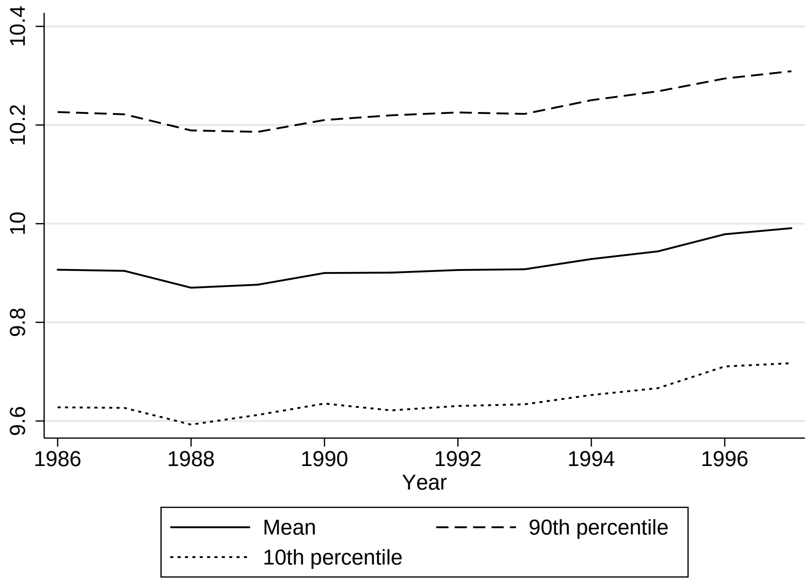


Figure 2: Log monthly wage (excluding bonuses) by level (average over workers).

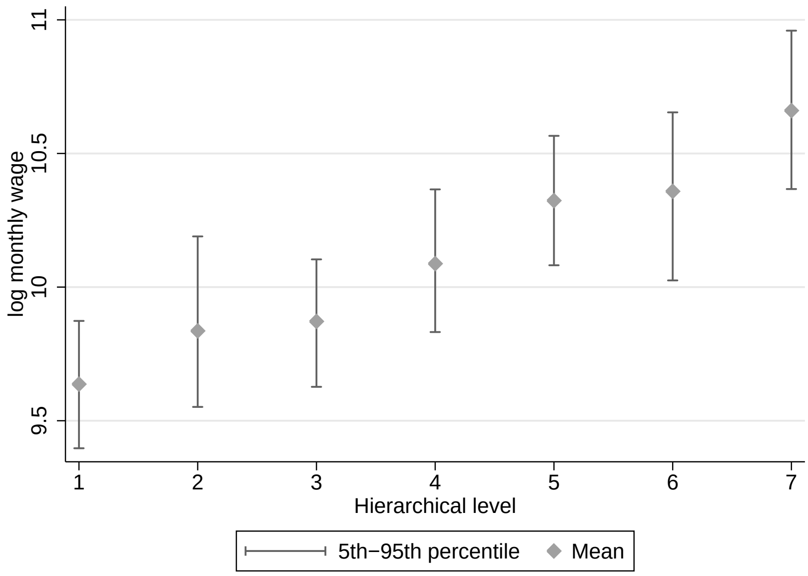
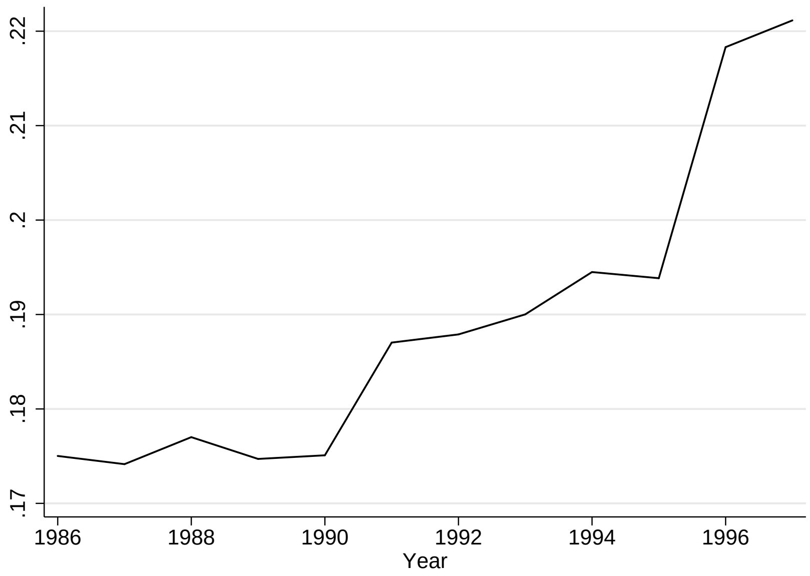


Figure 3: Internal wage dispersion (for the fixed part of the wage) measured as the standard deviation of the idiosyncratic error term from Equation (2) (mean over firms).



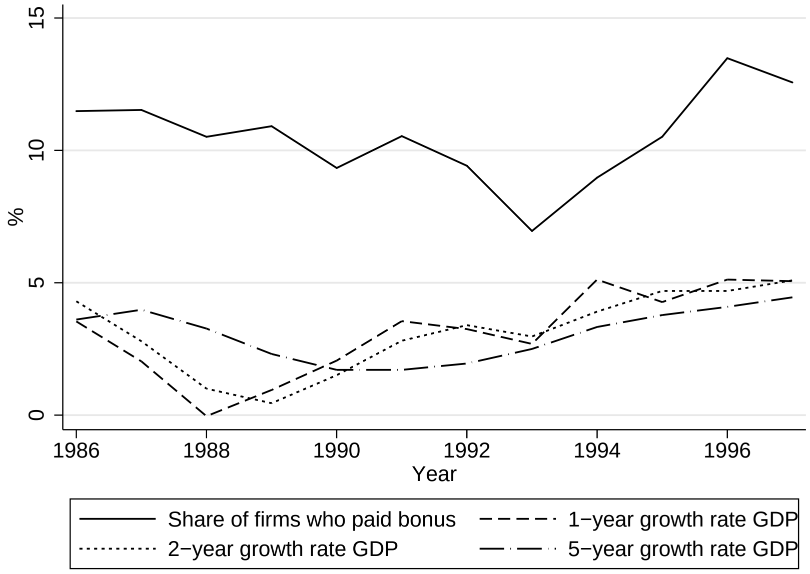
4.2.2 The variable part of the wage

Figure 4 shows the share of firms in a given year that have paid a bonus[13] to one or several of its workers. On average, about 10% of firms pay bonuses in a given year. In the same figure I have also plotted the 1, 2 and 5-year growth rate in GDP as indicators of the business cycle.[14] The share of firms that pay bonuses has, to some extent, moved with the business cycle. The correlation coefficient between the shares of firms paying bonuses and the GDP growth rates are .250, .324 and .615, with only the correlation between the share of firms and the 5-year GDP growth rate being significant at the 5% level of significance. Figure 5 shows the average (over all firms) of the ratio between sum bonuses and total wages. These numbers show that the variable part of the wage is about 0.5%, but if we do the same calculations restricting the ratio to workers who have received bonus the number 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 6 reveals that there has been a large increase in the standard deviation in bonuses (mean over firms) since 1993

[13]The bonus variable is defined as the average bonus per month during the last 12 months prior to 1 September.

[14]In computing the GDP growth rates I used figures taken from Statistics Norway (2003).

Figure 4: Share of firms that have paid a bonus in a given year.



and onwards. Relating this figure to Figure 4 it is clear that the dispersion in bonuses has increased simultaneously with bonus usage.

Wages tend to increase with the hierarchical level, confront Figure 2. Figure 7 shows that there is strong convex relationship between bonuses and hierarchical level.[15] 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 when it comes to 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 during the years 1986–1997. The most interesting observation from Figure 8[16] 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. But this adds to the previous comment on the use of and dispersion in bonus payments: from 1993, the use of bonus payments has increased, the dispersion in bonuses has increased, and top management in firms has experienced a very high increase in the size of bonuses.

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

[16]See footnote 15.

Figure 5: Bonus as a share of total wages (average over all firms).

Figure 6: The standard deviation of bonuses (average over all firms).

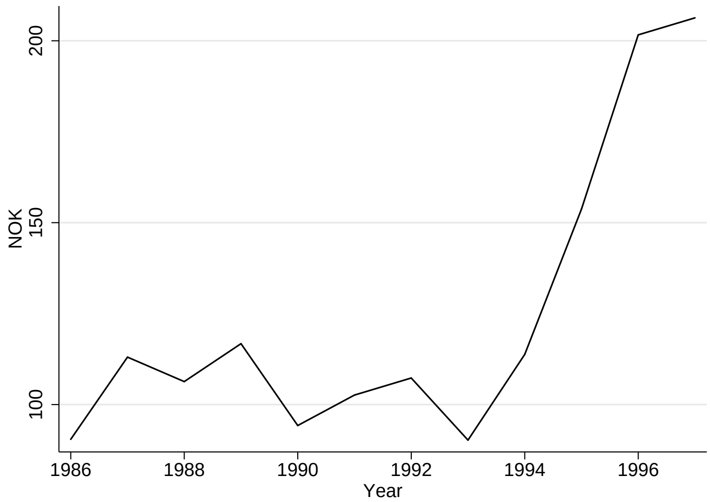


Figure 7: Bonus by level (average over workers).

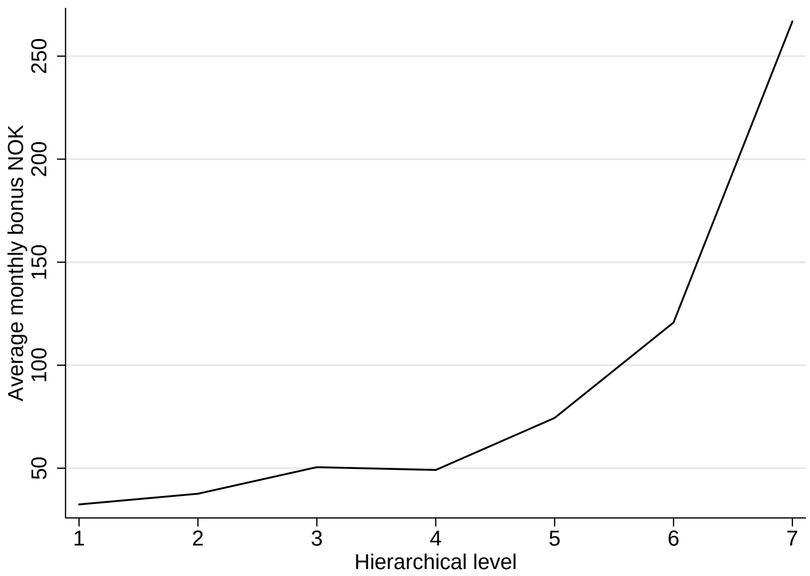
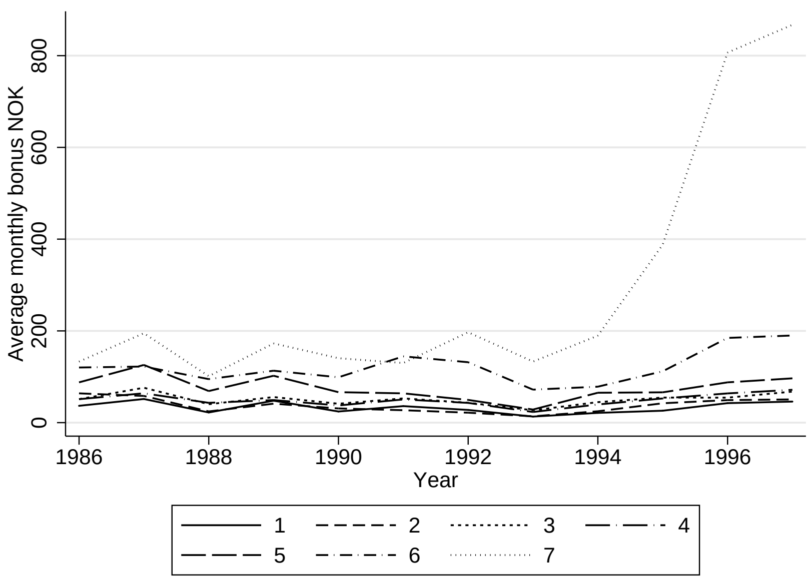


Figure 8: Bonus by level and year (average over workers).



5 Linking wage dispersion and firm performance

5.1 Empirical strategy

From Section 2, it is clear that the empirical predictions from the different theories relating internal wage dispersion and firm performance move in different directions. Ideally, I would like an empirical strategy that allows for not only testing the sign of the dispersion parameter, but also to distinguish between the competing theories. Consider the case where the estimated dispersion parameter is greater than zero, implying that greater wage dispersion is positively associated with higher performance. By itself, this is not sufficient to conclude that firms use tournaments. The positive relationship is only *one* of the predictions of this theory.[17] In this paper, I restrict the analysis, and as such follow the methodologies of the majority of the 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

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

$\log Y_{jt}$ is gross production value per employee at market prices. *bonus* is a dummy taking the value one if the firm has paid bonus in a given year and zero otherwise. The rational for including the dummy is to assess whether 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–both linear and nonlinear terms and both dispersion measures for the fixed part and variable parts of the wage. $\mathbf{I}_{jt}$ is a vector with the inputs log capital[18] per employee, log material costs per employee and

[17] There are several studies that attempt to test tournament theory, especially using data from sports (Prendergast, 1999). But, as Milkovich and Newman (2005) note on p. 78: "[M]ost work is not a round of golf or a good jump shot. Virtually all the research that supports hierarchical structures and tournament theory is on situations where individual performance matters most (auto racing, bowling, golf tournaments) or, at best, where the demand for cooperation among a small group of individuals is relatively low (professors, stockbrokers)." Gibbs (1994) claims that: "many claimed tests of tournaments are really tests of the more general hypothesis that firms use promotion-based incentive schemes, either tournaments *or* standards."

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

log firm size measured as number of employees. The vector $\mathbf{E}_{jt}$ is the aggregate characteristics of the work force: (i) the share of workers with more than 12 years of education; (ii) the share of workers with more than 10 years of tenure; (iii) the share of workers who are younger than 25 years; (iv) the share of workers who are older than 50 years; (v) the share of females and (vi) 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.

5.1.1 Identification

By identification, I mean: How do we know that the parameter β_1 and the parameter vector $\boldsymbol{\gamma}$ in Equation (6) can be given a causal interpretation? In discussing the identification problem I consider four cases. First, assume that firms are experimenting with an incentive scheme, that is changing whether or not to use bonuses and the size of wage dispersion. If this is the case, variation in the incentive schemes is exogenous and the OLS estimator gives a causal interpretation.

In the second case, assume that there are some unobservable characteristics of the firms v_j which have an impact on productivity. An example is the quality of the management; e.g., that management is quick in implementing new technology and work practices. This could also have implications for wage policy if management is quick in adapting new wage policies which (at least *ex ante*) is assumed to increase productivity. In other words, the firm specific effect v_j is correlated with the incentive scheme. If this is the case, we can control for the firm specific characteristics by using a fixed effects model and, hence, obtain a causal interpretation since a fixed effects model will pick up the within-variation over time (the transition from one wage policy regime to another).

To explain the third case, assume that we observe a firm with high productivity and high wage dispersion. One explanation is that the firm is performing well because the wage dispersion creates incentives. The other explanation is that the firm performs well (the firm is exposed to a positive productivity shock $\varepsilon_{jt} > 0$) and has decided to share the profits from this shock with its workers in a way that increases (not necessarily intentionally) the internal wage dispersion. This case implies an inverse causality problem; i.e., it is not possible to see the direction of causality. To solve this potential endogeneity problem, I use Instrumental Variable (IV) estimation.

As an instrument, I use the share of white-collar workers who paid membership fees to a union. For this to be a valid instrument it can have no direct effect on productivity; the effect must go through the incentive scheme.

Information on unionization comes from the NRD and is only available for the years 1991–1995. I assume that bonuses used as incentives in a firm's wage policy, are less used in firms where a large share of the workers are union members. The reason is that bonuses may increase wage differences among the workers and this is not necessarily in the union's interest. LO, the main union in Norway, claims: "[T]o 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 [...] is to halt the unhealthy development of pay increases, options, and bonus arrangements to top leaders."[19, 20]

Finally, a fourth case is possible. Assume that firms are perfectly optimizing with respect to the incentive scheme. Then a marginal change in the incentive scheme does not change productivity. Empirically, this implies that we will find no effect of the incentive scheme on productivity. The problem is again lack of exogenous variation in the incentive scheme, and must be solved by using IV estimation.

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[19] LO (2005, p.9)

[20] Previous studies also show that firms with a higher degree of unionization have a smaller wage dispersion than firms with a 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 inter-establishment and intra-establishment wage distributions for manual workers are narrower in plants with recognised unions." (Booth, 1995, p. 179).

5.2 Results

5.2.1 Unconditional measures

Table 2 shows the results using OLS on the econometric specification (6).[21] When using the OLS estimator, I set the value of v_j to zero and include nine industry dummies. In each of the six models I use different unconditional dispersion measure for the fixed part of the wage (the dispersion measures for the variable part are the same in all models); e.g., in model (3), I use the ratio of the 95th and 5th percentiles. The bonus dummy is significant and positive implying that firms that have bonuses have higher productivity than firms without a bonus payment as part of their wage policy. The estimated parameters for the dispersion of the variable part of the wage appear to indicate a U-shaped relationship. This means that an increase in dispersion in the variable wage portion is negatively associated with firm performance up to a certain point, whereupon the relationship turns positive. But even though the parameters are statistically significant, their size, and hence, their impact on firm performance, seems to be very small. The results further show that none of the unconditional measures for the fixed part of the wage are statistically significant. But they all seem to indicate the same inverse U-shaped relationship found in previous empirical work. The R^2 is the same for all the models in Table 2, regardless of which unconditional dispersion measure used for the fixed part of the wage.

In order to control for unobserved heterogeneity among firms, I allow for fixed effects in the error term. The estimation results are presented in Table 3. The bonus dummy variable remains positive in all models and statistically significant in five of the six models. The dispersion measures for the variable part of the wage are no longer significant and their sign have shifted. Again we see that the dispersion measures for the fixed part of the wage are not statistically significant, except in one case; the ratio of the 99th to the 50th percentile turns out to be statistically significant. The inverse U-shape seems to be present in the fixed effects estimation as it was when applying OLS (except for the 90/50 ratio). Again, we see that the explanatory power of the econometric specification does not depend on which of the

[21] To make the tables smaller and more readable, I only report the estimates of the parameter β_1 and the parameter vector $\boldsymbol{\gamma}$ from Equation (6).

Table 2: Unconditional measures. OLS results.

	CV (1)	99/50 (2)	95/05 (3)	90/10 (4)	90/50 (5)	50/10 (6)
bonus	.047**	.045**	.045**	.046**	.046**	.045**
	(.022)	(.021)	(.021)	(.021)	(.021)	(.021)
σ bonus	-.00002**	-.00002***	-.00002***	-.00002***	-.00002***	-.00002***
	(6.88e-06)	(5.51e-06)	(5.90e-06)	(6.06e-06)	(5.47e-06)	(5.63e-06)
σ^2 bonus	5.02e-10***	4.80e-10***	4.82e-10***	4.94e-10***	4.82e-10***	4.72e-10***
	(1.53e-10)	(1.28e-10)	(1.34e-10)	(1.35e-10)	(1.28e-10)	(1.30e-10)
disp	2.993*	13.804	10.563	5.130	9.238	12.020
	(1.647)	(8.679)	(6.555)	(7.893)	(18.786)	(11.933)
disp^2	-27.570	-6.382	-4.717	-2.207	-4.222	-5.671
	(29.967)	(4.124)	(3.020)	(3.682)	(9.057)	(5.729)
N	10143	10143	10143	10143	10143	10143
R^2	.872	.872	.872	.872	.872	.872

***/**/* significant at 1, 5 and 10 % significance level.

Huber-White robust standard errors allowing for clustering of errors in parentheses.

unconditional dispersion measures is used.

5.2.2 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 OLS while models (3) and (4) are estimated using fixed effects. In model (1), where I have not decomposed the Theil index, all the dispersion measures turns out to be statistically significant and indicate an inverse U-shape between dispersion and firm performance. In the fixed effect model of this specification, model (3), only the squared term of the Theil index is statistically significant. In model (2) I have decomposed the Theil index into the inter- and intrapart, see Equation (4). The estimation results show that it is the dispersion *between* the hierarchical levels that is (statistically) significant and which drives the significance of the Theil index in model (1) as well. This result is compatible with tournament theory where it is the wage spread between the hierarchical levels that creates incentive. Controlling for firm fixed effects removes the statistical significance, implying that the relationship is driven by differences between firms. In both the models (3) and (4) the dummy for the bonuses is barely not significant (p-values of .106 and .101).

Table 3: Unconditional measures. Fixed effects results.

	CV (1)	99/50 (2)	95/05 (3)	90/10 (4)	90/50 (5)	50/10 (6)
bonus	.013*	.012	.013*	.013*	.013*	.013*
	(.008)	(.008)	(.008)	(.008)	(.008)	(.008)
σ bonus	5.10e-06	5.48e-06	5.34e-06	5.25e-06	4.80e-06	5.29e-06
	(3.63e-06)	(3.41e-06)	(3.48e-06)	(3.43e-06)	(3.45e-06)	(3.40e-06)
σ^2 bonus	-9.84e-11	-1.08e-10	-1.03e-10	-9.98e-11	-9.02e-11	-1.01e-10
	(8.17e-11)	(7.86e-11)	(7.95e-11)	(7.79e-11)	(7.87e-11)	(7.72e-11)
disp	1.862	12.638*	6.904	6.675	-.949	10.588
	(1.307)	(6.649)	(4.982)	(5.918)	(15.817)	(10.774)
disp^2	-23.653	-6.015*	-3.126	-3.058	.549	-5.080
	(24.329)	(3.154)	(2.285)	(2.760)	(7.646)	(5.171)
N	10143	10143	10143	10143	10143	10143
R^2 (within)	.73	.73	.73	.73	.729	.729

***/**/* significant at 1, 5 and 10 % significance level.

Huber-White robust standard errors allowing for clustering of errors in parentheses.

Table 4: Theil index results.

	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 models)	.872	.872	.73	.729

***/**/* significant at 1, 5 and 10 % significance level.

Huber-White robust standard errors allowing for clustering of errors in parentheses.

5.2.3 Conditional measures

In Table 5, I present the estimation results using the conditional measures defined in Section 3. We start by looking at columns (1)–(3). Again the bonus dummy is positive and significant. The dispersion in bonus payment is also significant, although the linear term is not significant in model (2). Turning to the fixed part of the wage, in models (1) and (2) in the table I use the first alternative approach–the specification given by Equation (2)–where the dispersion measure is defined as the standard deviation of the idiosyncratic error term. As in the case with unconditional measures, the parameters are not statistically significant. Model (2) differ from model (1) by including the firm fixed effect as an explanatory variable. The parameter estimate is positive and highly statistically significant. But, the inclusion of the fixed effect as an explanatory variable does not change the explanatory power of the model (the R^2 is approximately unchanged). In other words, the firm fixed effects does not contribute much in explaining the variation in firm productivity.

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, confront Equation (5). Again we see that the estimated parameters for the variable part are significant, but none of the dispersion measures for the fixed part are statistically significant. Applying fixed effect models does not add any new insights, see models (4) and (5) in the table.[22] In other words, neither dispersion within nor dispersion between the hierarchical levels has any effect on the firm's productivity. This in contrast to the Theil index measure which showed that it is the wage dispersion between hierarchical levels that is important (Table 4).

5.2.4 IV estimation

The analysis so far have showed that (1) it is difficult to find a link between the dispersion in the fixed part of the wage and firm performance, (2) even though there is a *statistically* significant relationship between the dispersion in the bonus payment and firm performance its *economic* significance is very small, and (3) there is a positive and significant relationship

[22] The dummy variable for the bonus payment is barely (its p-value is .101) not significant in model (4).

Table 5: Conditional measures.

	OLS			Fixed effects	
	(1)	(2)	(3)	(4)	(5)
bonus	.045**	.036*	.046**	.013	.013*
	(.021)	(.020)	(.021)	(.008)	(.008)
σ bonus	-.00002***	-6.22e-06	-.00002***	5.68e-06	4.93e-06
	(3.51e-06)	(5.05e-06)	(5.78e-06)	(3.51e-06)	(3.48e-06)
σ^2 bonus	4.73e-10***	2.95e-10**	5.17e-10***	-1.14e-10	-1.05e-10
	(1.30e-10)	(1.21e-10)	(1.36e-10)	(8.07e-11)	(7.87e-11)
σ ε_{ijt} from Eq. (2)	.297	.113		.030	
	(.182)	(.176)		(.161)	
σ^2 ε_{ijt} from Eq. (2)	-.466	-.292		-.120	
	(.322)	(.315)		(.312)	
firm fixed effects		.465***			
		(.053)			
σ ε_{ijt} from Eq. (5)			.095		-.055
			(.195)		(.170)
σ^2 ε_{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
R^2 (within for FE models)	.872	.876	.872	.729	.73

***/**/* significant at 1, 5 and 10 % significance level.

Huber-White robust standard errors allowing for clustering of errors in parentheses.

between firm productivity and whether or not the firm has bonus payment as part of their wage policy. But this final finding does not necessarily represent a causal relationship between bonuses and productivity, confront with my discussion on identification in Section 5.1.1. To deal with this endogeneity problem I use instrumental variable techniques to instrument the dummy variable for bonus payment. In the remainder of this subsection, I do not include wage dispersion measures in the regressions. (The argument for this is covered by points (1) and (2) at the beginning of this paragraph.) In other words, I restrict the IV-analysis to the dummy variable only.

Start by considering the regression of the endogenous variable on all the exogenous variables including union share, see the lower panel in Table 6 columns (2) and (4). The sign of the union share parameter shows us that the higher the unionization in the firm, the lower the probability (since the dummy is a binary variable) that the firm is employing some form of bonus payment.

The results of the IV estimation are reported in the upper panel in Table 6. Since I now use a sub-sample covering a different time span, I have estimated Equation (6)[23] without controlling for endogeneity in both an OLS and fixed effects framework as benchmarks, see columns (1) and (3).[24] None of the IV estimation results are statistically significant (columns (1) and (4)).[25]

5.3 Robustness checks (and a small extension)

The use of different dispersion measures by itself can be interpreted as a check of robustness. But I have also specified profit per employee, instead of log gross production value per employee, as the dependent variable. 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

[23] Without controlling for wage dispersion (the argument is given in the first paragraph of this section).

[24] In contrast to where I use the whole time span and control for wage dispersion, the dummy variable is not statistically significant in this sub-sample. This implies that the positive relationship between the dummy for bonus payment and firm productivity does not hold (statistically) in this sub-sample.

[25] I have also tried lagged values of the endogenous variable as instrument. The results are not reported since they do not provide any new insights.

Table 6: Instrumental Variable Regressions. Lower panel shows results from the first stage in the IV-estimation.

	OLS	IV	FE	IV panel
	(1)	(2)	(3)	(4)
bonus	.007	.391	.011	.053
	(.013)	(.354)	(.011)	(.229)
N	4407	4407	4407	4407
R^2 (within for FE models)	.897	.861	.784	.783
Lower panel: *Results from the first stage*[a]				
degree of unionization		-.056***		-.087***
		(.017)		(.032)
N		4407		4407
R^2 (within for FE models)		.031		.013

***/**/* significant at 1, 5 and 10 % significance level.

Huber-White robust standard errors allowing for clustering of errors in parentheses.

[a] Non-adjusted standard errors reported for the first stage.

these estimations are not reported since they do not add any new significant information which would alter the above results. The bonus dummy, however, is not significant in as many cases as when using log gross production value per employee as the dependent variable.

As an alternative to using different dispersion measures, I have tried to only look at dispersion measures for the top levels of the firm hierarchy. The results do not add any significant new insights.

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 their wage policy. Second, the coverage of the bonus scheme defined as the fraction of the white-collar workers who have received bonus. Third, the intensity of bonus payment defined as total bonuses paid in a firm as fraction of the total wage for white-collar workers. Fourth, the dispersion in bonus payment measured (as before) as the standard deviation of bonuses. But the results from these estimations are too unstable to give any strong conclusions and are therefore not reported.

6 Summary and conclusion

Writing about wage structure, Lazear and Shaw (2005) state that: "The 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 looked at the relationship between internal wage dispersion and firm productivity. With respect to the wage dispersion measures, I have looked at both conditional and unconditional measures where the main difference between the two types of measures has been whether or not 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 wage dispersion within and between hierarchical levels. Further, I have distinguished between wage dispersion in the fixed and variable part of the wage. To perform the study I used a data set which is very well suited for the research question and which covers white-collar workers in Norway during the period 1986–1997.

The main findings are the following: (1) internal wage dispersion, controlled for worker heterogeneity, has increased during the time period analyzed; (2) there is no significant link between dispersion in the fixed part of the wage and how well the firm performs; (3) even though there is a statistically significant relationship between the dispersion in bonus payments and firm performance, its economic significance is very small; and (4) there is a positive and significant relationship between firm productivity and whether the firm has a bonus payment as part of its wage policy. However, when controlling for endogeneity, this relationship does not hold.

In addition, I have showed that for the variable part of the wage: (1) both the use and size of bonuses appears to have increased somewhat from 1993 and onwards; (2) the mean firm standard deviation in bonus payment has increased significantly from 1993; (3) the size of the bonus is convexly related to the firm's hierarchical levels; and (4) growth in the size of bonus payments has been especially strong for the top worker level in firms.

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

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