Piece-Rate Contracts for Other-Regarding Workers

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Abstract:
When workers are paid with piece rates, inequality arises naturally. We consider workers who care about income comparisons and are either status-seeking or inequality averse. We identify circumstances under which inequality attitudes lead workers to exert more effort than they would otherwise, and also circumstances under which workers’ inequality attitudes lead firms to set lower piece rates than they would otherwise. The key behavioral assumption for both of these results to hold when workers are identical is behindness aversion, the property that changes in inequality matter more to the worker when he is behind than when he is ahead.

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Keywords: Piece rate compensation, inequality aversion, status seeking, wage compression, inequality premium

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1. Introduction

When workers are paid according to their performance, pay inequality arises naturally. Two separate strands of the economics literature suggest that this inequality matters to the workers. First, Frank (1985) argues that humans are hard-wired with a preference for higher status, and therefore like any change that moves them up relative to their coworkers. On the other hand, experimental evidence on ultimatum games, dictator games, and the like have led researchers to assume that subjects dislike inequality (e.g. Fehr and Schmidt, 1999; Bolton and Ockenfels, 2000), and therefore dislike any change that makes payoffs less equal. Either way, pay inequality matters to workers.

The purpose of this paper is to explore piece-rate contracts1 for these other-regarding workers, with a focus on two questions. First, how do attitudes toward inequality affect how workers respond to incentives? Second, how do attitudes toward inequality affect the incentives offered by the firm?

There are at least two good reasons for addressing these questions. First, since there is a chance that workers do care about how much their coworkers are paid, it is important to derive the correct incentive system in the presence of these preferences. Second, and perhaps more importantly, Frank (1984a) establishes that real-world incentive pay systems tend to exhibit wage

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1We look specifically at linear wage contracts, primarily because linear wage contracts, although generally suboptimal, have proven to be an extremely useful vehicle for exploring the effects of risk attitudes on incentive pay (e.g. Gibbons, 1997). However, Holmstrom and Milgrom (1987) show that in a natural class of dynamic moral hazard problems, linear contracts are actually optimal.

2In the Frank Hahn Lecture, Fehr and Fischbacher (2002) state that “neither the effects nor the determinants of material incentives can be adequately understood if one neglects social preferences and that the interaction between material incentives and social preferences is likely to have important effects on the optimality of different types of contracts and property rights.” (p. C2)
Wage compression has been addressed in a variety of other contexts, including centralized and decentralized bargaining and tournaments (see Moene and Wallerstein, 1997; Main, O’Reilly, and Wade, 1993; Lazear, 1989; Kandel and Lazear, 1992; among others). The practice of wage compression is often supported for the reason that it should reduce disharmony among coworkers; however, it is not clear that wage compression is always beneficial because better workers may feel slighted (Lazear, 1989). Importantly, however, the degree of wage compression observed in firms cannot be explained by risk aversion alone (Frank, 1984a).

In his model, workers have different marginal products, output is observed perfectly, and all workers are competitive. Workers who have above-average productivity at their places of employment get utility from their status, while workers who are below average get disutility. Consequently, to keep the below-average workers, the above-average workers must accept a lower wage, which is then used to provide additional compensation for the below-average workers.

**Footnotes:**

3. Wage compression has been addressed in a variety of other contexts, including centralized and decentralized bargaining and tournaments (see Moene and Wallerstein, 1997; Main, O’Reilly, and Wade, 1993; Lazear, 1989; Kandel and Lazear, 1992; among others). The practice of wage compression is often supported for the reason that it should reduce disharmony among coworkers; however, it is not clear that wage compression is always beneficial because better workers may feel slighted (Lazear, 1989). In addition, it is commonly posited that wage compression is a result of risk aversion. Importantly, however, the degree of wage compression observed in firms cannot be explained by risk aversion alone (Frank, 1984a).

4. In his model, workers have different marginal products, output is observed perfectly, and all workers are competitive. Workers who have above-average productivity at their places of employment get utility from their status, while workers who are below average get disutility. Consequently, to keep the below-average workers, the above-average workers must accept a lower wage, which is then used to provide additional compensation for the below-average workers.
preferences and effort costs. First, other-regarding workers exert more effort than self-oriented ones when they are either competitive (i.e. have a preference for status) or behindness averse. This result establishes that piece rates can motivate other-regarding workers more than they motivate purely self-interested ones, and so firms can get a bigger bang for their buck when they use incentive pay with the right types of other-regarding workers. Our second result is that if workers are identical and either inequality averse or behindness averse, the firm’s profit-maximizing piece rate is lower than it would be if workers were purely self-interested. In other words, inequality aversion and behindness aversion both lead to wage compression.

To capture the different inequality attitudes, we employ the Fehr-Schmidt (1999) model of other-regarding preferences. There are several reasons for using their model: it can fit data from a variety of experimental settings (as shown in their original paper), it has an axiomatic foundation (Neilson, 2005), and it has been used successfully in other applications of other-regarding preferences (e.g. Itoh, 2004). In the Fehr-Schmidt model, an individual receives (self-oriented) utility from his own payoff but (social) disutility from any difference between his partner/opponent’s payoff and his own. In a principal-agent setting, the agents’ payoffs are determined by both the pay they receive from the principal and the effort costs they bear. We modify the original Fehr-Schmidt model in two ways, first to allow for other behavioral patterns besides inequality aversion, and second to make social disutility depend on pay differences while self-oriented utility depends on pay minus effort costs.

Although there are several good reasons for assuming that workers compare pay but not effort costs, it is not entirely clear what workers actually compare. In his book addressing wage rigidity, as support for internal pay equity, Bewley (1999) states that employees care about their pay
relative to that of their co-workers. Additionally, he finds that even when pay secrecy is a company policy, workers often tell one another how much they make. Accordingly, we choose to focus our analysis on comparisons of gross wages, but in Section 7, we also explore the implications of our model when workers compare net wages.5

Other researchers have also looked at the effects of other-regarding preferences in performance-pay settings. Bartling and von Siemens (2005) derive optimal incentive contracts for risk, inequality, and behindness averse agents in a moral hazard setting. They find that behindness aversion increases the agency costs of providing incentives because agents suffer both from inequality and risk. However, their model is restricted to a setting in which agents have a binary effort choice. Our model is more general than this, as we allow for a continuum of effort choices. Rey Biel (2004) looks at a two-worker joint-production game with binary effort choices and finds that inequality aversion allows the firm to induce the desired effort for less pay by designing a compensation scheme that imposes inequality off of the equilibrium path. Demougin and Fluet (2003) also demonstrate how firms can use the threat of inequality to induce workers to exert effort for less pay. Englmaier and Wambach (2003, 2005), Dur and Glazer (2004), and Itoh (2004) all examine incentive contracts when agents care about inequality relative to the principal (instead of their coworkers). However, Itoh (2004) also compares agents with other-regarding preferences, and

5 In contrast to Bewley’s findings, researchers in the social psychology literature suggest that individuals use comparisons which are biased in a self-serving manner. This suggests, for example, that when an individual works harder than his coworker, he compares net pay, whereas when the coworker works harder, he compares gross pay (see Walster, et al. 1978). Similarly, Messick and Sentis (1979, 1983) and Cook and Yamagishi (1983) suggest that individuals who exert less effort view equal wages as being fair, whereas those who exert more effort are likely to view wages proportional to effort as being fair. In short, the current literature suggests that what workers compare is likely context-dependent.
he finds that as agents become more inequity averse, wages become smaller and the principal’s expected utility increases. Furthermore, when there are multiple symmetric other-regarding agents, as agents become more inequity averse, wages become smaller and the principal’s expected utility increases. Grund and Sliwka (2002) show that inequality aversion can lead competitors to increase their effort in an appropriately-designed tournament.

The paper proceeds as follows. Section 2 provides a brief description of the model. Other-regarding preferences are discussed in a general context in Section 3, and Section 4 compares the effort choices of other-regarding workers and self-oriented workers. Section 5 introduces the inequality premium and determines how it responds to changes in the piece rate and the parameters of the preference representation. Section 6 examines the impact of other-regarding preferences on the optimal piece rate. Section 7 checks the robustness of the results when workers compare net rather than gross wages, and Section 8 offers a conclusion. All proofs are collected in an appendix.

2. Description and Timing of the Model

In this principal-agent model, the principal is risk neutral and the workers are risk neutral but other-regarding. The timing is as follows. The principal offers all workers a single pay schedule \((s, b)\) consisting of a salary component, \(s\), and a piece rate component, \(b\). Workers observe

\[\text{6 All the results of this paper still hold if the workers are allowed to be risk averse. Risk neutrality is assumed for reasons of transparency.}\]

\[\text{7 If workers have different effort cost functions, the optimal piece rate scheme would entail different piece rates and different salaries for the two workers. Many real-world firms, however, offer a single piece rate scheme to all of their workers, and the situation described here fits those firms. Of course, if the salary is insufficient to meet one worker’s participation constraint, that worker exerts no effort.}\]
the contract and decide whether they want to participate or not, and if they choose to participate, they exert the level of effort which maximizes their expected utility. The principal observes the output from each worker and pays the agent according to the specified contract.

Workers generate output by exerting effort. When worker $i$ exerts effort $e_i$, his output is given by $e_i + \epsilon_i$, where $\epsilon_i$ is a random variable caused by measurement error by the employer. Each $\epsilon_i$ is drawn independently from the distribution $F$. Worker pay is determined by $s$ and $b$: if worker $i$ is observed to generate output $e_i + \epsilon_i$, his pay is $w_i = s + b(e_i + \epsilon_i)$. Exerting effort is costly, and worker $i$'s effort-cost function is given by $c_i(e_i)$, which is assumed to be zero at zero and strictly increasing and strictly convex. Worker $i$'s net income from the employment relationship is defined as $s + b(e_i + \epsilon_i) - c_i(e_i)$, or $w_i - c_i(e_i)$.

3. Preferences

It is assumed that a worker’s utility depends on his own payoff and a comparison of his own income with that of his coworker. Let worker 1 be the worker whose decision we are modeling, and let worker 2 be his coworker. Worker 1's utility function is given by

$$U(w_1, c_1(e_1), w_2) = E[u(w_1 - c_1(e_1))] - aE[V(w_2 - w_1)].$$  \hspace{1cm} (1)

The function $u$ represents worker 1's own utility from his net wage and is referred to as the self-oriented utility function, the function $V$ represents his disutility from inequality in gross wages and is referred to as the social disutility function, and $a \geq 0$ is a shift parameter that reflects the strength
of the decision-maker’s other-regarding preferences.\(^8\)

We assume that \(u\) is linear and strictly increasing with \(u(x) = x\) and that \(V\) takes the following form:

\[
V = \begin{cases} 
\nu(\eta) & \eta \geq 0 \\
\lambda \nu(-\eta) & \eta < 0 
\end{cases}
\]  

(2)

where \(\nu\) is nonnegative, strictly increasing, and strictly convex with \(\nu(0) = 0\). The function \(V\) captures different types of equity attitudes according to the value of \(\lambda\).\(^9\) First, note that \(\eta \geq 0\) when \(w_1 \leq w_2\), which means that worker 1 is behind in the payoff comparison, while when \(\eta \leq 0\) worker 1 is ahead in the comparison.\(^10\) Since \(V\) is subtracted from \(u\) in the specification of \(U\), the assumptions \(\nu(0) = 0\) and \(\nu' > 0\) mean that the worker dislikes being behind. Also, the property \(\nu' > 0\) means that the worker prefers to catch up when he is behind. If \(\lambda > 0\), worker 1 also dislikes being ahead. Since, when \(\lambda > 0\), the worker dislikes any situation in which wages are unequal, \(\lambda > 0\) implies inequality aversion. In contrast, when \(\lambda < 0\) worker 1 likes being ahead and prefers to move farther ahead, or, equivalently, prefers that worker 2 move farther behind. This behavioral

\(^8\) The functional form in (1) corresponds to the Fehr-Schmidt (1999) model of inequality aversion if all components of income (and not just gross wages) matter for comparison, if both \(w_1 - c_1(e_1)\) and \(w_2 - c_2(e_2)\) are nonstochastic, and if \(V\) is piecewise linear.

\(^9\) The function \(V\) is reminiscent of the value function used in cumulative prospect theory (Tversky and Kahneman, 1992). In that setting, individual choice under risk, the value function is specified to capture the reflection effect (choice patterns over gains are the opposite of choice patterns over losses) and loss aversion (losses have a larger effect than gains), and \(\lambda\) would be interpreted as a loss aversion parameter. The function also captures one of the features of the Fehr-Schmidt model: the function used to govern positive payoff differences is a multiple of the function used to govern negative payoff differences.

\(^10\) Ahead and behind are both weak comparisons here, implying that when \(\eta = 0\) worker 1 is both ahead and behind.
pattern is commonly referred to as *competitiveness*, where the decision maker chooses to increase the difference between his payoff and his opponent’s payoff (MacCrimmon and Messick, 1976). This can also be thought of as status seeking, as in Frank (1985).

An increase in \( \lambda \) represents a movement toward inequality aversion and away from competitiveness, and so \( \lambda \) is referred to as the *inequality aversion parameter* since increases make the worker more inequality averse. The magnitude of \( \lambda \) is also meaningful. When \(|\lambda| < 1\), being behind by a certain amount generates more disutility than the utility gained or lost by being ahead an equal amount. Accordingly, when \(|\lambda| < 1\) the individual is *behindness averse*. When \(|\lambda| > 1\), being ahead has a larger effect than being behind. Fehr and Schmidt (1999) support a behindness averse specification, and behindness aversion is also consistent with the logic of loss aversion. Figure 1 shows the \( V \) function for different values of \( \lambda \).

Finally, if a worker chooses not to enter the employment relationship, he exerts no effort and receives no pay, so his income is nonstochastic and zero. Moreover, if he is not in the employment relationship, he has no “coworker” in the true sense of the word, and therefore has no obvious candidate for comparison. Accordingly, we assume that if the worker is not in the employment relationship, the second component of the preference function is irrelevant, and his utility is \( u(0) = 0 \).

### 4. The Agent’s Problem

According to the preferences specified in equation (1), the self-oriented utility function \( u \) depends on net income, but the social-disutility function \( V \) depends on the difference between gross incomes. For worker 1, then, since worker i’s gross income is \( s + b(e_i + \epsilon_i) \), the social-disutility
function $V$ is a function of $b(e_2 - e_1 + \epsilon_2 - \epsilon_1)$. Suppose that worker 2's effort level is given at $e_2$.

Worker 1 chooses $e_1$ to maximize

$$U(e_1, e_2) = E[s + b(e_1 + \epsilon_1) - c_1(e_1)] - aE[V(b(e_2 - e_1 + \epsilon_2 - \epsilon_1))],$$

which is assumed throughout to be strictly concave in $e_1$ so that a unique maximum exists.\(^{12}\)

Let $z = \epsilon_2 - \epsilon_1$, and let $G$ be the distribution function for the random variable $z$, with density function $g$. Since $\epsilon_1$ and $\epsilon_2$ are drawn independently from the same distribution, $z$ is symmetric about zero, which implies that $g(z) = g(-z)$. From the definition of $V$ in (2), if $e_2 - e_1 = k < 0$ we have $V(k) = \lambda v(-k)$, which combined with the symmetry of $g(z)$, yields

$$\int_{-\infty}^{k} V(-k + z)dG(z) = \lambda \int_{-\infty}^{\infty} v(k + z)dG(z),$$

as illustrated in Figure 2. We can then rewrite

$$E[V(b(e_2 - e_1 + z))] = \int_{e_2 - e_1}^{\infty} v(b(e_2 - e_1 + z))dG(z) + \lambda \int_{e_2 - e_1}^{\infty} v(b(e_1 - e_2 + z))dG(z).$$

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\(^{11}\) We have simplified notation, writing $U(e_1, e_2)$ instead of the more cumbersome $U(s + b(e_1 + \epsilon_1), c_1(e_1), s + b(e_2 + \epsilon_2))$.

\(^{12}\) Compute $\partial^2 U/\partial e_1^2 = -c_1'' - ab^2EV''$. By assumption, $c_1'' \geq 0$. $U$ is strictly concave in $e_1$ if $V''$ is not too negative, that is, if $V$ is not too concave.
The first integral on the right-hand side of (5) is the contribution to expected social utility from being behind, and the second integral is the contribution from being ahead.

Since each worker’s income is random, it is useful to define notions of ahead and behind in expectation. If $e_1 \leq e_2$ worker 1 is said to be \textit{behind in expectation}, and when $e_1 \geq e_2$ he is said to be \textit{ahead in expectation}. A worker could be behind in expectation, for example, if his marginal effort costs are higher than his opponent’s, and so he exerts less effort than his opponent. Since the noise terms are drawn identically and independently, if he exerts less effort his expected output is less than his coworker’s. Note that by the conventions established here, when $e_1 = e_2$ worker 1 is both ahead in expectation and behind in expectation.

The optimal effort level, $e_1^*$, satisfies the first-order condition

$$b - c_1'(e_1) - a \frac{\partial}{\partial e_1} E[V(b(e_2 - e_1 + z))] = 0. \tag{6}$$

From (5), we get

$$\frac{\partial}{\partial e_1} E[V(b(e_2 - e_1 + z))] = -b \int_{e_1 - e_2}^{e_1} v'(b(e_2 - e_1 + z))dG(z) + b\lambda \int_{e_1 - e_2}^{e_1} v'(b(e_1 - e_2 + z))dG(z)$$

$$- v(0)g(e_1 - e_2) + \lambda v(0)g(e_2 - e_1)$$

$$= -b \int_{e_1 - e_2}^{e_1} v'(b(e_2 - e_1 + z))dG(z) + b\lambda \int_{e_1 - e_2}^{e_1} v'(b(e_1 - e_2 + z))dG(z). \tag{7}$$

The two terms in the middle line of the equation are zero because $v(0) = 0$. Let $e_1^0$ satisfy $c_1'(e_1^0) = b$. Then from (6), $e_1^0$ is the optimal effort level when the worker is
not concerned with his coworker’s payoff, that is, when \( a = 0 \). The first proposition compares the optimal effort level when inequality matters, \( e_1^* \), to the optimal effort level when it does not, \( e_1^0 \).

**Proposition 1.** An other-regarding worker exerts more effort than a self-oriented one (i.e. \( e_1^* > e_1^0 \)) when one of the following conditions holds:

(i) The worker is competitive (i.e. \( \lambda < 0 \)), or

(ii) The worker is inequality averse, behindness averse, and behind in expectation at \( e_1^0 \) (i.e. \( \lambda \in [0,1) \) and \( e_1^0 < e_2 \)).

Proof in Appendix.

The proposition states that competitive workers exert more effort for a given piece rate than self-oriented ones do, and that inequality averse workers who are also behindness averse exert more effort than self-oriented ones do when they would expect to be behind at the self-oriented level of effort.

In the absence of other-regarding preferences, the worker chooses the effort level that equates the piece rate and the marginal cost of effort. In contrast, the presence of inequality affects the marginal condition, for the simple reason that by raising or lowering his effort level the worker can change the amount of inequality. The proposition identifies inequality attitudes which lead the worker to choose more effort.

The results of Proposition 1 are straightforward to see when one assumes no measurement error, so that \( \varepsilon_1 = \varepsilon_2 = 0 \). Then

\[ e_1^0 \] is also the effort exerted by a risk averse but non-other-regarding worker.
Suppose that choosing $e_1^0$ leaves worker 1 behind, i.e. $e_1^0 < e_2$. Differentiating $U$ with respect to $e_1$ and evaluating at $e_1^0$ yields $abv'(b(e_2 - e_1^0)) > 0$, so the worker prefers to exert more effort than $e_1^0$. Now suppose that choosing $e_1^0$ moves worker 1 ahead of worker 2. This time differentiation at $e_1^0$ yields $-ab\lambda v'(b(e_2 - e_1^0))$, which is positive if $\lambda < 0$, that is, if the worker is competitive. The conditions in the proposition are stronger than these because of the measurement error. The same intuition holds, though. If the worker is competitive, increases in his effort make the expected income difference $b(e_2 - e_1)$ smaller, which increases his utility through the function $V$. Accordingly, the piece rate motivates him to exert extra effort in order to move farther ahead of (or catch up to) the other worker. In much the same way, if the worker is inequality averse, he wants to narrow any income gap. He can do this by exerting more effort when he is behind or by exerting less effort when he is ahead. However, with measurement error both events occur with positive probability. In order for the worker to exert more effort when he is behind in expectation at $e_1^0$, the impact of being behind must outweigh the impact of being ahead, which holds if $\lambda \in [0,1)$.

A look at (6) shows that $\partial^2 U(e_1^0, e_2)/\partial e_1 \partial a = [\partial U(e_1^0, e_2)/\partial e_1]/a$, and so an increase in $a$ magnifies the effect of inequality on effort. Also,

$$\frac{\partial^2}{\partial e_1 \partial \lambda} U(e_1^0, e_2) = -ab \int_{e_2 - e_1^0}^\infty v'(b(e_1^0 - e_2 + z))dG(z) < 0. \tag{9}$$

As the worker becomes less competitive, or more inequality averse, the effect on effort diminishes. This makes sense, because a competitive worker always provides more effort than $e_1^0$, but an
inequality averse worker may exert less than $e_1^0$. The move from competitiveness to inequality aversion reduces the amount of effort provided.

Finally, a look at (7) allows a discussion of when the presence of other-regarding preferences might lead to less effort. According to the proposition, one looks at the case in which the worker is inequality averse and $e_1^0 > e_2$, so that choosing $e_1^0$ places the worker ahead of his coworker in expectation. Because $e_1^0 > e_2$, the first integral in (7) is over a smaller probability mass than the second term. Consequently, when $\lambda \geq 1$ the second term dominates the first, and the worker exerts less effort than $e_1^0$ when he is ahead of his coworker. This can also occur when $\lambda$ is less than but close to one, which has the interpretation that the decision-maker is inequality averse but not very behindness averse.

When workers have identical preferences and costs, for each value of $b$ there is a symmetric equilibrium in which both workers exert the same effort level, $e^*$. Take the first derivative of (3) with respect to $e_1$ and substitute $e_1 = e_2 = e$, and that effort level, $e^*$, solves

$$b - c'(e^*) + a \frac{\partial}{\partial e_1} E[V(bz)] = 0. \tag{10}$$

The derivative $de^*/da$ tells how the symmetric equilibrium effort level changes when the workers become more sensitive to inequality. From standard comparative statics techniques, the sign of $de^*/da$ is the same as the sign of $\partial E[V(bz)]/\partial e_1$,\textsuperscript{14} which from (5) is

\textsuperscript{14} The first order condition has $U_1(e_1, e_2) = 0$. Implicitly differentiating with respect to $a$, holding $e_2$ constant, yields $U_{11} de_1/da + \partial U_1/\partial a$. Since $U_{11} < 0$ by assumption, $de_1/da$ and $\partial U_1/\partial a$ have the same sign. Furthermore, as already argued, $\partial U_1/\partial a$ has the same sign as $U_1$.\textsuperscript{14}
which is positive when $\lambda < 1$. This establishes the next proposition, whose proof is omitted.

**Proposition 2.** If workers are identical and are either competitive, behindness averse, or both (i.e. $\lambda < 1$), then in symmetric equilibrium, when they become more other-regarding (i.e. $a$ increases), they both exert more effort.

According to Proposition 2, if the workers have identical costs and preferences that exhibit either competitiveness or inequality aversion combined with behindness aversion, their other-regarding preferences provide an intrinsic incentive that works alongside the piece rate in motivating effort. Competitive workers exert additional effort because they like their incomes moving ahead of their coworker's income, and they dislike it when their incomes fall behind. Inequality averse workers dislike moving ahead and moving behind, but behindness aversion states that moving behind has the larger effect. So, the inequality averse workers exert additional effort in order to avoid falling behind their coworkers.

This result is reminiscent of the results from promotion tournaments (e.g. Lazear and Rosen, 1981). In tournaments, workers exert effort in an attempt to win a prize, and the larger the prize, the harder they work. When workers are identical, as they are in Proposition 2, they have equal chances of winning the tournament in equilibrium, yet they still work harder when the prize increases. Essentially, if they do not work harder when the prize increases, their opponents have an incentive to exert even more effort, and the non-responding worker’s probability of winning falls.
So, workers respond to higher prizes by exerting more effort to avoid falling behind. Similarly in this setting, an increase in $a$ intensifies the “rewards” from being ahead and the “losses” from being behind, and the workers respond to this by exerting more effort in an attempt to not fall behind.

5. Inequality premia

When workers are not other-regarding, measurement error causes their participation constraints, or individual rationality constraints, to change. Measurement error introduces income risk, and when workers are risk averse the firm must pay a risk premium to induce them to participate in the employment relationship. In this setting with risk neutral but other-regarding workers, different considerations occur because of inequality, which arises for two reasons. First, measurement error introduces inequality even when both workers exert the same amount of effort. Second, inequality occurs when one worker chooses more effort than the other, which may come about because of such factors as cost differences or heterogeneous preferences. When workers are other-regarding, the firm must pay an inequality premium in order to satisfy the workers’ participation constraints. In this section, we explore properties of the inequality premium.

With noise, but no coworker, worker 1’s utility is given by $E[s + b(e_1 + \epsilon_1) - c_1(e_1)] = s + be_1 - c_1(e_1)$. With a coworker, utility is given by $U(e_1, e_2) = s + be_1 - c_1(e_1) - aE[V(b(e_2 - e_1 + \epsilon_2 - \epsilon_1))]$. We define the *inequality premium* by the value $\theta_i$ that solves $s + be_1 - c_1(e_1) - \theta_i = U(e_1, e_2)$, or

$$\theta_i = aE[V(b(e_2 - e_1 + \epsilon_2 - \epsilon_1))].$$

**Proposition 3.** The inequality premium is increasing in an individual’s degree of inequality.
aversion ($\partial \theta / \partial \lambda > 0$).

Proof in Appendix.

Proposition 3 says that for any type of other-regarding preferences, the inequality premium rises when the worker becomes more inequality averse (less competitive). To understand why, first note that the parameter $\lambda$ only comes into play when the worker is ahead. When $\lambda < 0$ he likes being ahead, but when $\lambda > 0$ he dislikes it. Increasing $\lambda$ either moves the worker closer to the range where he dislikes being ahead, or farther into that range. Either way, the inequality premium rises.

**Proposition 4.** The inequality premium is increasing in the piece rate ($\partial \theta / \partial b > 0$) when one of the following two conditions holds:

(i) The worker is inequality averse ($\lambda \geq 0$), or

(ii) The worker is competitive, behindness averse, and behind in expectation ($\lambda \in (-1, 0)$ and $e_1 \leq e_2$).

Proof in Appendix.

Proposition 4 states that the inequality premium rises as the piece rate rises when either the worker is inequality averse or when he is competitive, behindness averse, and behind in expectation. An inequality averse worker dislikes being either ahead or behind and, since $\nu$ is increasing, he dislikes it more the further ahead or behind he is. Increasing the piece rate scales up the inequality, making the worker worse off and raising the inequality premium. A competitive worker dislikes being behind but likes being ahead. Behindness aversion means that the effect when behind
outweighs the effect when ahead, and the assumption that he is behind in expectation places greater probability mass on the event that he is behind. An increase in the piece rate scales up the inequality, and since the effect of being behind outweighs the effect of being ahead, the inequality premium rises.

6. The optimal piece rate

The purpose of this section is to address two issues concerning the optimal piece rate set by the firm. First, is the choice of piece rate impacted by the inequality attitudes of the workers? Second, are there circumstances under which the workers’ other-regarding preferences lead to wage compression?

If \( p \) is the price of output, the optimal piece rate chosen by the firm maximizes expected profit, \( \pi \), given by

\[
\pi = pe^* - (s + be^*),
\]

subject to the agent’s incentive compatibility constraint (given by equation (6), which defines \( e^* \)) and the individual rationality constraint, which says that accepting employment earns him at least a certain equivalent income of zero.\(^{15}\)

\(^{15}\) In most of the incentive pay literature, analyses look at maximizing total surplus rather than expected profit. In this setup maximizing expected profit generates the same result as maximizing total surplus. The total surplus (or total certainty equivalent) has two components: the firm’s certainty equivalent (or certain equivalent income), which is expected revenue minus expected worker compensation, and the worker’s certainty equivalent (or certain equivalent wealth), which is his expected wage minus the cost of both exerting effort and bearing risk and inequality.
\[ s + be^* - c(e^*) - \theta_j(b,s,a,\lambda) \geq 0. \tag{14} \]

Suppose that the workers are identical, in terms of both preferences and costs, so that they both choose the same effort level.\(^\text{16}\) The expression for per capita expected profit, after substituting in the constraint, is given by

\[ \pi = pe^* - c(e^*) - \theta_j(b,s,a,\lambda). \tag{15} \]

Differentiating (15) with respect to \( b \) yields the first-order condition given by

\[ \frac{\partial \pi}{\partial b} = (p - c'(e^*)) \frac{de^*}{db} - \frac{\partial \theta_j}{\partial b} = 0. \tag{16} \]

This determines the optimal piece rate \( b^* \).\(^\text{17}\)

If workers are not other-regarding, the first-order condition reduces to \( (p - c'(e))\frac{de^*}{db} = 0 \), and the optimal piece rate is the one that induces the amount of effort that equates the price and marginal effort cost. When workers are other-regarding, the optimal piece rate could be either higher or lower than the one that is optimal when workers are inequality neutral. Equation (16)

\(^\text{16}\) This assumption is made because if workers had different costs, for example, the firm would want to set different piece rates for the two workers. Since we are interested in the inequality generated when all workers receive the same piece rate, the assumption of identical workers is natural. If workers had different piece rates, this would provide another potential dimension for comparison for the social disutility function.

\(^\text{17}\) Second order conditions require that \( (p - c'(e^*))\frac{\partial^2 e^*}{\partial b^2} - c''(e^*)\frac{\partial^2 e^*}{\partial b^2} - \theta_j'' \frac{\partial \theta_j}{\partial b^2} < 0 \), which always holds if we assume \( \frac{\partial^2 \theta_j}{\partial b^2} > 0 \) and \( \text{sgn}(p - c'(e^*)) = -\text{sgn}(\frac{\partial^2 e^*}{\partial b^2}) \).
suggests two counteracting forces that govern the choice of the optimal piece rate when workers become more other-regarding. One is an *inequality premium effect*, which puts downward pressure on piece rates, and it is captured by the change in the term $\theta \partial \theta / \partial b$ as $a$ increases. As the workers become more other-regarding, the firm has an incentive to reduce the piece rate, thereby reducing the inequality premium and hence the total compensation it must provide the worker. The second is an *incentive effect*, which may put upward pressure on piece rates, and it is captured by the change in the term $(p - c'(e)) \partial e^*/ \partial b$ as $a$ increases. As workers become more other-regarding they may become more responsive to incentives, prompting the firm to increase the piece rate to take advantage of this increased responsiveness. Neither of these effects exist when workers are only risk averse and not other-regarding.

The impact on the optimal piece rate depends on which of these two effects dominates. The next proposition establishes that the inequality premium effect dominates in an interesting class of problems. Suppose that both workers are identical, and let $b^0$ be the piece rate for which $c'(e^0(b^0)) = p$, so that $b^0$ is the optimal piece rate when workers are not other-regarding. Letting $b^*$ denote the optimal piece rate when workers are other-regarding (as defined by equation (16)), we get the following result.

**Proposition 5.** Suppose that workers are identical, inequality averse and/or behindness averse ($\lambda > -1$), and not too other-regarding ($0 < a < A$ for some $A > 0$). Then $b^* < b^0$.

Proof in Appendix.

To understand Proposition 5, first assume that $de^*/ \partial b > 0$, so that workers respond to incentives.
Proposition 4 states that if the workers are either inequality averse, behindness averse, or both,\[ \frac{\partial \theta}{\partial b} > 0. \] Equation (16), the first-order condition governing the optimal piece rate, can then only hold if \( p > c'(e^*) \). Recalling that \( c'(e^0) = p \) and that marginal costs are increasing, it follows that \( e^* < e^0 \), and \( de^*/db > 0 \) then implies that \( b^* < b^0 \). Proposition 5 establishes that other-regarding preferences can contribute to wage compression, and this may help explain why, as Frank (1984a) discusses, the degree of wage compression observed in firms is more than that predicted by risk aversion alone.

The condition that workers are not too other-regarding guarantees that \( de^*/db > 0 \). When \( a = 0 \) the workers are not other-regarding and their effort choices are governed by the condition \( c'(e^0) = b \). Consequently, \( de^*/db > 0 \) when \( a = 0 \). By continuity there exists some \( A > 0 \) such that \( de^*/db > 0 \) whenever \( a \in (0,A) \).

7. Cost comparisons in the social disutility function

In this section we explore the robustness of the results to a change in the specification of preferences. In particular, we change the worker’s preferences so that he cares not just about pay differences but also about effort cost differences.

Assume in equation (1) that the worker compares his own pay minus effort costs to his coworker’s pay less effort costs. Worker 1 chooses \( e_1 \) to maximize

\[
U(e_1, e_2) = E[s + b(e_1 + e) - c_1(e_1)]
- aE[V(b(e_2 - e_1 + e_2 - e) - (c_2(e_2) - c_1(e_1)))].
\] (17)
The key difference between this case and the benchmark case of earlier sections is that the worker's first-order condition for maximization is changed. Differentiate (17) with respect to $e_1$ to get

$$\frac{\partial U}{\partial e_1} = (b - c_1'(e_1))(1 + aE[V']),$$

(18)

and let $e_1^{**}$ solve the first order condition in (18). Note that (18) is equal to zero when $c_1'(e_1) = b$, which is exactly the definition of $e_1^0$, the optimal effort for a self-oriented worker. This proves the following proposition.

**Proposition 6.** Assume that workers compare net income as in (17). Then other-regarding workers exert the same level of effort as self-oriented ones (i.e. $e_1^{**} = e_1^0$).

When workers compare effort costs as well as pay levels, piece rates do not provide any extra incentives over the self-oriented case. Thus, Proposition 1 is not robust to this change in the preference specification. It is informative to explore why not. In the benchmark case, at $e_1^0$, a marginal increase in effort leads to no additional self-oriented utility, but it does lead to a marginal increase in expected income, and so it leads to a marginal change in inequality. The worker likes this marginal change in inequality when he is competitive, because the increased effort makes the income comparison more favorable in expectation. He also likes the marginal change when he is inequality averse, behindness averse, and behind in expectation, because the additional income reduces the amount of inequality and places more probability mass on the event where he is ahead. When effort costs enter the social comparison, though, the marginal increase in effort does not
change the social comparison because it changes income and effort costs in exactly the same way, and this is regardless of whether the worker is competitive or inequality averse.

Even though the counterpart of Proposition 1 does not hold in this setting, the inequality premium exhibits properties similar to those in the benchmark setting and leads to the same wage compression result. To that end, let $b^{**}$ denote the optimal piece rate for the firm when workers compare net income.

**Proposition 7.** Assume that workers are identical, compare net income as in (17), and are inequality averse and/or behindness averse ($\lambda > -1$). Then the inequality premium is increasing in the piece rate and in the degree of inequality aversion ($\partial \theta / \partial b > 0$ and $\partial \theta / \partial \lambda > 0$), and the optimal piece rate is lower than it would be for self-oriented workers ($b^{**} < b^0$).

Proof in Appendix.

The result of Proposition 7, that $\partial \theta / \partial b > 0$, means that the inequality premium increases when the piece rate increases, and is consistent with Proposition 3. The second result states that the inequality premium increases when the workers become more inequality averse, as measured by $\lambda$, and is consistent with Proposition 4. The final result states that the firm’s profit-maximizing piece rate is less than the one it would set if workers were inequality neutral, i.e. when $a = 0$. This last result is consistent with Proposition 5, and so the primary finding that other-regarding attitudes can lead to reduced incentives when workers are either inequality averse, behindness averse, or both extends to the case in which workers compare net incomes rather than gross pay.
8. Conclusions

This paper demonstrates two major results. First, if workers are identical, care about wage differences, and are behindness averse, they work harder than they would if they were self-oriented. Second, the effect of other-regarding behavior on the optimal piece rate is governed by two effects: other-regarding workers exerting more effort puts upward pressure on the piece rate as workers become more other regarding (the incentive effect), but other-regarding workers must also be compensated for facing inequality and this puts downward pressure on the optimal piece rate (the inequality premium effect). When workers are behindness averse the inequality premium effect dominates, and so the existence of workers with other-regarding attitudes leads the firm to reduce the incentive pay in its compensation scheme, which is wage compression.

When workers compare net rather than gross wages, the results change somewhat. In contrast to the results in Section 4, we find that piece rates do not provide any extra incentives over the self-oriented case. On the other hand, in this setting, the inequality premium exhibits similar properties to those in the setting where workers compare gross wages, and hence the wage compression result still holds.

Behindness aversion provides a link between the two main results. Workers provide extra effort if they are competitive, or if they are both inequality averse and behindness averse. The inequality premium rises with the piece rate and wage compression results if workers are inequality averse, or if they are both competitive and behindness averse. So, when workers are behindness averse, both results hold, and it does not matter if they are also competitive or inequality averse. In this sense, and in this setting, behindness aversion is more important than the other behavioral patterns. In spite of this, behindness aversion has received little attention in the literature, and it deserves more investigation.
Appendix

Proof of Proposition 1. By (7) and the definition of $e_1^0$,

$$
\frac{\partial}{\partial e_1} U(e_1^0, e_2) = -a \frac{\partial}{\partial e_1} E[V(b(e_2 - e_1^0 + z))] \\
= ab \int_{e_1^0 - e_2}^{\infty} v'(b(e_2 - e_1^0 + z))dG(z) - ab\lambda \int_{e_2 - e_1^0}^{\infty} v'(b(e_1^0 - e_2 + z))dG(z). \quad (A1)
$$

Since $v' > 0$, the first term is positive. If (i) holds, so that $\lambda < 0$, the second term is positive, and $\partial U(e_1^0, e_2)/\partial e_1 > 0$. If (ii) holds, so that $\lambda \in [0,1)$ and $e_1^0 \leq e_2$,

$$
\frac{\partial}{\partial e_1} U(e_1^0, e_2) = ab \int_{e_1^0 - e_2}^{\infty} v'(b(e_2 - e_1^0 + z))dG(z) - ab\lambda \int_{e_2 - e_1^0}^{\infty} v'(b(e_1^0 - e_2 + z))dG(z) \\
\geq ab \int_0^{\infty} v'(bz)dG(z) - ab\lambda \int_0^{\infty} v'(bz)dG(z) \quad (A2) \\
= (1 - \lambda)ab \int_0^{\infty} v'(bz)dG(z) \\
> 0.
$$

The first inequality holds because by replacing $e_1 - e_2$ with zero, the first integral is taken over a smaller probability mass, while the second integral is taken over a larger probability mass. For the second inequality, $\lambda$ is replaced by 1, which is larger than any value that it can take. Under both conditions (i) and (ii), then, $\partial U(e_1^0, e_2)/\partial e_1 > 0$, and, since $\partial U(e_1^*, e_2)/\partial e_1 = 0$, it follows that $e_1^* > e_1^0$.

\(\Box\)

Proof of Proposition 3. From (12) and (5) we have
\[
\frac{\partial \theta_i}{\partial \lambda} = a \frac{\partial E[V(b(e_2 - e_1 + z))]}{\partial \lambda}
\]
\[
= a \int_{e_2-e_1}^{\infty} v(b(e_2 - e_1 + z))dG(z) > 0.
\] □ (A3)

**Proof of Proposition 4.** From (12) and (5) we have

\[
\frac{\partial \theta_i}{\partial b} = a \frac{\partial E[V(b(e_2 - e_1 + \epsilon_2 - \epsilon_1))]}{\partial b}.
\] (A4)

From (5),

\[
\frac{\partial \theta_i}{\partial b} = a \frac{\partial E[V(b(e_2 - e_1 + z))]}{\partial b}
\]
\[
= a \int_{e_1}^{\infty} v'(b(e_2 - e_1 + z)) \cdot (e_2 - e_1 + z)dG(z) + a\lambda \int_{e_2-e_1}^{\infty} v'(b(e_1 - e_2 + z)) \cdot (e_1 - e_2 + z)dG(z).
\] (A5)

Differentiating again yields

\[
\frac{\partial^2 \theta_i}{\partial b^2} = a \frac{\partial^2 E[V(b(e_2 - e_1 + z))]}{\partial b^2}
\]
\[
= a \int_{e_1}^{\infty} v''(b(e_2 - e_1 + z)) \cdot (e_2 - e_1 + z)^2dG(z) + a\lambda \int_{e_2-e_1}^{\infty} v''(b(e_1 - e_2 + z)) \cdot (e_1 - e_2 + z)^2dG(z).
\] (A6)

First suppose (i) holds. Inequality aversion implies that $\lambda > 0$, and therefore the last line in (A5) and the last line in (A6) are the sums of two integrals of positive-valued functions, implying that $\partial \theta_i / \partial b > 0$ and $\partial^2 \theta_i / \partial b^2 > 0$.

Now suppose (ii) holds. Because $\lambda \in (-1,0)$ and $e_1 < e_2$,
\[
\frac{\partial E[V(b(e_2 - e_1 + z))]}{\partial b} > \int_0^\infty v'(bz) \cdot z dG(z) - \int_0^\infty v'(bz) \cdot z dG(z) = 0.
\] (A7)

Consequently, \( \partial \theta / \partial b > 0 \). A similar argument establishes that \( \partial^2 \theta / \partial b^2 > 0 \). □

Proof of Proposition 5. From equation (16), the optimal piece rate \( b^* \) is determined by

\[
(p - c'(e^*)) \frac{de^*}{db} = \frac{\partial \theta_i}{\partial b}.
\] (A8)

When \( A > -1 \), by Proposition 4 \( \partial \theta / \partial b > 0 \). When \( a = 0 \), \( e^* \) solves \( c'(e^*) = b \), so \( de^* / db = 1 / c'' > 0 \). By continuity, there exists an \( A > 0 \) such that when \( a \in (0, A) \), \( de^* / db > 0 \). From equation (A8), \( p - c'(e^*) = (\partial \theta / \partial b) / (de^* / db) > 0 \), and so \( p - c'(e^*) > 0 \). Letting \( e^0 \) denote the effort level that makes \( c'(e^0) = p \), strict convexity of the effort cost function implies that \( c'(e^*) < c'(e^0) \) and therefore \( e^* < e^0 \). The result follows from \( de^* / db > 0 \). □

Proof of Proposition 7. Since workers are identical, \( e_1 = e_2 \), implying that

\[
V(b(e_2 - e_1 + z) - (c_2(e_2) - c_1(e_1))) = V(bz).
\] (A9)

From equations (A9) and (A4),

\[
\frac{\partial \theta_i}{\partial b} = a \frac{\partial E[V(bz)]}{\partial b} = a(1 + \lambda) \int_0^\infty v'(bz) zdG(z).
\] (A10)
Then $\partial \theta / \partial b > 0$ follows from $\lambda > -1$. Also,

$$\frac{\partial \theta}{\partial \lambda} = a \int_0^\infty v(bz) dG(z) > 0.$$  \hspace{1cm} (A11)

Finally, from equation (16) we have $p - c'(e^*) = (\partial \theta / \partial b)(de^*/db)$, and by Proposition 6 $de^*/db = de^0/db = 1/e'' > 0$. Consequently $e^* < e^0$, and since $de^*/db > 0$, it follows that $b^* < b^0$. \hfill \square
References


Holmstrom, Bengt and Paul Milgrom (1987). “Aggregation and Linearity in the Provision of


The $V$ function with $\lambda > 1$, $\lambda = 1$, $0 < \lambda < 1$, and $\lambda < 0$. 
\[ \int_{-\infty}^{k} V(-k+z)dG(z) = \lambda \int_{-k}^{\infty} v(k+z)dG(z) \]