Output and Wages with Inequality Averse Agents*

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Abstract

We analyze a two-task work environment with risk-neutral but inequality averse individuals. For the agent employed in task 2 effort is verifiable, while in task 1 it is not. Accordingly, agent 1 receives an incentive contract which, due to his wealth constraint, leads to a rent that the other agent resents. We show that greater inequality aversion unambiguously decreases total output and therefore average labor productivity. More specifically, inequality aversion reduces effort, wage and payoff of agent 1. Effects on wage and effort of agent 2 depend on whether effort levels across tasks are substitutes or complements in the firm's output function.

JEL Classification: D2, J3

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1 Introduction

In a recent study, Brosnan and Waal (2003) analyzed the response of capuchin monkeys to unequal pay. In the baseline test, two monkeys received a token that could immediately be returned to the experimenter for a cucumber. The monkeys exchanged successfully in 95 per cent of the cases. In the next test, one monkey exchanged for cucumber and the other one for grapes. Now more than 40 per cent of the monkeys that were rewarded with cucumbers, the less favored reward, refused to exchange. The rejection rate even increased to 80 per cent when the other monkey received the better reward without any effort (i.e. without having to hand over a token).

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There is by now a plethora of papers in economics arguing that rejection of unequal pay is not restricted to capuchin monkeys, but is probably just as typical of human beings.[1] According to these studies, individuals are not entirely self-centered, but care about fairness and relative rewards. Thus, workers may envy those who get a better deal and suffer disutility from being treated 'unfairly'. Conversely, they may also have empathic preferences and dislike outperforming co-workers. In this paper we analyze some implications of other-regarding preferences for optimal contract design. If 'inequality aversion' differs between socio-economic systems—e.g., Europe versus the US—or even between corporate cultures, how would this be reflected in the organization of work?

We consider the situation of a firm employing risk-neutral and wealth constrained agents in two different tasks or occupations. In one task, effort—respectively a perfectly correlated signal—is verifiable. In the other task it is not, leading to moral hazard. For example, one may think of skilled and unskilled labor, where the activity of the latter is less complex and, therefore, relatively easy to verify. Alternatively, it may simply be that some activities are inherently more difficult to monitor than others; think of sales representatives versus employees working in-house. Similarly, the effort of a manager is probably more difficult to assess than that of a worker at a conveyor belt.

In such a framework, providing incentives is costly for the principal. The workers with non-verifiable effort—category 1 agents—must be motivated through some form of performance pay. This implies paying out rent because of the agents' wealth constraint. By contrast, workers with verifiable effort—category 2 agents—receive a fixed wage contract and no rent. If these workers are inequality averse, they suffer disutility from the other agents' rent and this requires compensation. This 'inequality premium' therefore increases the firm's costs of providing incentives to the agents with non verifiable effort.

Accordingly, we find that greater inequality aversion leads to smaller effort, wage and payoff (i.e. wage minus effort cost) for agents exerting tasks subject to moral hazard. By contrast, the effect on agents with verifiable effort is ambiguous. Greater inequality aversion does not necessarily mean higher wages as compensation. The reason is that these workers' equilibrium effort may decrease, remain constant or even increase, depending on whether effort levels are complements or substitutes across tasks in the principal's revenue function. Nevertheless, payoff differences decrease with the extent of inequality aversion. Wage differences also decrease unless tasks are strongly complementary.

We also analyze the implications of an improvement in the monitoring

[1] For recent surveys see Konow (2003), Camerer (2003) as well as Fehr and Schmidt (2003).

technology. Better monitoring or more informative performance measures reduce the marginal cost of providing incentives to category 1 agents. As a result, the firm requires that these agents exert more effort. If this also leads to a higher payoff for these workers, then the payoff for the other category of workers must also increase due to the larger inequality premium. However, it does so to a lesser extent so that overall inequality is larger.

There are several recent papers analyzing contracts with inequality averse agents. Bartling and Siemens (2005), Itoh (2004) and Neilson and Stowe (2004) all analyze an environment with one principal and two agents. However, in contrast to our paper they consider situations where both agents receive incentive contracts and compare their payoff (or income) ex-post, i.e. after the bonuses for good signal realizations have been paid. Furthermore, only Bartling and Siemens (2005) analyze a setting where agents face a limited liability constraint. Englmaier and Wambach (2004) and Dur and Glaser (2004) analyze sharing rules when an inequity averse agent compares his payoff to that of the principal. Siemens (2004) analyzes optimal employment contracts in an adverse selection model. There are also some contributions that analyze inequality aversion in the context of team production (e.g., Biel (2004), Demougin and Fluet (2003)).

The paper is structured as follows. Section 2 introduces the basic model. Sections 3 and 4 analyze the effects of inequality aversion on effort levels, wages and payoffs. Section 5 expands the picture by adding monitoring to the model. Finally, in the concluding section we discuss economic applications, in particular cross-country differences in productivity and mergers among firms with different corporate cultures.

2 The model

We consider a two-task work environment, assuming for simplicity that each task occupies a single agent. The value of output for the firm is $v(e_1, e_2)$, an increasing and concave function where $e_i \in \mathbb{R}^+$ is the effort in task i or equivalently the effort of agent i, $i = 1, 2$. Later in the text, we further characterize $v(e_1, e_2)$ in terms of whether inputs are substitutes or complements. All parties are risk-neutral and exerting effort in task i costs $c_i(e_i)$. We impose the standard assumptions $c_i'(e_i)$, $c_i''(e_i) > 0$ for $e_i > 0$, $c_i(0) = c_i'(0) = 0$ and $\lim_{e_i \to \infty} c_i'(e_i) = \infty$, which ensure an interior solution.

Tasks differ in the verifiability of effort. We assume e_2 is verifiable. The principal therefore offers agent 2 a contract specifying a fixed wage payment w and the desired effort level, leading to the payoff

$$\pi_2 = w - c_2(e_2). \tag{1}$$

By contrast, neither the value of output nor the effort of agent 1 are verifiable, implying moral hazard with respect to the first task. However,

the parties observe a contractible signal $s \in \{0, 1\}$ where $s = 1$ is favorable information about e_1 (see Milgrom (1981)). Note that in the risk-neutral agency problem all relevant information from a mechanism design point of view can be summarized by a binary statistic (see, e.g., Kim (1997)). The assumption remains somewhat restrictive, as it presupposes that the distribution of the principal's information on e_1 is independent of e_2.[2] We denote with $p(e_1)$ the probability of the favorable outcome given the agent's effort, with $p'(e_1) > 0$ and $p''(e_1) \leq 0$.[3] Given the binary nature of the signal, the incentive contract for agent 1 reduces to a fixed payment F and a bonus b which the agent receives when $s = 1$. Agent 1's expected payoff is therefore

$$\pi_1 = F + p(e_1)b - c_1(e_1). \tag{2}$$

Workers are assumed to be financially constrained; otherwise the first-best would be feasible as is well known. To economize on notation, we simply assume that wages must be non negative. Similarly, the agents' reservation utility is set equal to zero.

We capture the idea of inequality aversion by assuming that a worker's well-being depends on how his *expected* payoff compares to that of co-workers. Specifically, agent i's utility is written as

$$u_i(\pi_i, \pi_j) = \pi_i - \beta_i \max[\pi_j - \pi_i, 0] - \gamma_i \max[\pi_i - \pi_j, 0]. \tag{3}$$

The second term on the right hand side is the disutility from disadvantageous inequality. Parameter $\beta_i \geq 0$ may be interpreted as the propensity for envy. The agent is 'envious' in the sense that his utility is reduced if he receives a *lower* expected payoff than the other agent. The third term is the disutility from advantageous inequality, with $\gamma_i \geq 0$ as the parameter for empathy. An agent feels 'empathy' if his utility is reduced when he receives a *higher* payoff than the other agent. We assume $\gamma_i < 1$ so that agents experiencing empathy nevertheless prefer that their own payoff increases, even when this also increases inequality.

This specification of inequity aversion is similar to the approach in Fehr and Schmidt (1999), but new aspects arise from the consideration of incentive contracts. First, we assume that agents account for differences in effort cost when comparing each other. Accordingly, if two agents receive the same wage but one of them is working much harder, this is likely to cause envy.

[2] Otherwise, the principal might choose e_2 with a view to obtaining a more informative signal in the moral hazard problem with agent 1. In particular, our set-up does not include the case where the principal's verifiable information is $v(e_1, e_2) + \epsilon$, unless output is additively separable in e_1 and e_2.

[3] These conditions guarantee that the agent's problem is well behaved. They are equivalent to considering binary signals satisfying MLRC and CDFC within the class of differentiable signals with constant support.

Conversely, the situation where the harder working agent receives a higher wage seems to be less prone to cause envy.[4]

Second, we assume that agents compare their payoffs ex-ante, i.e. before the signal has been realized, and not ex-post. This approach stresses how relative comparisons affect participation constraints, which refer to ex-ante expected utilities. The problem that we have in mind are wage differences between larger groups such as workers and managers. Though an individual manager may receive a low payoff at a particular point in time, this will do little to appease a worker's envy as long as there are enough other managers earning very high payoffs. Finally, we wish to point out that a comparison of ex-ante payoffs substantially simplifies the following analysis.

To simplify notation in what follows, we write

$$u_i(\pi_i, \pi_j) = \pi_i - \alpha_i(\pi_j - \pi_i), \quad \text{with} \quad \alpha_i = \begin{cases} \beta_i & \text{if} \quad \pi_i \leq \pi_j \\ -\gamma_i & \text{if} \quad \pi_i > \pi_j. \end{cases} \tag{4}$$

The incentive compatibility condition for agent 1 follows from maximizing his utility with respect to e_1, thereby taking π_2 as given. The difficulty with the above formulation is that (4) is non-differentiable at $\pi_1 = \pi_2$. However, observe that $u_1(\cdot)$ is a strictly increasing function of $\pi_1(\cdot)$, i.e. a monotonic transformation. Hence the agent's utility maximizing effort choice can be obtained equivalently by maximizing the expected payoff $\pi_1(e_1)$, which is everywhere differentiable and concave. This yields the incentive compatibility condition

$$e_1 = \arg\max_{\tilde{e}_1} F + p(\tilde{e}_1)b - c_1(\tilde{e}_1), \tag{5}$$

from which the bonus to induce effort e_1 is

$$b = \frac{c_1'(e_1)}{p'(e_1)}. \tag{6}$$

We write the *expected* bonus as

$$B(e_1) \equiv \frac{p(e_1)c_1'(e_1)}{p'(e_1)}. \tag{7}$$

Using this, the firm's profit maximization problem is

$$\max_{\{e_1, e_2, w, F\}} v(e_1, e_2) - w - F - B(e_1), \tag{8}$$

subject to participation of agents 1 and 2, as well as limited liability:

$$\begin{aligned} \pi_1 - \alpha_1(\pi_2 - \pi_1) &\geq 0, && (\mathrm{PC}_1) \\ \pi_2 - \alpha_2(\pi_1 - \pi_2) &\geq 0, && (\mathrm{PC}_2) \\ w,\, F,\, F + b &\geq 0. && (\mathrm{LL}) \end{aligned}$$

[4]See Siemens (2004) for a more extensive discussion about whether agents compare income or rent.

Noting that $b > 0$, and since $w \geq 0$ follows from agent 2's participation constraint, the limited liability constraints reduce to $F \geq 0$. Next we derive two lemmas which greatly simplify the characterization of the equilibrium.

Lemma 1 *The participation constraint of agent 2 binds and $\pi_1 \geq \pi_2$, so that $\alpha_1 \leq 0$ and $\alpha_2 \geq 0$.*

Proof. See Appendix.

In words, if inequality aversion matters with respect to the contracts offered by the firm, this can only be due to the fact that agent 2, the worker with the observable effort, is envious of agent 1 and possibly also because agent 1 feels empathy for agent 2. Of course, the issue of envy or empathy can be relevant only if payoffs are unequal in equilibrium.

Lemma 2 *The participation constraint of agent 1 never binds and $F = 0$.*

Proof. See Appendix.

Intuitively, agent 1 gets a rent due to the moral hazard problem and because of his binding limited liability constraint. Given $F = 0$, this agent's payment reduces to the bonus b paid in the case of favorable realizations of the signal. Recalling that the bonus depends only on the required effort and not on inequality aversion, the extent to which agent 1 feels empathy does not directly affect the contract he is offered, although empathy will reduce his utility and hence his actual rent. In the proof of the lemma, the fact that the rent remains positive despite empathy is shown to follow from the assumption $\alpha_1 > -1$; that is, an agent prefers that his own payoff increases even if this also increases inequality. To complete the preceding results, we show that agent 1's expected payoff is indeed strictly greater than that of agent 2.

Proposition 1 *In equilibrium, $u_1 > u_2$ and $\pi_1 > \pi_2$.*

The first statement follows directly from the lemmas. Using (4), $u_1 > u_2$ is equivalent to

$$\pi_1(1 + \alpha_1 + \alpha_2) > \pi_2(1 + \alpha_1 + \alpha_2), \tag{9}$$

where $1 + \alpha_1 + \alpha_2 > 0$ since $\alpha_1 > -1$ and $\alpha_2 > 0$, thereby implying $\pi_1 > \pi_2$.

3 Effort and output

From lemma 1 we know that the participation constraint of agent 2 binds. Hence, we can solve PC_2 for the wage

$$w = c_2(e_2) + \frac{\alpha_2}{1 + \alpha_2}[B(e_1) - c_1(e_1)]. \tag{10}$$

Agent 2 is compensated for his effort cost and for the disutility he suffers from the larger net payoff earned by agent 1. We henceforth refer to the latter term as the 'inequality premium'.

Using (10) and lemma 2, the principal's maximization problem can be restated as

$$\max_{\{e_1,e_2\}} v(e_1,e_2) - c_2(e_2) - \frac{\alpha_2}{1+\alpha_2}[B(e_1) - c_1(e_1)] - B(e_1). \tag{11}$$

The first term represents the benefits of inducing effort. The next two terms are the wage of agent 2. The final term is the expected bonus paid to agent 1, who is compensated for his effort cost $c_1(e_1)$ and receives the net payoff $B(e_1) - c_1(e_1)$.

The first order conditions with respect to e_1 and e_2 are

$$v_{e_1}(e_1,e_2) + \left(\frac{\alpha_2}{1+\alpha_2}\right) c_1'(e_1) - \left(1 + \frac{\alpha_2}{1+\alpha_2}\right) B'(e_1) = 0 \tag{12}$$

$$v_{e_2}(e_1,e_2) - c_2'(e_2) = 0. \tag{13}$$

It follows immediately that the empathy parameter of agent 1, α_1, has no effect on equilibrium values. The reason is simply that this agent's participation constraint does not bind, as shown in the preceding section. Empathy reduces the agent's utility, but does not affect the cost to the firm of inducing effort. Thus, it is only agent 2's propensity for envy, α_2, that will matter in equilibrium. Accordingly, when we refer to an increase in inequality aversion, we shall mean an increase in the propensity for envy, irrespective of whether the propensity for empathy also increases.

A larger α_2 makes it more costly for the principal to provide incentives to agent 1, since it increases the compensation that must be paid to the envious agent 2. The firm therefore adjusts by requiring less effort from agent 1, which means a lower powered contract with a smaller bonus. Differentiating the equilibrium conditions and applying Cramer's rule yields (see Appendix),

$$\frac{de_1}{d\alpha_2} = \varphi\left(v_{e_2e_2} - c_2''\right) < 0, \tag{14}$$

where

$$\varphi \equiv \frac{\left(\frac{1}{(1+\alpha_2)^2}\right)(B' - c_1')}{\left[v_{e_1e_1} + \left(\frac{\alpha_2}{1+\alpha_2}\right)c_1'' - \left(1 + \frac{\alpha_2}{1+\alpha_2}\right)B''\right](v_{e_2e_2} - c_2'') - (v_{e_1e_2})^2} > 0 \tag{15}$$

and where $v_{e_ie_j}$ denotes the cross partial derivative.

To see that the signs are correct, note that $B'(e_1) > c_1'(e_1)$ from the definition of the expected bonus and the curvature assumptions. Furthermore, the denominator in (15) is positive provided that the second-order condition for an interior maximum is satisfied, which we assume to be the

case.[5] The signs then follow from the concavity of the output function and the convexity of the cost functions.

Turning to agent 2, observe from (10) that a larger α_2 increases the inequality premium, which depends on e_1, but does not directly affect the marginal costs of inducing effort e_2. However, there is an indirect effect if $v_{e_1e_2} \neq 0$, which results from changes in the equilibrium effort of agent 1. If $v_{e_1e_2} > 0$, then as e_1 falls so do marginal returns to the complementary input e_2; hence a lower e_2 becomes optimal. By contrast, if $v_{e_1e_2} < 0$, then the lower e_1 increases marginal returns to e_2 and requiring more effort from agent 2 becomes optimal. Formally, again using Cramer's rule,

$$\frac{de_2}{d\alpha_2} = -\,\varphi\, v_{e_1e_2}\,. \tag{16}$$

Finally, we show that more inequality aversion reduces total output in equilibrium or equivalently that it leads to a fall in the average productivity of labor (measured as average per-worker output). Differentiating the value of output function,

$$\frac{dv(e_1,e_2)}{d\alpha_2} = v_{e_1}\frac{de_1}{d\alpha_2} + v_{e_2}\frac{de_2}{d\alpha_2} = \varphi\left(v_{e_1}v_{e_2e_2} - v_{e_2}v_{e_1e_2} - v_{e_1}c_2''\right) < 0, \tag{17}$$

where the sign of the expression in parenthesis follows from the concavity of the output function.[6] We summarize the results of this section in the following proposition.

Proposition 2 *More inequality aversion reduces equilibrium output and the effort of agent 1. The effort of agent 2 decreases (increases) if the cross derivative $v_{e_1e_2}$ is positive (negative).*

4 Wages and payoffs

We now analyze how inequality aversion affects wages and payoff differences. Total differentiation of the expression for agent 2's wage in (10) yields

$$\frac{dw}{d\alpha_2} = \frac{B(e_1) - c_1(e_1)}{(1+\alpha_2)^2} + \left(\frac{\alpha_2}{1+\alpha_2}\right)[B'(e_1) - c_1'(e_1)]\frac{de_1}{d\alpha_2} + c_2'(e_2)\frac{de_2}{d\alpha_2}. \tag{18}$$

[5]The denominator is the determinant of the Hessian of the objective function, which must be positive for a regular interior maximum. This will be the case if $c_1'' - B'' < 0$—a sufficient condition for this is $c_1''' \geq 0, p''' \leq 0$—and if the absolute value of the cross partial derivative $v_{e_1e_2}$ is not too large.

[6]Differentiating the marginal rate of substitution, the isoquant has the correct curvature if

$$\frac{d}{de_2}\left(-\frac{de_1}{de_2}\right) = \frac{d}{de_2}\left(\frac{v_{e_2}}{v_{e_1}}\right) = \frac{v_{e_1}v_{e_2e_2} - v_{e_2}v_{e_1e_2}}{v_{e_1}^2} < 0.$$

Recall that agent 2's wage consists of the inequality premium and the compensation for effort cost. The first term in (18) describes the *direct* effect of an increase in α_2; that is, the increase of agent 2's inequality premium when holding e_1 fixed. The second term is the indirect effect on the inequality premium that works via the induced change in e_1. In particular, as e_1 falls, the net payoff $B(e_1) - c_1(e_1)$ of agent 1 decreases, implying that there is less to be envious about. Accordingly, this effect reduces agent 2's inequality premium. Without a further specification of functional forms it is therefore unclear whether changes in α_2 increase or reduce the inequality premium.

Finally, from proposition 2 we know that e_2 remains unchanged only if $v_{e_1 e_2} = 0$. In all other cases there will be a third effect as changes in α_2 affect agent 2's effort and therefore his effort cost. Obviously, the effects of inequality aversion on payoffs – i.e. wage less effort costs – are the same, except that the last effect disappears.

Despite the ambiguous effect of inequality aversion on the wage and payoff of agent 2, payoff differentials always decrease in α_2. The reason is simply that payoff differentials become more costly as inequality aversion increases. To prove this, substitute from (1), (2) and (10) to obtain

$$\pi_1 - \pi_2 = \frac{B(e_1) - c_1(e_1)}{1 + \alpha_2}. \tag{19}$$

Total differentiation then yields

$$\frac{d(\pi_1 - \pi_2)}{d\alpha_2} = \frac{B'(e_1) - c_1'(e_1)}{1 + \alpha_2} \frac{de_1}{d\alpha_2} - \frac{B(e_1) - c_1(e_1)}{(1 + \alpha_2)^2} < 0. \tag{20}$$

The wage differential is obtained by adding $c_1(e_1) - c_2(e_2)$ to (19), yielding

$$\frac{d[B(e_1) - w]}{d\alpha_2} = \left(\frac{B'(e_1) + \alpha_2 c_1'(e_1)}{1 + \alpha_2} \right) \frac{de_1}{d\alpha_2} - \frac{B(e_1) - c_1(e_1)}{(1 + \alpha_2)^2} - c_2'(e_2) \frac{de_2}{d\alpha_2}. \tag{21}$$

Usually, this term will be negative. Only if effort is strongly complementary so that $de_2/d\alpha_2 < 0$ (see proposition 2), may wage differentials increase in α_2.

Proposition 3 *More inequality aversion reduces the wage and payoff of agent 1 and leads to smaller payoff differences between agents. Wage differences also decrease, unless e_1 and e_2 are strongly complementary.*

5 Monitoring and spillovers

The consideration of inequality aversion leads to interesting feed-back effects. For instance, suppose that for some exogenous reason the technology used

to monitor the category 1 worker improves. Improvements in information technology suggest that such a development may actually have taken place over the last two decades or so (see Garicano (2000)).

In the absence of inequality aversion, this would only affect the agent who receives an incentive contract. This changes once we allow for inequality aversion. Let θ represent the monitoring technology. A better technology affects the probability with which a good signal is observed. As a result, the expected bonus $B(e_1, \theta)$ for inducing a given effort level now becomes a function of θ. Intuitively, with better monitoring the firm can elicit a desired effort level with a smaller expected bonus. Furthermore, the marginal cost to the firm of inducing additional effort should decrease in θ. Therefore, we assume $B_\theta(e_1, \theta) < 0$ and $B_{e_1\theta}(e_1, \theta) < 0$.[7]

We first determine the effect of θ on agent 1's payoff. Total differentiation yields

$$\frac{d\pi_1}{d\theta} = B_\theta + (B_{e_1} - c_1')\frac{de_1}{d\theta} \tag{22}$$

where

$$\frac{de_1}{d\theta} = \frac{\left(1 + \frac{\alpha_2}{1+\alpha_2}\right)(v_{e_2e_2} - c_2'')B_{e_1\theta}}{\left[v_{e_1e_1} + \left(\frac{\alpha_2}{1+\alpha_2}\right)c_1'' - \left(1 + \frac{\alpha_2}{1+\alpha_2}\right)B_{e_1e_1}\right](v_{e_2e_2} - c_2'') - (v_{e_1e_2})^2} > 0. \tag{23}$$

The latter, again applying Cramer's rule, is obtained from the equilibrium conditions (12) and (13) rewritten so as to incorporate monitoring (the denominator in (23) is positive by the second-order condition). As in section 3, the effect on e_2 depends solely on the sign of the cross derivative $v_{e_1e_2}$.

A better monitoring technology has two effects on agent 1's payoff. First, the bonus that is required to induce a desired effort level falls. Secondly, better monitoring technology implies that it becomes optimal for the principal to induce more effort. As a result, the overall effect on the agent's payoff is ambiguous.[8]

Turning to agent 2's payoff, note that from (1), (2) and (10),

$$\pi_2 = \left(\frac{\alpha_2}{1 + \alpha_2}\right)\pi_1. \tag{24}$$

The payoff of agent 2 is simply his inequality premium, by which he is compensated for envying the payoff of agent 1. Obviously, the required compensation increases in agent 1's payoff and this spillover is larger the greater the degree of inequality aversion α_2. The next result follows straightforwardly.

[7] See Demougin and Fluet (2001) for a general formulation.

[8] To provide an example, π_1 increases if $c_1(e_1) = 0.5e_1^2$ and $p(e_1, \theta) = e_1^\theta$, where $e_1, \theta \in [0, 1]$. See Demougin and Fluet (2001) for a justification of this specification of monitoring technology.

Proposition 4 *If an improvement in the technology to monitor agent 1 increases (decreases) the payoff of this agent, then the payoff of agent 2 and payoff differences also increase (decrease). Spillovers are greater, the greater the degree of inequality aversion.*

6 Concluding remarks and discussion

This paper has analyzed a simple two-task environment in which a firm employs two wealth constrained agents. For agent 2, effort is verifiable, while for agent 1 it is not. Accordingly, only agent 1 receives an incentive contract, which leads to a positive rent and a payoff that the other agent resents. Inequality aversion affects the optimal contracts of both agents. In particular, more inequality aversion on the part of agent 2 reduces the effort, wage and payoff of agent 1. It also leads to a compression of payoffs. If the principal's revenue is additively separable in the agents' effort, then the effort of agent 2 remains unchanged, but wage differences decrease. Finally, an improvement in the monitoring technology affects the payoff of both agents in the same direction, but effects on agent 1 are more pronounced.

These results are based on the assumption that agents compare expected payoffs. We have motivated this approach in section 2, but it might be interesting to see how the results are affected if actual payoffs (or income) are compared instead. In the case of a bad signal realization agent 1 would then envy agent 2, a situation that does not arise in our model. The additional effects complicate the analysis and, presumably, lead to less clear-cut results.

The analysis may help understand differences in productivity and wage spread across countries with different cultural norms. For example, there is some empirical evidence that preferences for a more equal income distribution are stronger in Western Europe than they are in the United States (Corneo 2001, Alesina, Tella and MacCulloch 2003, Schwarze and Härpfer 2003). There is also evidence that productivity and wage inequality is lower in Western Europe than in the US (e.g. Hall and Jones (1999), Katz and Autor (1999)). Our paper provides a possible explanation for this pattern although there are, of course, alternative ones (e.g., Bental and Demougin (2005)).

The analysis is also useful to understand problems that may arise in mergers because of different corporate cultures. Though corporate cultures are multifaceted constructs, one important aspect is the degree to which employees find an unequal income distribution acceptable. For example, consider two firms each of which having a structure as described in the present paper. Suppose employees in firm H are more inequality averse than those in firm L. Ceteris paribus, firm L would be characterized by higher wages for type 1 employees and by larger payoff differences (see proposition 3).

To focus on merger costs that arise from inequality aversion, consider the costs of implementing the effort levels that existed before the merger. Furthermore, assume that after the merger the type 1 employee in firm H compares his payoff with that of the type 1 employee in firm L. This leads to envy and the wage of the type 1 employee in firm H must increase in order to implement pre-merger effort levels. As a consequence, the wage of the type 2 employee in firm H also increases. Observe that there is no opposite effect in the other firm, where the costs of implementing pre-merger effort levels remain constant.

Obviously, this discussion neglects that firms may adjust effort levels after the merger. The merger may also have positive effects on the revenue function. Nevertheless, the analysis shows that it is often not possible for the merged firm to simply replicate the behavior of the previously separate firms if different corporate cultures continue to prevail.

Furthermore, there exists some anecdotic evidence for an upward adjustment of wages in merged firm. For example, one reason why the merger between Daimler Benz and Chrysler Corporation started off rocky was that senior executives at Daimler earned a lot less than their Chrysler counterparts. To narrow the gap, pay packages to Daimler managers were substantially increased (Schellhardt 1999).[9]

7 Appendix

Proof of Lemma 1. Contrary to the claim that PC_2 is binding, suppose

$$\pi_2 - \alpha_2(\pi_1 - \pi_2) > 0. \tag{25}$$

Observe that α_2 has been defined such that $\alpha_2(\pi_1 - \pi_2) \geq 0$. Hence $\pi_2 = w - c_2(e_2) > 0$. If PC_1 were also not binding, then the firm could increase its profits by reducing w. Accordingly, PC_1 would have to be binding so that

$$\alpha_1\pi_2 = (1 + \alpha_1)\pi_1 \tag{26}$$

Adding this to (25) yields

$$\pi_2(1 + \alpha_1 + \alpha_2) > \pi_1(1 + \alpha_1 + \alpha_2). \tag{27}$$

From the definition of α_i it is not possible for α_1 and α_2 to be both negative. Furthermore, $\alpha_i > -1$ by assumption. Therefore, $1 + \alpha_1 + \alpha_2 > 0$

[9] Another example how equity concerns can wreck mergers is given by Bartling and Siemens (2005). They discuss the 1980 acquisition of Houston Oil and Minerals Corporation by Tenneco, Inc., where only the former had a corporate culture of high powered incentive payments.

and (27) implies $\pi_2 > \pi_1$. Writing out the participation constraints for this case yields

$$\begin{aligned} [F + B(e_1) - c_1(e_1)](1 + \beta_1) - \beta_1[w - c_2(e_2)] &= 0 \qquad (28) \\ [w - c_2(e_2)]\,(1 - \gamma_2) + \gamma_2[F + B(e_1) - c_1(e_1)] &> 0. \qquad (29) \end{aligned}$$

However, this can not be a solution of the firm's problem, since it could increase profits by reducing w. Hence we have derived a contradiction and conclude that PC_2 is binding.

Obviously, this implies $u_1 \geq u_2 = 0$. Upon substitution from (4),

$$\pi_1(1 + \alpha_1 + \alpha_2) \geq \pi_2(1 + \alpha_1 + \alpha_2), \qquad (30)$$

which has already been shown to imply $\pi_1 \geq \pi_2$. Therefore, the only relevant forms of inequality aversion are 'empathy' ($\alpha_1 \leq 0$) for agent 1 and 'envy' ($\alpha_2 \geq 0$) for agent 2. □

Proof of Lemma 2. Suppose to the contrary that PC_1 binds. Solving PC_2 for π_2 and substituting this into PC_1, we find

$$\pi_1(1 + \alpha_1) - \frac{\alpha_1\alpha_2}{1 + \alpha_2}\pi_1 = 0. \qquad (31)$$

Since $1 + \alpha_1 > 0$ and given that $\alpha_1\alpha_2/(1 + \alpha_2) \leq 0$ by lemma 1, this can only be satisfied if $\pi_1 = 0$. Denote the signal elasticity by $\epsilon(e_1) = e_1 p'(e_1)/p(e_1)$ and observe that $\epsilon(e_1) \in [0, 1]$ by concavity of $p(e_1)$. Upon substitution and noting that $e_1 c_1'(e_1) > c_1(e_1)$ by strict convexity of the cost function,

$$B(e_1) = \frac{e_1 c_1'(e_1)}{\epsilon(e_1)} > c_1(e_1), \qquad (32)$$

a contradiction to $\pi_1 = 0$ (see equation (2), keeping in mind $F \geq 0$).

Using the results that PC_2 is binding while PC_1 is not, the firm's problem can be rewritten as

$$\max_{\{e_1, e_2, F\}} v(e_1, e_2) - \left(c_2(e_2) + \frac{\alpha_2}{1 + \alpha_2}[F + B(e_1) - c_1(e_1)] \right) - F - B(e_1), \qquad (33)$$

$$\text{s.t. } F \geq 0. \qquad (34)$$

Obviously, the firm will choose $F = 0$. □

Calculation of $de_1/d\alpha_2$. Denoting the principal's objective function (11) by G and applying Cramer's rule yields

$$\frac{de_1}{d\alpha_2} = -\frac{\det \begin{pmatrix} G_{e_1\alpha_2} & G_{e_1e_2} \\ G_{e_2\alpha_2} & G_{e_2e_2} \end{pmatrix}}{\det \begin{pmatrix} G_{e_1e_1} & G_{e_1e_2} \\ G_{e_2e_1} & G_{e_2e_2} \end{pmatrix}} = -\frac{G_{e_1\alpha_2} G_{e_2e_2}}{G_{e_1e_1} G_{e_2e_2} - (G_{e_1e_2})^2}. \qquad (35)$$

Upon substitution, this yields (14) and (15). Calculation of $de_2/d\alpha_2$ and $de_1/d\theta$ proceeds in the same way.

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