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The Intensity of Incentives in Firms and Markets: Moral Hazard with Envious Agents

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GOVERNANCE AND THE EFFICIENCY
OF ECONOMIC SYSTEMS
GESY

Discussion Paper No. 115

**The Intensity of Incentives in
Firms and Markets: Moral Hazard
with Envious Agents**

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April 2006

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The Intensity of Incentives in Firms and Markets: Moral Hazard with Envious Agents

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Abstract

While most market transactions are subject to strong incentives, transactions within firms are often not incentivized. We offer an explanation for this observation based on envy among agents in an otherwise standard moral hazard model with multiple agents. Envious agents suffer if other agents receive a higher wage due to random shocks to their performance measures. The necessary compensation for expected envy renders incentive provision more expensive, which generates a tendency towards flat-wage contracts. Moreover, empirical evidence suggests that social comparisons like envy are more pronounced among employees within firms than among individuals who interact only in the market. Flat-wage contracts are thus more likely to be optimal in firms than in markets.

JEL Classification: D82, J3, M5

Keywords: Envy, moral hazard, flat-wage contracts, within-firm vs. market interactions

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1 Introduction

While most market transactions are subject to strong incentives, transactions within firms or organizations are often less explicitly incentivized. For example, freelance writers are commissioned to write articles of precisely specified length, business consultants are paid hourly wages while completing a particular mandate, and the salaries of independent software programmers condition on processing a specific project. Yet permanent employees conducting the same task often receive fixed wages.¹ This paper offers an explanation for these differences in incentive intensities in firms and markets that is based on social preferences.

In particular, we consider envious agents in an otherwise standard moral hazard model with multiple agents. An envious agent suffers a utility loss whenever another agent receives a higher wage. Each agent can exert some costly but unobservable effort that increases the principal's expected revenue. To provide incentives the principal must thus condition the agents' wages on stochastic performance measures. Most analyses of the principal-agent problem focus on the resulting trade-off between incentives and risk; yet envious agents must also be compensated for their expected utility loss from unfavorable wage inequality. We show that if the agents are risk-averse and there is no limited liability, then envy renders incentive provision more expensive relative to the case with purely self-interested agents. However, the agents can always be induced to choose their cost-minimizing effort levels by paying them equal flat-wages. In this case envy causes no additional costs. Since envy increases the cost of implementing higher effort levels, flat-wages can be optimal in situations in which the principal would otherwise provide incentive contracts. Furthermore, social comparisons like envy appear to be more pronounced among employees within firms (or other organizations) than among individuals who only interact in the market. It then follows that envy is more likely to render flat-wage contracts optimal within firms than in markets – even if the underlying principal-agent problems are otherwise identical.

The implications of our analysis hinge on the result that envy *increases* the costs of providing incentives. Yet if an agent can reduce the probability of receiving a lower wage than his

¹This observation goes back at least to Williamson (1975).

colleague by exerting more effort, envy causes a positive incentive effect. In fact, Itoh (2004) shows in a principal-agent setting with risk-neutral agents and limited liability, that envy can reduce the agency costs of providing incentives. To relate these contrary results, we initially develop a general model of moral hazard with multiple envious agents that (i) allows for both risk-neutral and risk-averse agents and (ii) comprises the cases with and without limited liability.

We derive the following results. By transforming the principal's maximization program we show that envy affects the principal's minimum cost of providing incentives in exactly two ways. First, envy allows the principal to punish an agent by paying the other agent a higher wage. If monetary punishments are restricted by limited liability, envy thus enlarges the principal's feasible set of utility combinations for the agents. Second, envious agents must be compensated for their suffering from expected unfavorable wage inequality. This causes additional costs if the agents are to receive contracts that generate unequal wages with strictly positive probability. Envy can thus both decrease and increase the principal's minimum costs of providing incentives.

For the remainder of the paper we focus on the canonical case with risk-averse agents and unlimited liability. Since there is no limited liability, the cost-decreasing effect of envy cannot arise. To counteract the cost-increasing effect of envy, the principal can adjust incentive contracts to mitigate or avoid expected wage inequality. However, an optimal incentive contract (for selfish agents) serves the dual role of providing incentives and allocating risk. It is therefore not possible to reduce expected wage inequity without impairing the allocation of risk. A reduction in expected wage inequity reduces the necessary compensation for envious agents, but since the agents are also risk-averse it increases the compensation for their risk exposure. Therefore, with risk-averse agents and unlimited liability envy unambiguously increases the costs of providing incentives relative to the case with purely self-interested agents. Moreover, envy appears to be less pronounced in case the (otherwise identical) principal-agent relationship represents market interactions rather than a firm. Our analysis then implies that there exist situations in which flat-wages are optimal within firms whereas incentive contracts are optimal in the market.

Our assumptions concerning the agents' social preferences and reference groups are based on sound empirical evidence. Field data by Blinder and Choi (1990), Campbell and Kamlani (1990), and Agell and Lundborg (2003) show that equity concerns are important within firms where they constitute a reason for downwards wage rigidity. In a related survey study, Bewley (1999) finds that "the main function of internal pay structure is to ensure internal pay equity, which is crucial for good morale." (p. 82) In addition, numerous carefully conducted laboratory experiments confirm that fairness and equity concerns are important human motives.² These findings are in line with Festinger (1954), who develops a theory of social comparisons based on the assumption that equity concerns are more pronounced among individuals who perceive themselves to be equal. Adams (1963) subsequently argues that "co-workers will more neatly fit this criterion than will other persons." (p. 424) Akerlof and Yellen (1988) summarize this line of reasoning: "But, in contrast to the marketplace, where traders have little personal contact, in the workplace, where personal contact is close, other emotions such as 'concern for fairness', pejoratively called 'jealousy', are also important." (p. 45)

Case studies analyzing the success of mergers also suggest that the boundary of the firm can define the workers' reference group. A prominent example is Williamson's (1985, p. 158) discussion of the 1980 acquisition of Houston Oil and Minerals Corporation by Tenneco, Inc., the largest conglomerate in the U.S. at that time. Houston's business was to find and develop petroleum and mineral deposits, and it had an unusually large bonus program in place to reward its employees for the successful discovery and development of new reserves. To preserve Houston's entrepreneurial and risk-taking corporate culture, Tenneco planned to maintain this pay structure upon merger, but ultimately failed to do so. The reasons for this failure were apparently equity concerns within the conglomerate. Tenneco's vice president for administration told the *The Wall Street Journal*: "We have to ensure internal equity and apply the same standards of compensation to everyone."³ As a result, Tenneco could not match job offers by outside employers who apparently had fewer constraints on their incentive structure. Within a year a large fraction of Houston's employees had left for better opportunities elsewhere. Ultimately, this exodus caused the failure of the merger.

²Fehr and Schmidt (2006) provide an extensive overview of the literature.

³*The Wall Street Journal*, A-1, February 9, 1982.

Related Literature

In a seminal paper, Holmström and Milgrom (1991) propose multi-tasking as an explanation for the different incentive intensities in firms and markets. Like Williamson, they distinguish employees from contractors by the condition of asset ownership. Contractors own and thus care for their productive assets even when output-based incentives are high. In contrast, employees use their firms' assets. They abrade these assets when output-based incentives are high. Therefore, to keep the balance between asset maintenance and output production, optimal output-based incentives for employees are low-powered as compared to those for contractors. Central to Holmström and Milgrom's analysis is the assumption that the value dissipation of assets is hard to measure. Addressing the same question, Baker, Gibbons, and Murphy (2002) analyze an infinitely repeated trade situation with incomplete contracts à la Grossman and Hart (1986). Repeated game effects might induce an agent to choose a desired action (and the principal to pay a promised bonus). Baker et al. show that asset ownership influences whether such relational contracts can be self-enforcing. If the agent is employed, the principal owns the productive asset in case he refuses to pay the bonus. Yet if the agent is a contractor, the principal must buy the asset in case he reneges. Since the temptation to renege is otherwise too large, the promised bonus and thus incentives must be muted within firms to render the efficient relational contract feasible. In contrast, our explanation for low-powered incentives in firms is based on the agency cost increasing effect of envy. It applies in single-tasking settings as well as in one-shot situations. Further, asset ownership is not part of our explanation; the model thus readily applies to the service sector where often (as the example of freelance writers indicates) only human assets are essential for production.⁴

Our general model also sheds light on a number of recent articles that analyze the effect of social preferences in moral hazard settings with multiple agents. Itoh (2004) and Demougin and Fluet (2006) determine the conditions for the optimality of team evaluation in a setting with risk-neutral agents and limited liability.⁵ As shown in our model, envy can then have both a cost-decreasing and cost-increasing effect. Yet if the agents are risk-neutral, optimal

⁴Note that it might be very difficult to prevent employees to capitalize on their human capital. For example, lawyers often take important clients with them when leaving a law firm.

⁵In a linear incentive model, Bartling (2006) analyzes the trade-off between relative and team performance evaluation with risk- and inequity averse agents and correlated outcomes.

contracts for purely self-interested agents are not unique and, in particular, include an extreme team contract in which the agents are paid a positive wage only if all agents are successful. By choosing such a team contract, all wage inequity can be avoided at no cost. However, firms can use individual or relative performance evaluation to exploit the positive incentive effect of envy.⁶ Applied to the research question addressed in this paper, Itoh's and Demougin and Fluet's findings imply that incentives in firms are more pronounced as compared to the market.⁷

The rest of the paper is organized as follows. Section 2 introduces the general moral hazard problem and discusses the agents' social preferences. Section 3 analyzes the impact of envy on the principal's indirect cost function in a general set-up that allows for both risk averse and risk neutral agents and comprises the cases with and without limited liability. Section 4 focuses on the case with risk averse agents and unlimited liability and derives our results on the optimality of flat-wage contracts and the difference between firms and markets. Section 5 discusses implications of our analysis. Section 6 concludes.

2 The Model

Before turning to a moral hazard model with risk-averse agents and no limited liability, we begin with a characterization of the impact of envy in a more general setup. This allows us to analyze also risk-neutral agents and limited liability. Consider a principal who employs two agents. If employed, each agent chooses an effort level e from a finite set E . The effort vector $\mathbf{e} \in E^2$ determines the probability $\pi(\mathbf{x} | \mathbf{e})$ of some outcome vector $\mathbf{x}$ drawn from a finite set X . Both the dimensionality of $\mathbf{x}$ and the probability mass function π are not restricted. Our model thus comprises situations with individually attributable outcomes, non-separable outcomes, or both. There is no restriction on the correlation of individually attributable outcomes. An outcome realization $\mathbf{x}$ determines the principal's gross profit via the function $f : X \rightarrow \mathbb{R}$. While effort is taken to be non-contractable, the principal can verify the outcome

⁶In a setting of complete information this positive incentive effect of envy is studied by Rey Biel (2004).

⁷Also related, Demougin, Fluet, and Helm (2005) and Neilson and Stowe (2005) investigate reasons for wage compression. They find that social preferences can cause incentives to be muted. However, Demougin et al. eliminate the incentive effect of social preferences by assuming that agents compare expected rents ex-ante, and Neilson and Stowe restrict attention to independent piece-rates.

vector. A contract thus assigns each agent a wage w for every outcome realization $\mathbf{x}$. We restrict wage payments to lie in a compact interval $[\underline{w}, \bar{w}] \in \mathbb{R}$. We can thus discuss the effect of envy in case of limited liability. Moreover, we thereby render the relevant subset of the contract space - the constraint set - bounded. This simplifies the technical analysis. When talking about the case without limited liability we assume the interval $[\underline{w}, \bar{w}]$ to be sufficiently large as to impose no binding restrictions on the principal's wage choices.

Preferences

As discussed in the introduction, empirical evidence suggests that workers suffer from unfavorable wage inequality. We thus take the agents in our model to be envious, a concept formalized, for example, by Bolton (1991) and nested in the theory of inequity aversion by Fehr and Schmidt (1999) and Bolton and Ockenfels (2000). We assume that an envious agent who receives a lower wage than the other agent suffers a utility loss from the unfavorable wage inequality. Starting with Festinger (1954), there is a large body of empirical research in sociology and psychology in support of the assumption that people are most likely to compare themselves to others with similar characteristics. We acknowledge that comparisons between agents and principal might occur; however, we focus on envy among agents and assume that agents do not compare themselves to the principal.⁸

Formally, if agent i exerts effort e_i and receives wage w_i , his *overall utility* is defined as

$$U_i(w_i, w_j, e_i) = u(w_i) - \psi(e_i) - \gamma_i(w_i, w_j) S(w_i, w_j) \quad (1)$$

if the other agent j gets wage w_j . It is thus additively separable in the following three components. First, agent i enjoys utility $u(w_i)$ from his wage payment w_i by the principal. The function u is identical for both agents; it is strictly increasing, unbounded, continuous, and weakly concave. For the moment being we thus allow for both risk neutrality and risk aversion. Second, agent i bears the personal cost $\psi(e_i)$ of his effort choice. The function ψ is assumed to be identical for both agents; it is continuous, and strictly increasing.

⁸Dur and Glaser (2004) and Englmaier and Wambach (2005) introduce social preferences in models of moral hazard with a single agent. Itoh (2004) investigates both horizontal and vertical social comparisons.

Finally, an envious agent i suffers a utility loss $\gamma_i(w_i, w_j) S(w_i, w_j)$ if the other agent j receives a higher wage w_j .⁹ Envy is split into the two components $S(w_i, w_j)$ and $\gamma_i(w_i, w_j)$ to simplify algebraic manipulations and comparative statics. The function $S : \mathbb{R} \rightarrow \mathbb{R}$ measures the perceived wage inequality depending on the absolute wage difference $|w_i - w_j|$. It is zero at $w_i = w_j$, strictly increasing in $|w_i - w_j|$, and thus weakly positive. We assume S to be continuous, but we impose no restrictions concerning the curvature or differentiability. The weight γ_i measures how much agent i suffers from the wage inequality depending on whether he is ahead or behind; it is defined as

$$\gamma_i(w_i, w_j) = \begin{cases} 0 & \text{if } w_i \geq w_j \\ \alpha_i & \text{if } w_i < w_j. \end{cases} \quad (2)$$

The constant $\alpha_i \geq 0$ can thus be interpreted as agent i 's degree of envy. We do not restrict α_i to equal α_j , thus agents might differ in their degree of envy. The vector $\boldsymbol{\alpha} = (\alpha_i, \alpha_j)$ describes the agents' degrees of envy.

Both agents maximize their expected overall utility. Their outside options are normalized at zero. The principal is assumed to be risk neutral and interested only in his expected gross profit minus expected wage payments. We thus assume that he does not compare his profit to the agent's wage levels. This mirrors our assumption that the agents' reference groups are confined to the respective other agent.

3 The General Impact of Envy

The characterization of the optimal incentive contract follows Grossman and Hart (1983) and Mookherjee (1984). In the first step, the principal derives the second-best cost incentive scheme that implements a given effort vector $\mathbf{e}$ as a Nash equilibrium among the agents, subject to the constraints that the agents receive at least their reservation utilities and

⁹Clearly, agents might account for effort costs in their comparisons. But wages are directly comparable and thus constitute a natural reference point. Furthermore, self-serving biases are likely to be important: "Yes, the other agent worked very hard. But I also worked hard, thus he does not deserve to earn that much more." However, whether agents account for effort costs or not is ultimately an empirical question, and in Section 5 we argue that including effort costs in the comparisons would not affect our results.

choose the desired effort level. If a solution to this minimization problem exists, it yields the second-best costs. If no solution exists, these costs are set to plus infinity. Given degrees α of envy, this generates a second-best cost function $C^{SB}(\mathbf{e}, \alpha)$ for every effort vector $\mathbf{e}$. In the second step, maximizing the principal's expected profit minus costs determines the optimal effort vector $\mathbf{e}$ and the associated optimal contracts.

If the principal maximizes over the assigned wages, envy directly enters the participation and incentive constraints via the agents' utility functions. Since envy reduces utility, its effect on the participation constraint is clearly negative. Yet the influence on the incentive constraints is ambiguous: its effect depends on how the agent affects his expected utility loss from envy by choosing the desired effort. It may well be that envy provides an agent with an extra incentive to choose a (desired) high effort to reduce expected unfavorable wage inequality.

To clarify the effect of envy we therefore change the principal's control variables. Define agent i 's *utility from money* as the sum of his utility $u(w_i)$ from his wage and the potential utility loss $\gamma_i(w_i, w_j) S(w_i, w_j)$ from envy. An agent's utility from money is thus his overall utility U_i as defined in (1) excluding effort costs. Let the vector (v_i, v_j) denote a combination of utilities from money for agents i and j . Taking utilities from money as control variables, a contract is then a function $\mathbf{v} : X \rightarrow \mathbb{R}^2$ that assigns the agents utilities from money $v_i(\mathbf{x})$ and $v_j(\mathbf{x})$ conditional on the realized outcome $\mathbf{x}$. Let $\mathbb{V}$ be the space of all such functions, and let $V(\alpha)$ be the set of all utility from money combinations the principal can grant the agents by paying them wages in $[\underline{w}, \bar{w}]$. Moreover, envy might change the costs of providing the agents with certain utilities from money. Let the function $h : V(\alpha) \times \mathbb{R}^+ \times \mathbb{R}^+ \rightarrow \mathbb{R}$ characterize the principal's minimum costs if agents with degrees $\alpha \in \mathbb{R}^+ \times \mathbb{R}^+$ of envy are to receive a combination $(v_i, v_j) \in V(\alpha)$ of utilities from money. We call the function $h(\mathbf{v}, \alpha)$ the principal's *indirect cost function*. Note that both the correspondence V and the indirect cost function h depend on the degree α of envy in a way to be made precise below.

Suppose the principal wants to implement an effort vector $\mathbf{e}$ at the least cost, facing agents with degrees α of envy. The second-best costs $C^{SB}(\mathbf{e}, \alpha)$ are then determined by minimizing his expected wage payments

$$\sum_{\mathbf{x} \in X} \pi(\mathbf{x} | \mathbf{e}) h(\mathbf{v}(\mathbf{x}), \alpha) \quad (3)$$

with respect to the contract $\mathbf{v}$, subject to the constraints

$$\sum_{\mathbf{x} \in X} \pi(\mathbf{x} | \mathbf{e}) v_i(\mathbf{x}) - \psi(e_i) \geq 0 \quad (4)$$

$$\sum_{\mathbf{x} \in X} [\pi(\mathbf{x} | \mathbf{e}) - \pi(\mathbf{x} | e'_i, e_j)] v_i(\mathbf{x}) - [\psi(e_i) - \psi(e'_i)] \geq 0 \quad (5)$$

$$\mathbf{v}(\mathbf{x}) \in V(\alpha) \quad (6)$$

for $i = 1, 2$, all $e'_i \in E$, and all $\mathbf{x} \in X$. The participation constraints (4) ensure that both agents accept the contract. The incentive constraints (5) render it optimal for each agent to choose the desired effort level conditional on the other agent doing the same. Finally, the limited liability constraint (6) restricts the principal to assign utilities from money that are attainable by paying wages from the interval $[\underline{w}, \bar{w}]$. A contract is *incentive compatible* if it satisfies the incentive constraints (5). It is *incentive feasible* if in addition it fulfils the participation constraints (4). The contracts satisfying the constraints (4) and (5) form the *feasible set*. Finally, the *constraint set* consists of all incentive feasible contracts that also fulfil the limited liability constraint (6).

Inspection of the principal's program shows that envy enters the program in two ways: First, via the set $V(\alpha)$ of possible utilities from money and, second, via the indirect cost function $h(\mathbf{v}, \alpha)$. In the following we analyze the impact of these two effects on the principal's second-best costs $C^{SB}(\mathbf{e}, \alpha)$.

Set of Attainable Utility from Money Combinations

If the agents are to receive utilities from money (v_i, v_j) , their wages (w_i, w_j) must satisfy

$$u(w_i) - \gamma_i(w_i, w_j) S(w_i, w_j) = v_i \quad (7)$$

$$u(w_j) - \gamma_j(w_i, w_j) S(w_i, w_j) = v_j . \quad (8)$$

The following lemma greatly simplifies the ensuing analysis. All proofs are in the appendix.

Lemma 1 (Ranking) *Consider some (v_i, v_j) with $v_i \geq v_j$. Then any solution (w_i, w_j) to (7) and (8) satisfies $w_i \geq w_j$.*

Suppose agent i receives a weakly higher wage than agent j . Since both agents share the same utility from wage function, agent i then receives a weakly higher utility $u(w)$. Contrary to agent j , agent i does not suffer a utility loss from envy. Hence, agent i receives a weakly higher utility from money. This yields Lemma 1. If $v_i \geq v_j$, equations (7) and (8) are thus equivalent to

$$w_i = u^{-1}(v_i) \quad (9)$$

$$u(w_j) - \alpha_j S(u^{-1}(v_i), w_j) = v_j. \quad (10)$$

We can now analyze the set of attainable utility from money combinations. Rendering our previous definition more precise, let $V(\alpha)$ be the set of all utility from money combinations $(v_i, v_j) \in \mathbb{R}^2$ for which there exist wages $(w_i, w_j) \in [\underline{w}, \bar{w}]^2$ solving (7) and (8). Then

Proposition 1 (Attainable Utility from Money Combinations) *For given degrees α of envy and interval $[\underline{w}, \bar{w}]$ of possible wage levels,*

$$V(\alpha) = \left\{ (v_1, v_2) \in \mathbb{R}^2 : \text{if } v_i \geq v_j \text{ then } \right. \\ \left. v_i \in [u(\underline{w}), u(\bar{w})] \text{ and } v_j \in [u(\underline{w}) - \alpha_j S(u^{-1}(v_i), \underline{w}), v_i] \right\} \quad (11)$$

characterizes the set of attainable utility from money combinations. Envy thus increases the set of attainable utility from money combinations.

Envy never increases the utility of an agent, hence the maximum attainable utility from money remains at $u(\bar{w})$. However, an envious agent suffers a utility loss when the other agent receives a higher wage. By creating unfavorable wage inequality, the principal can reduce an envious agent's minimum utility from money below the level that a selfish agent derives from the minimum wage. Figure 1 offers an illustration. If both agents receive the minimum wage, there is no wage inequality and they receive the utility from money combination $[u(\underline{w}), u(\underline{w})]$. Suppose the principal now increases the wage of, say, agent 1 but holds the wage of agent 2 fixed. The utility from money of agent 1 then rises as he enjoys the increased wage. Since his wage is higher than agent 2's wage, he does not suffer from envy. Agent 2's utility from money, however, is reduced by envy. He now receives $u(\underline{w}) - \alpha_2 S(u^{-1}(v_1), \underline{w})$. In Figure 1 this

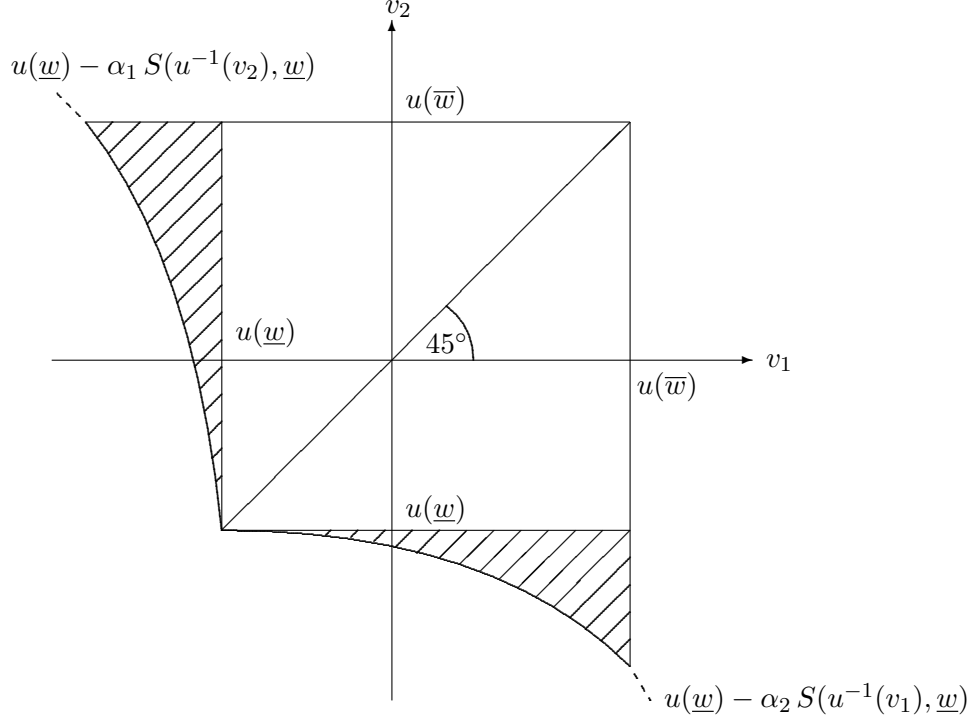


Figure 1: **Set of Attainable Utility from Money Combinations.** The shaded areas indicate the additional utility from money combinations rendered attainable by envy.

corresponds to a movement from the lower left corner of the set along the curve that confines the right shaded area from below. Envy thus enlarges the set of attainable utility from money combinations, that is, envy enlarges the principal's constraint set. A relaxed constraint set to the principal's program might allow the principal to employ a cheaper contract, hence envy can have a decreasing effect on the principal's second-best cost $C^{SB}(\mathbf{e}, \boldsymbol{\alpha})$.

The Principal's Indirect Cost Function

In the previous section we have identified a potential cost-decreasing impact of envy. We now turn to the effect of envy on the principal's indirect cost function $h(\mathbf{v}, \boldsymbol{\alpha})$ and show that envy can also increase the costs of providing incentives. Let

$$h(v_i, v_j, \boldsymbol{\alpha}) = \min \{w_i + w_j : (w_i, w_j) \text{ solves (9) and (10)}\} \quad (12)$$

characterize the principal's minimum costs of providing the agents with the utility from money combination $(v_i, v_j) \in V(\boldsymbol{\alpha})$ with $v_i \geq v_j$. Strict monotonicity of both the utility function u and the left hand side of (10) imply that (9) and (10) have a unique solution. Analyzing this solution, the effect of envy on the indirect cost function is the following.

Proposition 2 (Indirect Cost Function) *Suppose the principal wants to grant the agents utilities from money $(v_i, v_j) \in V(\alpha)$ with $v_i \geq v_j$. Then his indirect cost function $h(\mathbf{v}, \alpha)$ is*

1. *independent of α_i ,*
2. *independent of α_j if $v_i = v_j$, and*
3. *strictly increasing in α_j if $v_i > v_j$.*

Agent j 's envy thus causes strictly positive extra indirect costs if and only if $v_i > v_j$.

Inspection of (9) and (10) shows that the agents must receive different wages if and only if they are to receive different utilities from money. The agent with the lower wage, agent j , then suffers from envy. If he is to receive a particular utility from money, he must be compensated for the utility loss from envy. This entails extra costs for the principal that are increasing in agent j 's utility loss and thus in his degree α_j of envy. Consequently, envy renders a contract more expensive if and only if the agents are given different utilities from money with strictly positive probability in equilibrium. Envy can thus have an increasing effect on the principal's second-best costs $C^{SB}(\mathbf{e}, \alpha)$.

General Effect of Envy

The above analysis shows that the general impact of envy on the principal's program is twofold. First, envy might enlarge the set of attainable utility from money combinations. Second, envy might render the implementation of unequal utility from money combinations more expensive. The first effect relaxes the principal's liability constraint and thus weakly reduces the second-best costs, whereas the second effect on the indirect cost function weakly increases the second-best costs relative to the case with purely self-interested agents. The overall effect of envy on the principal's minimum costs of providing incentives thus depends decisively on the underlying principal agent problem.

4 Envy, Risk-Aversion, and Unlimited Liability

In the following we focus on the canonical case with risk-averse agents and unlimited liability. Further, we assume that each agent i manages his own project that generates a stochastic and individually attributable outcome x_i . Project outcomes are taken to be independent,

thus the probability $\pi_i(x_i|e_i)$ of outcome x_i exclusively depends on agent i 's effort.¹⁰ We consequently consider a situation with $\mathbf{x} = (x_1, x_2)$ and $\pi(x_1, x_2 | \mathbf{e}) = \pi_1(x_1 | e_1) \pi_2(x_2 | e_2)$. To avoid situations where there is no trade-off between incentives and insurance, we further assume that there is full support, $\pi(x_i|e_i) > 0$ for all efforts and outcomes. Finally, there is no limited liability: the interval $[\underline{w}, \bar{w}]$ is sufficiently large such that for every effort vector any solution to the principal's minimization program (3) to (5) satisfies the limited liability constraint (6) if the agents are not envious.

To formalize the total effect of envy we define the *envy costs* as the cost difference caused by envy if the principal wants to implement some effort vector $\mathbf{e}$,

$$EC(\mathbf{e}, \boldsymbol{\alpha}) = C^{SB}(\mathbf{e}, \boldsymbol{\alpha}) - C^{SB}(\mathbf{e}, \mathbf{0}). \quad (13)$$

Let $\underline{\mathbf{e}}$ denote the effort vector that minimizes each agent's effort cost, and call an effort vector *implementable* if the corresponding feasible set is non-empty. We then get the following result.

Proposition 3 (Envy Costs, Risk-Aversion, and Unlimited Liability) *Suppose the agents are risk-averse, there is unlimited liability, project outcomes are independent, and there is full support. Then the envy costs $EC(\mathbf{e}, \boldsymbol{\alpha})$ of any implementable effort vector $\mathbf{e}$ are strictly positive if and only if $\mathbf{e} \neq \underline{\mathbf{e}}$.*

The intuition for Proposition 3 is as follows. First, suppose the principal wants to punish an agent with wage inequality. Since there is unlimited liability, he can impose the same punishment by lowering the respective agent's wage. Reducing wages reduces the principal's expected costs. Thus, there is no benefit from punishing agents by creating wage inequality if there is no limited liability. Moreover, if the agents are risk-averse but not envious, the optimal contracts that implement a particular effort vector are unique. If at least one of the agents is to choose an effort level that is not cost-minimizing, he cannot receive a flat-wage. Since the outcomes are independent, the principal learns nothing about an agent's effort choice by observing the other agent's output. It then follows from Holmström's (1979) sufficient statistics result that an agent's contract conditions only on his own output. As there is always full support and outcomes are independent, the agents receive different utilities

¹⁰Our results also hold if outcomes are correlated except for the knife-edge cases in which there never arises wage inequality even with purely self-interested agents.

from money with strictly positive probability. It then follows from Proposition 2 that the contracts that are optimal for purely self-interested agents cause strictly higher costs with envious agents. Since envy renders all alternative (and therefore initially strictly more costly) contracts weakly more expensive, the principal's second-best costs must strictly increase.

Flat-Wage Contracts

In our moral hazard model with risk-averse agents and no limited liability, the implementation of all higher effort levels $e \neq \underline{e}$ causes wage inequality and thus strictly positive envy costs. The principal, however, can implement the effort levels $\underline{e}$ which minimize both agents' effort costs by paying flat-wages. Since both agents share the same effort cost function, there arises no wage inequality and thus no envy costs. Envy thus generates a tendency towards flat-wage contracts. In fact, if for all higher effort levels $e \neq \underline{e}$ the envy costs exceed the benefits from implementation,

$$EC(e, \alpha) \geq \sum_{x \in X} [\pi(x|e) - \pi(x|\underline{e})] f(x) - [C(e, \mathbf{0}) - C(\underline{e}, \mathbf{0})], \quad (14)$$

envy renders flat-wage contracts optimal. Clearly, there can be situations where the implementation of high effort does not increase the principal's profit by much. The right hand side of inequality (14) might then just exceed zero for some high effort levels. In such cases even moderate degrees of envy can have a dramatic effect on the optimal incentive contract: with purely self-interested agents the principal wants to implement high effort and thus provides strong monetary incentives, whereas flat-wages are optimal if the agents are envious.

Within-Firm vs. Market Interactions

Until now we have analyzed the principal's program given the agents' degrees of envy. However, the impact of social comparisons and envy is likely to depend on the institutional context. The principal agent model allows for different interpretations of what it represents. In the context of the theory of the firm, this point is made by Hart (1995) who stresses that principal-agent theory "does not pin down the *boundaries* of the firm" (p. 20). Our model can thus be interpreted as representing either a firm with two employees or market relationships between a buyer and two independent suppliers. Yet the empirical evidence as discussed in the introduction suggests that social comparisons like envy are more pronounced within firms than among agents that interact only in the market. Condition (14) then

directly implies that there might exist situations in which flat-wage contracts are optimal within firms, whereas incentive contracts are optimal in the market – even if the underlying principal-agent problems are otherwise identical. Our model thus provides a behavioral explanation for the empirically observed differences in incentive provision within firms and in the market.

Central to this explanation is the claim that the boundary of the firm can define the workers' reference group. Kole and Lehn's (2000) empirical study of USAir's merger with Piedmont Aviation provides further evidence, and it shows that the quantitative effects of internal equity requirements can be huge. To avoid labor conflicts the management of USAir had conceded its labor force wages that were relatively high as compared to industry standards. At the time of the merger, employees at USAir thus received more generous remuneration schemes as compared to their colleagues at Piedmont Aviation. After the merger, unions resisted plans to integrate Piedmont Aviation as a subsidiary with less generous labor contracts. The management of USAir gave in to this request for equal treatment and decided to adjust wages in Piedmont Aviation upwards, thereby boosting labor costs. As a consequence, net income fell from a projected gain of 206 to a loss of 63 million USD in the year of the merger.

5 Discussion

Including Effort Costs in the Social Comparisons

In our specification of envy, agents do not account for effort costs when comparing themselves to their colleagues. This assumption is technically necessary in order to separate an agent's overall utility into his utility from money and the effort costs. For a given outcome and resulting wages, an agent's utility loss from envy can otherwise depend on his effort choice. Since effort is not observable, there is no contract that can replicate the resulting effect on the incentive constraint of purely self-interested agents. However, this effect is likely to increase agency costs: an envious agent might shirk because the resulting reduction in effort costs reduces his suffering from envy in case the other agent is ahead. We thus conjecture that our results hold if agents include effort costs in their social comparisons.

Wage Secrecy

Our analysis shows that envy can increase the costs of providing incentives. If firms can prevent social comparisons by keeping wages secret, the additional agency costs can be avoided. At first sight, our results could thus be regarded as a rationale for the observation that many labor contracts prohibit employees from communicating their salaries to their colleagues. Yet it is far from obvious that secrecy of wages can prevent social comparisons. In the context of our model, even if the principal follows a policy of wage secrecy, agents are likely to form beliefs about the other agent's contract, effort choice, and thus wage. Furthermore, to uphold wage secrecy an agent's wage cannot condition on the other agent's performance. This, however, can be optimal to reduce the cost of envy. A policy of wage secrecy thus constrains the principal's contract choice, and if agents suffer from their beliefs about unequal wages as much as they suffer from observed differences, then wage secrecy only further increases the agency costs of providing incentives. This conclusion is in line with most textbooks on personal management, for example Henderson (2005), that recommend a policy of openness with regard to wages and salaries.

Theory of the Firm

Finally, our findings have implications for the theory of the firm. Evidently, the horizontal integration of firms can boost profits by realizing complementarities in production or other synergy effects. However, Williamson's (1985) discussion of Tenneco's acquisition of Houston Oil and Minerals Corporation arrestingly demonstrates that changing the boundary of the firm can change the workers' reference groups. Our analysis shows that such extended social comparisons can cause additional agency costs by imposing further restrictions on firms' wage schemes. If these costs are as substantial as in Kole and Lehn's (2000) case study of the merger of USAir with Piedmont Aviation, they can be decisive for the profitability of mergers and acquisitions.

6 Summary

This paper investigates the effect of envy in a moral hazard problem with multiple agents. We show that envy affects the principal's minimum cost of providing incentives via two channels. First, the principal can afflict agents with additional punishment by creating wage

inequality. If limited liability restricts the principal's use of monetary punishments, envy can therefore have a cost-decreasing effect. Second, envious agents must be compensated for their suffering from expected wage inequality if they are to accept the principal's contracts. Envy thus causes additional costs whenever wage inequality arises with positive probability. Since envy can have a cost-increasing and a cost-decreasing effect, its total impact depends on the underlying principal-agent problem.

However, we can show that in the canonical case of risk-averse agents and unlimited liability, envy never decreases the costs of providing incentives. First, there can be no cost-decreasing effect since there is no limited liability. Second, the principal cannot avoid or reduce expected wage inequality and the associated necessary compensation without impairing the allocation of risk. With risk-averse agent this increases the compensation for risk exposure. Yet envy causes no additional costs if the principal implements the cost-minimizing effort levels by paying the agents equitable flat-wages. Envy thus generates a tendency towards flat-wage contracts. Since social comparisons like envy appear to be more pronounced within firms than in the marketplace, our paper offers a rationale for the observation that most market transactions are subject to strong incentives while transactions within firms or organizations are often not incentivized – even if the underlying principal-agent problems are otherwise identical.

Appendix

Proof of Lemma 1

Suppose $w_i \geq w_j$. Thus $\gamma_i(w_i, w_j) = 0$, $\gamma_j(w_i, w_j) = \alpha_j$, and $u(w_i) \geq u(w_j)$. Substitution into (7) and (8) shows that this implies $v_i \geq v_j$. Q.E.D.

Proof of Proposition 1

It follows from (9) that $w_i \in [\underline{w}, \bar{w}]$ if and only if $u^{-1}(v_i) \in [\underline{w}, \bar{w}]$. It follows from Lemma 1 that any solution w_j to (10) must lie in the interval $[\underline{w}, u^{-1}(v_i)]$. For all $w_j \in [\underline{w}, u^{-1}(v_i)]$ the left hand side of (10) is strictly increasing and continuous in w_j . It takes on the value v_i for $w_j = u^{-1}(v_i)$. Since we have $v_i \geq v_j$, the mean value theorem and monotonicity imply the existence of a $w_j \in [\underline{w}, u^{-1}(v_i)]$ if and only if $u(\underline{w}) - \alpha_j S(u^{-1}(v_i), \underline{w}) \leq v_j$. Q.E.D.

Proof of Proposition 2

For $v_i \geq v_j$ consider (9) and (10). First, $w_i = u^{-1}(v_i)$ is unique by the strict monotonicity of u . Second, w_j is unique as the left hand side of (10) is strictly increasing in w_j for all $w_j \in [\underline{w}, u^{-1}(v_i)]$. Consequently, we get $h(v_i, v_j) = w_i + w_j$ with (w_i, w_j) uniquely defined. The properties of h follow directly from the properties of w_i and w_j as characterized below.

The solution $w_i = u^{-1}(v_i)$ is independent of α_i and α_j . If $v_i = v_j$, then $w_j = u^{-1}(v_i)$ is the unique solution to (10), and it is independent of α_i and α_j . If $v_i > v_j$, Lemma 1 implies that solutions to (10) satisfy $w_j < u^{-1}(v_i)$. $S(u^{-1}(v_i), w_j)$ is then strictly positive. Increasing α_j thus lowers the left hand side of (10) which implies a counterbalancing increase in w_j . *Q.E.D.*

Proof of Proposition 3

Necessity

The principal optimally implements $\underline{e}$ by paying both agents a flat-wage of $w = u^{-1}(\psi(\underline{e}))$. Since wage inequality never arises, the envy costs are zero.

Sufficiency

a) Suppose the principal wants the agents to choose an implementable effort vector $\mathbf{e} \neq \underline{\mathbf{e}}$ and agents are not envious. Since then $h(v_i, v_j) = u^{-1}(v_i) + u^{-1}(v_j)$, the principal's objective function (3) is continuous and strictly convex. Ignoring the limited liability constraint (6), the feasible set can be artificially bounded by applying a result of Bertsekas (1974). By the weak inequalities in (4) and (5) the feasible set is closed and thus compact. The considered effort vector is implementable such that the feasible set is non-empty. Since the principal's objective function is continuous, Weierstrass' theorem implies the existence of a solution $\mathbf{v}^*$. Since the objective function is strictly concave, the solution is unique. We consider the case without limited liability, thus $\mathbf{v}^*$ satisfies (6).

b) Since $\mathbf{e} \neq \underline{\mathbf{e}}$ there exists an agent i whose effort is not cost-minimizing. This agent cannot be paid a fixed wage, because he would then choose the cost-minimizing effort. Hence, there exist outcomes x_i and x'_i with $v_i^*(x_i) > v_i^*(x'_i)$. We assume independent outcomes, consequently Holmström's (1979) sufficient statistics result implies that each agent's wage

conditions only on his own output. There must thus exist an outcome (x_i, x_j) such that $v_i^*(x_i) \neq v_j^*(x_j)$. By assumption there is full support, therefore (x_i, x_j) arises with the strictly positive probability $\pi_i(x_i|e_i) \pi_j(x_j|e_j)$ in equilibrium.

c) Since there is no limited liability, the optimal contract $\mathbf{v}^*$ attains a global minimum. All other incentive feasible contracts cause the principal strictly higher costs. By Proposition 2 envy renders the optimal contract $\mathbf{v}^*$ strictly more expensive as there arises wage inequality in equilibrium. Since all other contracts are rendered weakly more expensive, the envy costs are strictly positive. *Q.E.D.*

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