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Optimal Incentive Contracts when Workers envy their Boss

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Optimal Contracts When a Worker Envies His Boss*

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Abstract

A worker's utility may increase with his income, but envy can make his utility decline with his employer's income. This paper uses a principal-agent model to study profit-maximizing contracts when a worker envies his employer. Envy tightens the worker's participation constraint and so calls for higher pay and/or a softer effort requirement. Moreover, a firm with an envious worker can benefit from profit-sharing, even when the worker's effort is fully contractible. We discuss several applications of our theoretical work: envy can explain why a lower-level worker is awarded stock options, why incentive pay is lower in non-profit organizations, and how governmental production of a good can be cheaper than private production.

Keywords: Principal-agent, Envy, Compensation, Contracts, Profit-sharing, Stock options, Public versus private production.

JEL codes: D23, J31, J33, M52.

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1 Introduction

Envy is common. Brown (1991, 1999) claims that it appears in all ethnographically and historically recorded societies. Experimental evidence for envy is provided by Camerer (2003): subjects presented with an unfair offer showed greater activity in the bilateral anterior insula of the brain, revealing that such an offer created negative emotions. Other experimental studies also suggest that fairness considerations are important (see the survey by Fehr and Schmidt (2003)). Even monkeys react with anger to unequal reward distributions (Brosnan and de Waal (2003)). Such feelings explain the rage of workers at American Airlines and at Delta Air Lines in 2003 who learned of bonuses for senior executives at the same time that workers were asked to accept wage cuts. Greenberg (1990) finds empirical evidence that employee theft increases when workers consider their pay to be inequitable. Survey evidence also shows that workers care about how their wage compares to the firm's profits, and that managers fear quits and reduced effort when the wage paid is unfair (Agell and Lundborg (1995), Bewley (1999)).

This paper considers the implications of envy for profit-maximizing contracts. We shall consider a worker who envies his employer, recognizing that increased effort may enrich his employer. We shall see that envy tightens the worker's participation constraint. As a result, pay must increase and/or required effort must be reduced. Further, though effort is contractible, the profit-maximizing contract may call for incentive pay. Such profit-sharing increases the worker's risk, but it also reduces the expected utility loss from envy, making the job more attractive to the worker, and so reducing the wage.

Envy can explain several stylized facts. First, it may explain why lower-level workers are awarded stock options though an individual worker's effort hardly affects the stock price. Second, envy can cause for-profit firms to provide stronger monetary incentives to workers than do non-profit firms. Third, envy can make public production of a good more efficient than private production.

2 Literature

Our discussion of envy relates to concern about relative status, as well studied by Frank (1984, 1985). He argues that a worker may prefer firm A which

pays less than firm B, if the wage firm A offers is high compared to what it pays others. Workers' concerns about their relative standing in the firm may therefore imply that a highly productive worker at a firm with many low-productivity workers may earn less than his marginal product. Likewise, a worker with low productivity must be paid a compensating wage for enduring a low-status compared to his co-workers. Fershtman, Hvide, and Weiss (2006) examine how such concern about relative status affects workers' effort and affects the pay package a firm should offer. Status concerns increase effort and may result in a 'rat race' among workers. A similar effect appears when people want to 'keep up with the Joneses;' see Dupor and Liu (2003).

Other papers assume that people dislike inequity or inequality (Fehr and Schmidt (1999), Bolton and Ockenfels (2000)). That is, instead of agents valuing a high-status position, they feel compassion for lower-ranked agents, and feel envy toward higher-ranked agents. Several recent papers explore optimal incentive contracts when workers feel envy and compassion toward co-workers. (See Bartling and Von Siemens (2006), Biel (2002), Demougin and Fluet (2006), Grund and Sliwka (2005), Itoh (2004), and Neilson and Stowe (2003)).

We ignore envy towards co-workers and, instead, focus on envy of the boss. As workers rarely earn more than their boss (professional sports may be an exception), our analysis ignores this possibility and, consequently, we need not consider how agents feel when they are relatively better off.[1] For our purpose, it is therefore immaterial whether people value high status (as in Frank (1985)) or suffer from it (as in Fehr and Schmidt (1999) and related work).

A few papers examine optimal contracts when workers envy their employer. Fehr and Schmidt (2000) and Fehr, Klein, and Schmidt (2001) study the employer's choice of a contract in a model where both the worker and the employer may care about fairness. The presence of fair-minded employers can make an incomplete bonus contract optimal, as fair-minded employers reward hard work with a bonus even when the contract does not oblige them to do so. Selfish employers mimic the contract offered by fair employers, but pay no bonus. Fair-minded workers (who face an additional utility loss,

[1] We also abstract from positive feelings, or from feelings of obligation toward the employer, which are prominent in Akerlof's (1982) model of the gift-exchange, and in Rabin's (1993) model of reciprocity; see Rotemberg (2002) for a survey. Further, we do not consider workers' promotions to a managing position. When a worker's chance of promotion increases in his effort, envy may increase effort; see Grund and Sliwka (2005).

increased inequality, when the employer appears to be of the selfish type and does not pay the bonus) may then exert less effort than selfish workers.

More closely related to our analysis is Englmaier and Wambach (2005). They study optimal incentive contracts when workers dislike inequality and employers are selfish. The authors concentrate on determining whether the incentive contract is linear in output, finding conditions under which it is. Since we assume two possible outcomes (output is either high or low), that is not our focus. Instead, we consider the implications of envy for the variation of pay with output or effort, and for worker's effort.

We differ from their work and from other work (e.g. Itoh (2004), Mayer and Pfeiffer (2004)) in applying the idea to new issues, including why lower-level workers are awarded stock options, and why government generally offers lower-powered incentives than do for-profit firms. Unlike Itoh (2004), we allow the worker to envy the employer both when output is high and when it is low. Moreover, we consider a risk-averse worker rather than a risk-neutral worker, so that the firm must consider how increased effort by the worker and incentive pay affect both the worker's envy and the risk he faces.

3 Assumptions

Consider the following principal-agent model. A risk-neutral employer hires a risk-averse worker. The employer maximizes profits, Π. Profits equal the worker's output (with a price normalized to 1) minus the amount (w) paid the worker. The firm contracts for the worker's effort $e \geq 0$. His effort yields output H with probability e and yields output L with probability $(1-e)$, where $H > L$. The worker's cost of effort is $c(e)$, with $c'(e) \geq 0$, $c''(e) > 0$, $c'(0) = 0$, and $c(0) = 0$. To ensure that effort, and so the probability of high output, is always less than 1, we assume that $\lim_{e \to 1} c(e) = \infty$. The worker earns a base salary a. If output is high, he also earns a bonus, b.

The worker's utility function is separable in his income (w), effort (e), and envy (x):

$$U = u(w) - c(e) - \gamma v(x),$$

with $\gamma \geq 0$ the weight on the disutility from envy. We model envy as increasing with the difference in income between the employer and the worker; we denote this difference by x. As noted in the previous section, we will only consider cases where a worker earns less than his boss. Hence, we assume that $x = \Pi - w > 0$. We assume that, for $x > 0$, the function $v(x)$ is

strictly convex. To make the analysis tractable, we make the more specific assumption that

$$v(x) = x^2,$$

implying that, for $x > 0$, $v'(x) = 2x > 0$, $v''(x) = 2 > 0$, and $v'''(x) = 0$, and so the worker's disutility from envy is increasing and strictly convex in the difference in income between the employer and the worker.[2]

To ensure that the worker is risk averse, the utility from income ($u(w)$) should be strictly concave. In particular, we assume that the utility function takes the following tractable form:

$$u(w) = \alpha w - \beta w^2,$$

with $\alpha > 0$, $\beta > 0$ and $\alpha - \beta H > 0$. The last inequality and the assumption that $x > 0$ ensure that the marginal utility of income, $u'(w) = \alpha - 2\beta w$, is always positive.[3] Note also that $u''(w) = -2\beta < 0$, and so the worker is risk averse, and that $u'''(w) = 0$.

A worker's outside option is self-employment or unemployment, which yields utility $\overline{U}$. We assume that a worker envies an employer only if the worker personally contributes to his employer's wealth. Under this assumption, a person who is self-employed or unemployed suffers no envy. The participation constraint is

$$E[u(w) - c(e) - \gamma v(x)] \geq \overline{U},$$

where E is the expectation operator.

When γ is large, no interior solution may exist. We abstract from this possibility.

[2] We differ from typical models of inequity aversion (Fehr and Schmidt, 1999) in assuming that the disutility from inequality is convex rather than linear. Corresponding to models of inequity aversion, we assume that people care about absolute differences rather than about relative shares.

[3] To see why, note that under the assumption that in equilibrium the worker suffers from envy, or equivalently that $x > 0$, it follows that $L - 2a > 0$ and that $H - 2a - 2b > 0$, or equivalently that $a < L/2$ and $a + b < H/2$. So the assumption that $x > 0$ implies that the wage is always smaller than half of low output and also always smaller than half of high output. Since $H > L$, a sufficient condition for the marginal utility of income, $u'(w) = \alpha - 2\beta w$, to be always positive is that $\alpha - \beta H > 0$, as we assume.

4 Analysis

In the standard principal-agent model with workers who are risk averse but not envious, the worker earns a fixed wage (making the firm bear all the risk), and the worker's marginal cost of effort equals the firm's expected marginal revenue from that effort. As we will see, a worker's envy of his boss can cause the profit-maximizing contract to impose some risk on the worker.

4.1 The profit-maximizing contract

Since effort is assumed contractible, the employer's optimization problem is

$$\max_{e,a,b} e(H-b)+(1-e)L-a.$$

When output is high, the worker earns $a+b$, the firm's profit is $H-a-b$, and so the worker's disutility from envy is $v(H-2a-2b)$; disutility from envy when output is low is $v(L-2a)$. The worker's participation constraint is thus

$$eu(a+b)+(1-e)u(a)-c(e)-\gamma\left[ev(H-2a-2b)+(1-e)v(L-2a)\right]\geq\overline{U}.$$

Let

$$g=eu(a+b)+(1-e)u(a)-c(e)-\gamma\left[ev(H-2a-2b)+(1-e)v(L-2a)\right].$$

The Lagrangian of the problem is

$$Z=e(H-b)+(1-e)L-a+\lambda\left(g-\overline{U}\right),$$

where λ is the Lagrange multiplier on the participation constraint.

In the following, let subscripts denote partial derivatives. The first-order necessary conditions for maximizing profits are:

$$\begin{aligned}
Z_e &= H-b-L+\lambda\left\{u(a+b)-u(a)-c'(e)-\gamma\left[v(H-2a-2b)-v(L-2a)\right]\right\}=0,\\
Z_a &= -1+\lambda\left\{eu'(a+b)+(1-e)u'(a)+2\gamma\left[ev'(H-2a-2b)+(1-e)v'(L-2a)\right]\right\}=0,\\
Z_b &= -e+\lambda\left[eu'(a+b)+2\gamma ev'(H-2a-2b)\right]=0,\\
\lambda &> 0\Longrightarrow Z_\lambda=g-\overline{U}=0,\\
\lambda &= 0\Longrightarrow Z_\lambda=g-\overline{U}>0.
\end{aligned}$$

Note that the first-order condition $Z_a = 0$ implies that $\lambda > 0$. Intuitively, an increase in the base salary always makes the employer worse off (first term of Z_a), and always benefits the worker (second term of Z_a). It follows that the participation constraint always binds, $Z_\lambda = 0$. If it does not bind, the employer can reduce the base salary and thus can increase his profits, without affecting the worker's willingness to participate. The second-order sufficient conditions for maximizing profits are satisfied, as shown in Appendix 7.1.

Proposition 1: When the worker is envious, a profit-maximizing employer shares profits with him.

Proof:

Combining the first-order conditions $Z_a = 0$ and $Z_b = 0$ and rewriting yields

$$u'(a) - u'(a+b) = 2\gamma \{v'[H - 2a - 2b] - v'[L - 2a]\}.$$

The left-hand side is zero when $b = 0$, and strictly increases with b. The right-hand side is zero when $b = (H - L)/2$, and strictly decreases with b. Since $H > L$, a unique profit-maximizing b exists, which satisfies $0 < b < (H - L)/2$.

QED

The result follows intuition: when the worker is risk averse and lacks envy, a fixed wage ($b = 0$) maximizes profits, and the firm bears all the risk. With envy, however, an increase in bonus pay can reduce the worker's expected utility loss from envy. For a given level of expected compensation $a + eb$, if $0 < b < (H - L)/2$, an increase in the bonus reduces the worker's expected utility loss from envy, and so relaxes the participation constraint. This relaxation allows the firm to reduce the base salary. The disadvantage of profit-sharing is the increased risk imposed on the worker, necessitating an increase in the base salary. The profit-maximizing contract trades off this cost and the benefit of increasing the bonus.[4]

Notice that were $v(x)$ linear, the expected utility loss from envy always increases with expected profits. So the only way to reduce the worker's expected disutility from envy, and thereby relax his participation constraint, is to reduce expected profits, clearly hurting the employer. The convexity

[4]Englmaier and Wambach (2005) obtain a similar result in a different but closely related setup with continuous outcomes and workers who are inequity averse. See their Propositions 1 and 2.

of $v(\cdot)$ implies that profit-sharing can reduce the expected utility loss from envy while increasing profits.

A different case is a risk-neutral worker (where $u(w)$ is a linear function). The profit-maximizing b would then be $(H-L)/2$. That is, the firm and worker equally share the difference between high and low output.[5] The intuition is that when the worker is paid a lump-sum plus half the difference between H and L, the difference in income between the employer and the worker becomes invariant with output.[6] Such a sharing contract minimizes the expected utility loss from envy for a given level of expected profits, as in Englmaier and Wambach (2005).

We wish next to determine how changes in envy affect the profit-maximizing contract. Our main result is in Proposition 2 below, where we show that increased envy increases bonus pay in the profit-maximizing contract. We also derive the effects of envy on the profit-maximizing contract's base pay, on effort, and on the employer's profits. To provide intuition for these results, we first give two lemmas which look at constrained problems: how the employer responds to increased envy when effort and bonus pay are fixed, and how the employer responds to increased envy when the base salary and bonus pay are fixed.

Lemma 1: For a given level of effort and bonus pay, an increase in the weight the worker places on envy induces the employer to pay a higher base salary.

Proof:

The first-order condition $Z_a = 0$ implies that $\lambda > 0$, and so the participation constraint always binds, $Z_\lambda = 0$. Differentiating the participation constraint with respect to a and γ, keeping e and b fixed, yields after some rewriting:

$$\frac{\partial a}{\partial \gamma} = \frac{ev(H-2a-2b)+(1-e)v(L-2a)}{eu'(a+b)+(1-e)u'(a)+2\gamma\left[ev'(H-2a-2b)+(1-e)v'(L-2a)\right]} > 0.$$

Clearly, both the numerator and denominator are positive.

[5] Some data support this prediction. Young and Burke (2001) find that in their sample of Illinois farms almost all contracts have the same tenant share for all types of crops, and that this share is one-half for 80 percent of the contracts.

[6] Note that given that the employer is always wealthier than the worker, a pay system with full incentives results in high income inequality when output is low, whereas under no incentive pay income inequality is high when output is high.

QED

Lemma 2: For a given level of base salary and bonus pay, an increase in the weight the worker places on envy induces the employer to soften the effort requirement.

Proof:

The first-order condition $Z_a = 0$ implies that $\lambda > 0$, and so the participation constraint always binds, $Z_\lambda = 0$. Differentiating the participation constraint with respect to e and γ, keeping a and b fixed, yields after some rewriting:

$$\frac{\partial e}{\partial \gamma} = \frac{ev(H-2a-2b) + (1-e)v(L-2a)}{u(a+b) - u(a) - c'(e) - \gamma\left[v(H-2a-2b) - v(L-2a)\right]} < 0.$$

The numerator is positive. The denominator is negative; this follows from the first-order condition $Z_e = 0$ together with the results that $\lambda > 0$ and $0 < b < (H-L)/2$.

QED

By our assumption that a person suffers from envy only when working for the employer, envy is a job disamenity; a worker must be compensated for the disamenity by a higher base salary and/or by a softening of the effort requirement in the contract. In the next subsection, we derive how effort, the base salary, and the bonus in the profit-maximizing contract are affected by the worker's envy.

4.2 Comparative statics

To evaluate some comparative statics, we totally differentiate the first-order conditions $Z_e = 0$, $Z_a = 0$, $Z_b = 0$, and $Z_\lambda = 0$ with respect to e, a, b, λ, and γ. Appendix 7.2 gives the proofs of the propositions listed below.

Proposition 2: Optimal bonus pay increases with the weight on envy in the worker's utility function.

Offering a higher bonus imposes more risk on the worker, but reduces his expected disutility from envy. When the worker places greater weight on envy, the benefit to the firm of offering a higher bonus increases, and so the profit-maximizing bonus increases.

Though the effect of envy on bonus pay is clear, envy has ambiguous effects on optimal effort and on the base salary. Envy affects optimal effort in three ways. First, the greater the weight the worker places on envy, the higher the marginal cost to the firm of inducing effort. (See the first-order condition $Z_e = 0$). The reason is that, since the profit-maximizing b lies between 0 and $(H - L)/2$, the worker suffers more envy when output is high than when it is low. Hence, when envy becomes more important to the worker, it becomes more costly to induce the worker to strive for high output. A second effect arises from the participation constraint: an increase in the weight the worker places on envy makes the participation constraint more binding, requiring the employer to soften the effort requirement. A third effect arises from an increase in the base salary: envy induces the firm to increase the base salary, relaxing the participation constraint, and so enabling the employer to demand higher effort. The sum of these effects can be positive or negative, depending on the exact properties of the functions $u(\cdot)$, $v(\cdot)$, and $c(\cdot)$. Intuitively, increasing pay and softening the effort requirement are substitutes. The profitability of increasing pay and reducing effort depends on the properties of the utility function: when envy greatly increases the marginal benefit of a wage increase, effort may increase. For similar reasons, the weight on envy has an ambiguous effect on the base salary. When envy greatly increases the marginal cost of demanding effort, effort may be reduced so much that the employer reduces the base salary (see Appendix 7.2).

Proposition 3: The employer's profits decline with the weight on envy in the worker's utility function.

Profits are always lower when the worker is more envious. This result also holds when envy induces higher effort. The reason is that the firm must fully compensate the worker for the cost of his effort.

5 Applications

5.1 Stock options to lower-level workers

Whereas stock options can align the interests of CEOs and shareholders, it is harder to see why lower-level workers get stock options, as each individual worker's effort hardly affects the stock price. Yet, many firms offer stock options to non-executive workers (Hall and Murphy (2003) and Oyer and

Schaefer (2005)). Workers' envy of the manager's wealth can explain this. As we saw, when utility is convex in envy, the profit-maximizing compensation schedule is not flat, though effort is fully contractible. Instead it pays a high wage when output (and profit) is high and a low wage when output (and profit) is low. The employer balances the cost of risk to the worker with the worker's expected disutility from envy. These effects can make a profit-maximizing firm award stock options to workers even if an individual worker's effort hardly affects the stock price.

Workers' envy may also affect the optimal compensation of the CEO. A grant of stock options to the CEO increases the disutility of workers from envy, and so requires an increase in workers' wages. Similarly, when workers also envy the stockholders' wealth, but CEOs are wealthier than the average stockholder, stock options to the CEO may call for the firm to increase the wage of workers. Thus, workers' envy may weaken the stockholders' incentive to award stock options to the CEO.

5.2 For-profit versus non-profit organizations

In a privately-held firm, the firm's owner is the residual claimant of net profit. In contrast, in a governmental or non-profit organization the residual claimants are a large fraction of the public, with incomes typically lower than those of owners of firms. Envy is thus likely less important for workers outside for-profit firms.[7]

The absence of envy makes a worker willing to work for a lower wage at a governmental job, and so some production can be cheaper in the public sector than in the private sector. It also means that non-profit organizations will optimally set weaker incentives than will comparable for-profit organizations.

Empirical evidence indeed suggests that government workers face lower-powered incentives than do workers in the private sector. Burgess and Metcalfe (1999) find that British firms in the private sector use incentive wages more extensively than do firms in the public sector, even after controlling for occupation, union density, and work force composition. They conclude

[7]For the same reason, corporate taxes and progressive taxation may reduce workers' envious feelings in for-profit firms, as the worker's marginal product contributes less to the firm's net profits. Thus, corporate taxes and progressive taxes may increase the output of lower-level workers. See also Agell and Lundborg (1992) on how tax policies affect output and unemployment in a general equilibrium model where workers care about the functional distribution of income.

that incentives in the public sector are too weak. Our analysis shows that the low envy in the public sector may be an explanation. Kikeri and Nellis (2002) discuss several studies which find an increase in performance-based incentives for workers in privatized firms. Martin and Parker (1997) report similar evidence for several British firms.

Other evidence shows that governmental workers earn less. Borjas (2003) finds that public sector workers in the United States earn about 5 to 10 percent less than comparable workers in the private sector. Moreover, several studies in Britain find that wages at firms increased after privatization. (See Bishop and Kay (1988), Haskel and Szymanski (1993), and Parker and Martin (1996)). La Porta and Lopez-de-Silanes (1999) find the same for Mexico, and Brainerd (2002) for Russia.[8]

6 Conclusion

We examined the behavior of a worker who envies his employer, and characterized the employment contract that may result. We showed that even when effort is contractible, envy can make profit-sharing optimal. Our analysis also implies that profits decline with the worker's concern about envy.

One way of reducing envy is to hide the total amount of executive compensation (Bebchuk and Fried (2003)). Another way to reduce envy is to make other attributes of the manager's job appear unattractive to his subordinates. Requirements for credentials (such as an MBA degree) by managers, can make executive positions appear less attractive to some workers, and thus reduce their envy. The nasty and brutal campaigns that candidates for political office endure, and the continued scrutiny by the press, can make citizens little envy a governor or senator, and therefore more willing to work for him. The strenuous training of Officer Candidate School in the military can similarly make enlisted soldiers more willing to obey their officers. In short, many phenomena which appear to fit a signaling story which sorts different types

[8] The literature offers several other explanations for low-powered incentives in government: the absence of market discipline (Niskanen (1971), Hanushek (1996), Acemoglu, Kremer, and Mian (2003)), optimal design of governmental agencies to limit collusion and corruption (Crozier (1967), Tirole (1986), and Banerjee (1997)), problems arising from the multi-task, multi-principal nature of many government jobs (Dixit (2002)), and selection and motivation of workers with a public service motivation (Francois (2000), Delfgaauw and Dur (2004), Besley and Ghatak (2005)).

of people into different positions, may instead or in addition reduce envy of superiors.

Experimental studies indicate that people differ in their concern about fairness (see Fehr and Schmidt (2003) for an overview). Interesting extensions of our model would therefore allow workers to differ in their degrees of envy, and allow a worker's degree of envy to be private information. Suppose a worker is either an envious type or else a non-envious type, differing only in the weight on envy, γ, in the utility function. First consider the case where non-envious workers are available in abundant supply. Clearly, if the firm could observe workers' types, then the firm would hire only non-envious workers: as we saw in Proposition 3, the firm's profit declines with the weight on envy (γ) in a worker's utility function. When the firm cannot observe types, the firm will again hire only non-envious workers. The firm can do so by offering a contract that makes a non-envious worker (a worker with low γ) indifferent between working for the firm and enjoying his reservation utility; an envious worker (a worker with high γ) will then prefer not to accept the contract (see Lemma 1 and 2).

Consider next the case where the supply of non-envious workers is limited. A firm which finds production sufficiently valuable maximizes profits by hiring some envious workers in addition to all available non-envious workers. When types are observable, the firm conditions an employment contract on the worker's type. The contract for envious workers will have more profit-sharing and a higher base salary and/or a lower effort requirement than does the contract for non-envious workers (see the results in Section 4). These contracts extract all the rents from workers.

When the firm cannot observe workers' types, it may be unable to separate types while extracting all the surplus from workers. A non-envious worker may have an incentive to claim that he is an envious worker and opt for the more favorable contract. In response to this adverse selection problem, the firm may decide to hire only non-envious workers: it offers a single contract that makes a non-envious worker indifferent between working for the firm and taking his outside option. Hiring only non-envious workers reduces the firm's output, but also reduces the firm's wage costs, as non-envious workers can be offered a less favorable contract when the firm chooses to attract only non-envious workers. Alternatively, when production is sufficiently valuable, the firm may hire both types of workers by offering separating contracts: one contract makes envious workers indifferent about accepting the job, while the other contract makes non-envious workers indifferent between

the two contracts, and so induces truthful revelation of type.[9] When the firm offers these contracts, envious workers obtain their reservation utility, but non-envious workers are paid more than necessary to yield their reservation utility. By distorting the bonus and/or effort requirement in the contract for envious workers, the firm can save on the rents left to the non-envious workers, thus increasing profits. Presumably, these contract distortions allow for more profit-sharing in the contract for envious workers compared to the profit-maximizing contract in Section 4, since, by doing so, the contract intended for envious workers becomes less attractive for non-envious workers. A full characterization of optimal contracts in this environment is, however, left for future research.[10]

Though our analysis considered only envy of income, it can also incorporate simple forms of envy of effort. Suppose envy increases with the difference in income between the boss and the worker, and decreases with the difference in their efforts. Suppose further that the boss's effort is fixed. If envy is separable in the two differences just described, then the cost of effort function, $c(e)$, already incorporates envy arising from differences in effort.

Our reasoning can be extended from production to consumption.[11] Suppose a consumer envies the wealth of the sellers of goods. As Kahneman, Knetsch, and Thaler (1986) document, consumers may refuse to buy from firms profiteering from natural disasters. Similarly, Olmstead and Rhode (1985) tell the fascinating story of California oil companies in the 1920s. Standard Oil of California, the dominant firm and price-setter, refused to raise gasoline prices when the real price of light crude doubled. And during the 1979 gasoline crisis, large oil companies such as Exxon and Mobil posted lower prices for gasoline and heating oil than did small companies (Erfle, Pound, and Kalt (1981), Erfle and McMillan (1990)). In our terms, we can think of a consumer's utility as increasing with his consumer surplus, and decreasing with the seller's profits. If price equals marginal cost, the quantity a consumer buys does not affect the firm's profits. But the more price exceeds marginal cost, the higher the seller's profits from each additional unit. Envy

[9] See, for example, Laffont and Martimort (2002) for an analysis of separating contracts.

[10] Recent studies on adverse selection arising from heterogeneity in workers' preferences include Prendergast (2004) on bureaucrats' bias for or against clients, Delfgaauw and Dur (2005) on intrinsically motivated workers, and Von Siemens (2005) on fair-minded and selfish workers. The latter paper studies workers who care about the income of their colleagues rather than about the income of their boss.

[11] See Rotemberg (2003) for a related argument based on reciprocal behavior.

will then reduce demand. In addition, envy makes demand more elastic, inducing the seller to charge a lower price than he would in the absence of envy. And, in analogy with our analysis of production, an increase in the tax rate on profits will increase consumer demand.

7 Appendix

7.1 Second-order conditions

The second-order sufficient conditions for maximizing profits are:

$$\begin{vmatrix} 0 & g_e & g_a \\ g_e & Z_{ee} & Z_{ea} \\ g_a & Z_{ae} & Z_{aa} \end{vmatrix} > 0,$$

$$\begin{vmatrix} 0 & g_e & g_a & g_b \\ g_e & Z_{ee} & Z_{ea} & Z_{eb} \\ g_a & Z_{ae} & Z_{aa} & Z_{ab} \\ g_b & Z_{be} & Z_{ba} & Z_{bb} \end{vmatrix} < 0.$$

where:

$$\begin{aligned}
g_e &= u(a+b) - u(a) - c'(e) - \gamma\left[v\left(H-2a-2b\right) - v\left(L-2a\right)\right] \\
g_a &= eu'\left(a+b\right) + (1-e)u'\left(a\right) + 2\gamma\left[ev'\left(H-2a-2b\right) + (1-e)v'\left(L-2a\right)\right] \\
g_b &= eu'\left(a+b\right) + 2\gamma ev'\left(H-2a-2b\right) \\
Z_{ee} &= -\lambda c''(e) \\
Z_{ea} &= Z_{ae} = \lambda\left\{u'(a+b) - u'(a) + 2\gamma\left[v'\left(H-2a-2b\right) - v'\left(L-2a\right)\right]\right\} \\
Z_{eb} &= Z_{be} = -1 + \lambda\left[u'\left(a+b\right) + 2\gamma v'\left(H-2a-2b\right)\right] \\
Z_{aa} &= \lambda\left\{eu''(a+b) + (1-e)u''(a) - 4\gamma\left[ev''\left(H-2a-2b\right) + (1-e)v''\left(L-2a\right)\right]\right\} \\
Z_{ab} &= Z_{ba} = \lambda\left[eu''(a+b) - 4\gamma ev''\left(H-2a-2b\right)\right] \\
Z_{bb} &= \lambda\left[eu''(a+b) - 4\gamma ev''\left(H-2a-2b\right)\right]
\end{aligned}$$

Note that:

$g_e < 0$: Using the first-order condition $Z_e = H - b - L + \lambda g_e = 0$, we obtain $g_e = -\frac{H-b-L}{\lambda}$. Since $\lambda > 0$ (by the first-order condition $Z_a = 0$) and $0 < b < (H-L)/2$ (by the first-order conditions $Z_a = 0$ and $Z_b = 0$), we have $g_e < 0$.

$g_a > 0$: Since $u'(\cdot) > 0$ and $v'(\cdot) > 0$, it follows that $g_a > 0$.

$g_b > 0$: Since $u'(\cdot) > 0$, $v'(\cdot) > 0$, and $0 < e < 1$, it follows that $g_b > 0$.

$Z_{ee} < 0$: Because $\lambda > 0$ and $c''(\cdot) > 0$.

$Z_{ea} = Z_{ae} = 0$: The first-order conditions $Z_a = 0$ and $Z_b = 0$ together imply that the terms in curly brackets sum to zero. See also the Proof of Proposition 1.

$Z_{eb} = Z_{be} = 0$: By the first-order condition $Z_b = 0$, the terms sum to zero.

$Z_{aa} < 0$: All terms are negative since $u''(\cdot) < 0$ and $v''(\cdot) > 0$.

$Z_{ab} = Z_{ba} < 0$: All terms are negative since $u''(\cdot) < 0$, $v''(\cdot) > 0$, and $0 < e < 1$.

$Z_{bb} < 0$: All terms are negative since $u''(\cdot) < 0$, $v''(\cdot) > 0$, and $0 < e < 1$.

Note further that

$Z_{bb} = Z_{ab} = Z_{ba}$.

$eZ_{aa} = Z_{bb} = Z_{ab} = Z_{ba}$ using the assumptions that $u'''(\cdot) = 0$ and $v'''(\cdot) = 0$.

$eg_a = g_b$ using the first-order conditions $Z_a = 0$ and $Z_b = 0$.

$g_e = -g_a (H - b - L)$ using the first-order conditions $Z_e = 0$ and $Z_a = 0$.

Computing the determinants of the two matrices above, we can write the second-order conditions as

$$2g_e g_a Z_{ea} - g_e^2 Z_{aa} - g_a^2 Z_{ee} > 0,$$

$$2g_e g_a \left(Z_{ea} Z_{bb} - Z_{eb} Z_{ab}\right) + 2g_e g_b \left(Z_{eb} Z_{aa} - Z_{ea} Z_{ab}\right) + 2g_a g_b \left(Z_{ab} Z_{ee} - Z_{ea} Z_{eb}\right) + g_e^2 \left(Z_{ab}^2 - Z_{aa} Z_{bb}\right) + g_a^2 \left(Z_{eb}^2 - Z_{ee} Z_{bb}\right) + g_b^2 \left(Z_{ea}^2 - Z_{ee} Z_{aa}\right) < 0.$$

Since $Z_{ea} = 0$, $Z_{aa} < 0$, and $Z_{ee} < 0$, the second-order condition on the first line is always satisfied. Simplifying the second-order condition on the second line using $Z_{ea} = Z_{ae} = Z_{eb} = Z_{be} = 0$ gives

$$2g_a g_b Z_{ab} Z_{ee} + g_e^2 \left(Z_{ab}^2 - Z_{aa} Z_{bb}\right) - Z_{ee} \left(g_a^2 Z_{bb} + g_b^2 Z_{aa}\right) < 0.$$

From $Z_{bb} = Z_{ab}$ and $Z_{aa} < Z_{ab}$, it follows that the second term is always negative. Combining the first and third terms gives

$$Z_{ee} \left(2g_a g_b Z_{ab} - g_a^2 Z_{bb} - g_b^2 Z_{aa}\right).$$

Substituting eg_a for g_b and eZ_{aa} for Z_{bb} and Z_{ab} gives

$$Z_{ee} \left(2e^2 g_a^2 Z_{aa} - e g_a^2 Z_{aa} - \left(e g_a\right)^2 Z_{aa}\right) = -g_a^2 Z_{ee} Z_{aa} e \left(1 - e\right),$$

which is always smaller than zero. So both second-order sufficient conditions for maximizing profits are satisfied.

7.2 Comparative statics

Totally differentiating the first-order conditions $Z_e = 0$, $Z_a = 0$, $Z_b = 0$, $Z_\lambda = 0$ to e, a, b, λ, and γ gives:

$$\begin{aligned} deZ_{ee} + daZ_{ea} + dbZ_{eb} + d\lambda Z_{e\lambda} + d\gamma Z_{e\gamma} &= 0, \\ deZ_{ae} + daZ_{aa} + dbZ_{ab} + d\lambda Z_{a\lambda} + d\gamma Z_{a\gamma} &= 0, \\ deZ_{be} + daZ_{ba} + dbZ_{bb} + d\lambda Z_{b\lambda} + d\gamma Z_{b\gamma} &= 0, \\ deg_e + dag_a + dbg_b + d\lambda g_\lambda + d\gamma g_\gamma &= 0. \end{aligned}$$

In addition to the terms we already derived in Appendix 7.1 we have:

$$\begin{aligned} Z_{e\lambda} &= g_e < 0, \\ Z_{e\gamma} &= -\lambda\left[v(H-2a-2b) - v(L-2a)\right], \\ Z_{a\lambda} &= g_a > 0, \\ Z_{a\gamma} &= 2\lambda\left[ev'(H-2a-2b) + (1-e)v'(L-2a)\right], \\ Z_{b\lambda} &= g_b > 0, \\ Z_{b\gamma} &= 2\lambda e v'(H-2a-2b), \\ g_\lambda &= 0, \\ g_\gamma &= -\left[ev(H-2a-2b) + (1-e)v(L-2a)\right]. \end{aligned}$$

Note that:
$Z_{e\gamma} < 0$: Because $\lambda > 0$, $0 < b < (H-L)/2$, and $v'(\cdot) > 0$.
$Z_{a\gamma} > 0$: Because $v'(\cdot) > 0$ and $\lambda > 0$.
$Z_{b\gamma} > 0$: Because $v'(\cdot) > 0$, $\lambda > 0$, and $0 < e < 1$.
$g_\gamma < 0$: Both terms within brackets are positive.

Using $Z_{ea} = Z_{ae} = Z_{eb} = Z_{be} = g_\lambda = 0$, and $Z_{e\lambda} = g_e$, $Z_{a\lambda} = g_a$, and $Z_{b\lambda} = g_b$, we can simplify the differential equations:

$$\begin{aligned} deZ_{ee} + d\lambda g_e + d\gamma Z_{e\gamma} &= 0, \\ daZ_{aa} + dbZ_{ab} + d\lambda g_a + d\gamma Z_{a\gamma} &= 0, \\ daZ_{ba} + dbZ_{bb} + d\lambda g_b + d\gamma Z_{b\gamma} &= 0, \\ deg_e + dag_a + dbg_b + d\gamma g_\gamma &= 0. \end{aligned}$$

Solving the system of equations yields:

$$\begin{aligned}
\frac{de}{d\gamma} &= \frac{Z_{e\gamma}\left(2g_ag_bZ_{bb}-g_a^2Z_{bb}-g_b^2Z_{aa}\right)+g_e\left[\begin{array}{c} Z_{a\gamma}Z_{bb}\left(g_a-g_b\right)+Z_{b\gamma}\left(g_bZ_{aa}-g_aZ_{bb}\right) \\ +g_\gamma Z_{bb}\left(Z_{bb}-Z_{aa}\right)\end{array}\right]}{Z_{ee}\left(g_a^2Z_{bb}+g_b^2Z_{aa}-2g_ag_bZ_{bb}\right)+g_e^2Z_{bb}\left(Z_{aa}-Z_{bb}\right)} \\
\frac{da}{d\gamma} &= \frac{-Z_{a\gamma}\left(g_e^2Z_{bb}+g_b^2Z_{ee}\right)+\left(g_eZ_{e\gamma}-g_\gamma Z_{ee}\right)\left(g_a-g_b\right)Z_{bb}+Z_{b\gamma}\left(g_ag_bZ_{ee}+g_e^2Z_{bb}\right)}{Z_{ee}\left(g_a^2Z_{bb}+g_b^2Z_{aa}-2g_ag_bZ_{bb}\right)+g_e^2Z_{bb}\left(Z_{aa}-Z_{bb}\right)} \\
\frac{db}{d\gamma} &= \frac{-Z_{b\gamma}\left(g_e^2Z_{aa}+g_a^2Z_{ee}\right)+\left(g_eZ_{e\gamma}-g_\gamma Z_{ee}\right)\left(g_bZ_{aa}-g_aZ_{bb}\right)+Z_{a\gamma}\left(g_ag_bZ_{ee}+g_e^2Z_{bb}\right)}{Z_{ee}\left(g_a^2Z_{bb}+g_b^2Z_{aa}-2g_ag_bZ_{bb}\right)+g_e^2Z_{bb}\left(Z_{aa}-Z_{bb}\right)}
\end{aligned}$$

Substituting eg_a for g_b and eZ_{aa} for Z_{bb} and Z_{ab} gives:

$$\begin{aligned}
\frac{de}{d\gamma} &= \frac{Z_{e\gamma}g_a^2+g_eg_\gamma Z_{aa}-g_eg_aZ_{a\gamma}}{-\left(g_e^2Z_{aa}+g_a^2Z_{ee}\right)} \\
\frac{da}{d\gamma} &= \frac{Z_{a\gamma}g_e^2+g_ag_\gamma Z_{ee}-g_ag_eZ_{e\gamma}}{-\left(g_e^2Z_{aa}+g_a^2Z_{ee}\right)}-e\frac{Z_{b\gamma}-eZ_{a\gamma}}{-\left(1-e\right)eZ_{aa}} \\
\frac{db}{d\gamma} &= \frac{Z_{b\gamma}-eZ_{a\gamma}}{-\left(1-e\right)eZ_{aa}}
\end{aligned}$$

Note that all the denominators are positive.

Proof of Proposition 2:

To evaluate $\frac{db}{d\gamma}$, we use the expressions for $Z_{b\gamma}$ and $Z_{a\gamma}$, the result that $0<b<(H-L)/2$, and the assumption $v''(\cdot)>0$, to sign the numerator:

$$Z_{b\gamma}-eZ_{a\gamma}=2\lambda e(1-e)\left[v'(H-2a-2b)-v'(L-2a)\right]>0.$$

Since the denominator is also positive, increased weight on envy increases the bonus.

Effect of envy on effort and on the base salary in the profit-maximizing contract

Consider how effort varies with the weight on envy, or consider $\frac{de}{d\gamma}$. The first and second terms in the numerator are negative. The third term in the numerator is positive. Substituting the expressions derived above, it follows that the sum of the terms has indeterminate sign, depending on the exact properties of the functions $u(\cdot)$, $v(\cdot)$, and $c(\cdot)$. Likewise, consider how base pay varies with the weight on envy, $\frac{da}{d\gamma}$. Note that the second term equals $-e\frac{db}{d\gamma}$. That is, the bonus pay, which the worker receives with probability e, is deducted from the base salary a. The numerator of the first term consists

of three effects, which work in different directions. The first two terms are positive, the third is negative. The sum of the terms has indeterminate sign. Thus, an increase in the weight the worker places on envy may raise or lower the base salary.

Proof of Proposition 3:

Recall that the firm's profits are $\Pi \equiv e(H-b)+(1-e)L-a$. Then

$$\frac{d\Pi}{d\gamma} = \frac{de}{d\gamma}(H-b-L) - e\frac{db}{d\gamma} - \frac{da}{d\gamma}.$$

Substituting our results for $\frac{de}{d\gamma}$, $\frac{da}{d\gamma}$, $\frac{db}{d\gamma}$, and using $g_e = -g_a(H-b-L)$ yields

$$\frac{d\Pi}{d\gamma} = \frac{g_\gamma}{g_a} < 0.$$

Thus, envy reduces the firm's profits.

8 Notation

a Base pay

b Bonus pay for high output

$c(e)$ Worker's cost of effort

e Effort, which equals probability output is high

H Firm's revenue when production is high

L Firm's revenue when production is low

$u(\cdot)$ Worker's utility from income

U Worker's utility

$\overline{U}$ Worker's reservation utility

$v(\cdot)$ Worker's disutility from envy

w Worker's wage

x Difference in income between the employer and the worker

γ Weight on envy in the worker's utility function

λ Lagrange multiplier on the participation constraint

Π Profits

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