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Abstract

In this paper, we examine the behavior of the agent who envies his principal's wealth, and characterize the properties of the optimal incentive scheme under adverse selection. Under restrictive envy conditions, contracting structures often differ from those predicted by standard solutions of canonical adverse selection problem .

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*This is very preliminary and incomplete. Comments are very welcome.

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1 Introduction

It is standard in economic analysis to assume that people maximizes their utility. This selfish analysis has been focused on the theory of contract with private information, but yet does not fully analyze the problem of the presence of concerning envy or other-regarding. We often think that worker who envies his employer's wealth and we found that such feeling may reduce or increase the worker's output or effort because of worrying about unfair distribution of wealth.

Recent researches assume that individual behavior is not only guided by payoff-equalizing motivations but also by concerns for overall welfare (Fehr and Schmidt (1999), Bolton and Ockenfels (2000)). The theoretical works introducing inequity aversion into moral hazard problem were conducted by Bartling and Siemens (2004), Biel (2003), Englmaier and Wambach (2002), Grund and Sliwka (2002), Itoh (2004), Neilson and Stowe (2004), among others, and into adverse selection problem were conducted by Sappington (2004), Siemens (2004). While these papers introducing inequity aversion show important effects of horizontal (agents compare their welfare among themselves) or vertical comparison (agents compare their welfare to their principal's), in the most of inequity with asymmetric information, they consider the case of contracting that inequity aversion matters whether people value high status or suffer from it.

This paper considers agent's (worker's) envy towards his principal (employer) of wealth under the framework of the adverse selection. In contrast to those papers, we ignore envy towards co-workers and instead analyze envy of the principal. In this point of view, Englmaier and Wambach (2002) analyze that optimal incentive contracts for agents who dislike inequality, whereas the principal is assumed to be selfish. They concentrate on determining whether the incentive contract is linear in output. More closely related to our analysis is Dur and Glazer (2003). They study a relationship of a principal with one agent who envies his principal's wealth, and show that envy amplifies the effect of incentives on effort, increases optimal pay and envy makes profit-sharing optimal. In contrast to our model, they analyzed the moral hazard model. Furthermore, they assume that exogenously that the output levels are given and employer could enjoy higher profits the less envious are workers. Instead, we introduce that the principal and the agent can contract at the interim stage with adverse selection framework, i.e., after the agent learns about his type. Thus we shall focus on the implications of envy for agents' outputs and for each agent's wage since we assume two possible types of agents with adverse selection model.

However, to cover broader cases of envy preferences, we follow Dur and Glazer (2003)'s theory of envy to extend our model by allowing the framework for adverse selection. In order to apply their theory, we assume that (i) agent envies the principal's profits or envy depends on relative income rather than principal's profits, and (ii) we distinguish between special and general envy. Specific envy arises when the agent contributes to his principal's wealth. Alternatively, the agent may envy the principal regardless of whether he works for him; general envy.

We differ from the papers of Dur and Glazer (2003), Englmaier and Wambach (2002) in two ways. First, we show that optimal outputs of agents are focused by how determining whether first-best or inefficient solutions. Second, for the saving of an efficient type's information rent how each agent's wage varies, and therefore different implications for wages contract the principal will offer.

The paper is organized as follows. Section 2 presents the model of adverse selection in presence of concern with envy. In Section 3 analyzes the optimal incentive contract. Section 4 discusses a brief conclusion.

2 A Basic Model

Consider a risk-neutral principal facing a risk-neutral agent and the principal wants to delegate to an agent the production of x units of a good. The principal is assumed throughout to be selfish while the agent has envy toward his principal. The value for the principal of these x units is $S(x)$ where $S^{'}(x) > 0, S^{''}(x) < 0$ and $S(0) = 0$. The value of these goods to the principal is represented by a strictly increasing, strictly concave function $S(x)$. To ensure that some production will take place in every type, we assume that $S^{'}(0) = \infty$, and to ensure that production is always finite, we assume that $\lim_{x \to +\infty} S^{'}(x) = 0$.

The production cost of the agent is unobservable to the principal, but it is common knowledge that there two types of agents, $T = \{\theta_0, \theta_1\}$ with $0 < \theta_0 < \theta_1$. The agents of type θ_0 are called efficient whereas agents of type θ_1 are called inefficient. In other words, each agent can produce goods x with type dependent cost function $C(x, \theta_0) = \theta_0 x$, where θ_0 occurs with probability ν or $C(x, \theta_1) = \theta_1 x$, where θ_1 occurs with probability $1 - \nu$. The economic variables of an employed agent's relationship with the principal we consider are the quantity produced x and the wage w received by the agent.

The timing in the model is as follows. At the beginning of period 1 each agent's type is assumed to be private information and thus only known to him. The principal proposes a menu of contract $\{(w_0, x_0), (w_1, x_1)\}$: If θ_0 (resp. θ_1), the principal offers the wage w_0 (resp. w_1) for the production x_0 (resp. x_1). After observing the terms of the contract, the agent either accepts or rejects the contract. In the latter case the game ends. If the agent accepts the contract, then he chooses the action that he prefers according to the terms of contract. In next period, agent works and the principal receives profit.

Following Dur and Glazer (2003), we assume that agents who are never richer than their principals and analyze the consequences of two different assumptions about how envy affects the agent's participation constraint under adverse selection framework. The agent's income, cost, and envy are separable in the utility function:

$$U_i = w_i - \theta_i x_i - \alpha\chi, i = 0, 1$$

where agent's concern for inequity represents envious feelings, with α the weight on envy in the agent's utility function[1]. The simplest assumption about the object of envy is that the agent's utility declines with his principal's profits ($\chi = S(x_i) - w_i$) which an agent envies an principal only if the agent personally contributes to his principal's wealth. Following Dur and Glazer (2003), we shall call this specific envy. We shall see that such specific envy always makes behavior differ from what it would be in the absence of envy.

On the other hand, we model envy as increasing with the difference in income between the principal and agent: Let the contract must be guarantee agent's reservation utility, taken here to be zero when choosing the outside opportunity. When envy increases with the difference in income ($\chi = S(x_i) - w_i - w_i$), and the wage at the firm can differ from income ($\hat{\chi} = S(x_i) - w_i - 0$) under outside option, an agent's disutility from envy may differ inside and outside the for-profit firm. This alternate assumption is that an agent envies the principal in question regardless of whether or not he works for him.

3 Results

3.1 Agent Envies Principal's Profits

Due to θ only taking two values, the difference $\theta_1 - \theta_0$ is denoted $\Delta\theta$ in below all section. Suppose that envy depends on the principal's profits. Given that envy depends on profit, each agent's utility function is $w_i - \theta_i x_i - \alpha\chi$. Then the envy-free utility when choosing the outside option is zero and the participation constraint is

$$w_i - \theta_i x_i - \alpha\chi \geq 0 \tag{1}$$

with specific envy. Furthermore, let an agent's envy when outside the firm be $\alpha\hat{\chi}$. The participation constraint is then

$$w_i - \theta_i x_i - \alpha\chi \geq -\alpha\hat{\chi} \tag{2}$$

with general envy. When agents are homogeneous, each agent realizes that, in equilibrium, the principal's profits do not depend on which person is hired. Hence, when envy depends on profits ($\chi = S(x_i) - w_i$), the value of χ equals the value of $\hat{\chi}$.

For future reference, we write the agent's participation constraint as

$$w_i - \theta_i x_i - \alpha\chi \geq -\alpha(1 - \beta)\hat{\chi} \tag{3}$$

[1]All our results are hold for a richer model, too, where the agent compares his net payoff ($w_i - \theta_i x_i$) with the principal's profits or incomes. But in order to keep exposition as simple as possible we omit. And the degree of envy here is linear rather than assumption of convexity for the simplicity and closed-form solution.

where $\beta = 0$ for general envy (that is, when envy arises even when another agent takes the job) and $\beta = 1$ for specific envy[2].

After the agent discovers his type, each agent interim participation constraints is written as

$$w_0 - \theta_0 x_0 - \alpha[S(x_0) - w_0] \geq -(1-\beta)\alpha[S(x_0) - w_0] \tag{PC_0}$$
$$w_1 - \theta_1 x_1 - \alpha[S(x_1) - w_1] \geq -(1-\beta)\alpha[S(x_1) - w_1] \tag{PC_1}$$

where (PC_0) and (PC_1) are efficient and inefficient agent's participation constraints that the contract must be guarantee agents' reservation utilities, respectively. Note that given the envy depends on profits, the value of χ equals $\hat{\chi}$ when agent envies principal's profits. Note also that there is a correlation among participation constraints of each type, but since the outside option does not provide a level of utility to the efficient agent that is high enough, it does not affect the optimal contract solution[3].

The principal wants to maximize expected profit

$$\max_{w_0,w_1,x_0,x_1} \nu[S(x_0) - w_0] + (1-\nu)[S(x_1) - w_1] \tag{$\mathbf{P}$}$$
$$\text{subject to } (\mathrm{PC}_0), (\mathrm{PC}_1) \text{ and}$$
$$w_0 - \theta_0 x_0 - \alpha[S(x_0) - w_0] \geq w_1 - \theta_0 x_1 - \alpha[S(x_1) - w_1] \tag{IC_0}$$
$$w_1 - \theta_1 x_1 - \alpha[S(x_1) - w_1] \geq w_0 - \theta_1 x_0 - \alpha[S(x_0) - w_0], \tag{IC_1}$$

where the incentive compatibility constraint (IC_0) ensures that the efficient agent will not gain by announcing θ_1 and the incentive compatibility constraint (IC_1) is that the inefficient agent truthfully reports his private information, but as is usual in adverse selection problems, this constraint is not binding, we can omit it[4]. By the definition of general and specific envy, note that it does not matter whether envy is general or specific at the moment the agent chooses the action.

Hence the optimal solution is obtained by maximizing the program. It is characterized as follows:

Proposition 1: *Suppose that agent is envious the principal's profits. The optimal menu of contracts entails:*
(i) No upward output distortion for the efficient type with respect to the first best, $S^{'}(x_0) = \theta_0$. A downward output distortion for the inefficient type,

$$S^{'}(x_1) = \frac{\theta_1(1+\alpha) - \nu\theta_0}{1+\alpha-\nu} \qquad \text{if } \beta = 0 \tag{4}$$

[2]We study the polar cases of specific envy and general envy, by letting β equal 1 or 0; a more general analysis would let it take intermediate values.

[3]See below that the efficient agent transfer payments in proposition 1 and 2 are always larger than the outside options. Thus we can exclude the case of countervailing incentives (Lewis and Sappington, 1989).

[4]See the proof of proposition 1 in this model.

with general envy, and

$$S^{'}(x_1) = \theta_1 + \frac{\nu}{1-\nu}\Delta\theta \qquad\qquad \textit{if } \beta = 1 \tag{5}$$

with specific envy.
(ii) When $\beta = 0$, only the efficient type receives a positive information rent and transfer given by

$$w_0 = \theta_0 x_0 + \Delta\theta x_1 + \alpha[S(x_0) - w_0 - (S(x_1) - w_1)] \tag{6}$$

the inefficient type gets $w_1 = \theta_1 x_1$. When $\beta = 1$, the efficient type receives a positive information rent and transfer given by

$$w_0 = \theta_0 x_0 + \Delta\theta x_1 + \alpha[S(x_0) - w_0], \tag{7}$$

the inefficient type gets also a positive transfer given by

$$w_1 = \theta_1 x_1 + \alpha[S(x_1) - w_1] \tag{8}$$

Proof: To solve for the maximization of **P** under PC$_i$ and IC$_i$, we observe that PC$_1$ and IC$_0$ imply PC$_0$, and we momentarily ignore IC$_1$. We will check later that it is satisfied by the solution obtained. We therefore left two constraints, PC$_1$ and IC$_0$. We can now substitute for the information rent and write the Lagrangian of the principal's program

$$\begin{aligned} L = {} & \nu[S(x_0) - w_0] + (1-\nu)[S(x_1) - w_1] \\ & + \lambda[w_0 - \theta_0 x_0 - \alpha(S(x_0) - w_0) - w_1 + \theta_0 x_1 + \alpha(S(x_1) - w_1)] \\ & + \pi[w_1 - \theta_1 x_1 - \alpha\beta(S(x_1) - w_1)], \end{aligned}$$

where λ is the multiplier of (IC$_0$) and π is the multiplier of (PC$_1$).

The first-order conditions of this program can be expressed respectively as

$$\frac{\partial L}{\partial w_0} = -\nu + \lambda + \lambda\alpha = 0 \tag{A-1}$$

$$\frac{\partial L}{\partial w_1} = -(1-\nu) - \lambda - \lambda\alpha + \pi + \pi\alpha\beta = 0 \tag{A-2}$$

$$\frac{\partial L}{\partial x_0} = \nu S^{'}(x_0) - \lambda\theta_0 - \lambda\alpha S^{'}(x_0) = 0 \tag{A-3}$$

$$\frac{\partial L}{\partial x_1} = (1-\nu)S^{'}(x_1) + \lambda\theta_0 + \lambda\alpha S^{'}(x_1) - \pi\theta_1 - \pi\alpha\beta S^{'}(x_1) = 0 \tag{A-4}$$

Summing A-1 and A-2, we obtain

$$\pi(1 + \alpha\beta) = 1 \tag{A-5}$$

and thus $\pi > 0$. Using A-5 and inserting it into A-1 yields

$$\lambda = \frac{\nu}{1+\alpha} > 0 \tag{A-6}$$

Therefore binding IC_0 implies IC_1.

Simplifying by using A-6 yields respectively

$$\begin{aligned} S^{'}(x_0) &= \theta_0 \quad \text{and} \\ S^{'}(x_1) &= \frac{\theta_1(1+\alpha) - \nu\theta_0(1+\alpha\beta)}{1+\alpha-\nu(1+\alpha\beta)}. \end{aligned} \tag{A-7}$$

Thus, A-7 yields (4) and (5) in the proposition 1, respectively.

Finally, in order to show $x_0 > x_1$, it is sufficient to show that $S^{'}(x_1) > S^{'}(x_0)$. By comparing the optimal output levels given by (4) and (5), we can easily check. Q.E.D.

Proposition 1 means that the first-best output ($S^{'}(x_0) = S^{'}(x_0^{FB}) = \theta_0$) can be still achieved by making the agent residual claimant for the principal's profit even though agent has envy toward principal. Note also that the contract, that makes the agent residual claimant for the principal's profit ensure the pure adverse selection outputs even though the agent has specific envy toward principal's profit. A comparison of the results obtained with specific and general envy shows that envy toward the principal's profit influences either wage or output. Note that Eq. (4) indicates that x_1 with general envy will be chosen at a level below that of the pure adverse selection problem.

In the case of general envy, if $S(x_0) - w_0 - (S(x_1) - w_1) > 0$, the efficient agent must not only get an information rent but he must also receive some residual claimant for the principal's profit to make him reveal his type truthfully. However, the efficient agent's information rent in this model is smaller than without envy (e.g. standard solution of adverse selection) and he receives profit-sharing of the principal. Thus agent's envy toward principal's profits influences the efficient type's wage w_0. With general envy, (6) shows getting a larger utility than the inefficient agent. Therefore, since the principal want to lower the information rent, the cause which is going to lessen the inefficient type's output x_1 will work and his output will become lower than his first-best of output. Consequently, saving of the efficient agent of wages w_0 is attained. Last term in profit sharing (6) also provides some insights about the optimal speed of profit sharing, namely the residual claimant. By reducing x_1, this speed is decreasing function of the $S(x_1) - w_1$ because of the assumption made on $S(\cdot)$. Thus, general envy becomes a substitute for high powered incentives shifting output upwards toward the first-best.

If envy is specific, then envy is only useful in giving the incentive transfer, but it has no impact on production. Like analysis of general envy, the principal will lower x_1, in order to lower the efficient agent's information rent. Instead, since there is existence of special envy, the principal must remunerate in some profits, and inefficient type's income exceeds his cost which plus the residual claimant of the principal's inefficient profit. The inefficient type's output is still equal to the distorted second-best output of pure adverse selection.

Finally, optimal wages are more than in the absence of envy ($\alpha = 0$), which we immediately get the result of comparison as corollary.

Corollary: *Suppose that the agent has envy toward the principal's profits. Then the principal's profit when the agent has specific envy is always smaller than that when agent has no envy.*

Contrary to standard adverse selection framework, the result of corollary is due to the fact that there is not only the distribution impact under the specific envy which is still equal to optimal outputs of standard adverse selection but also outputs distortion which each type must be given more incentive to envy the principal's profit.

We can explain the corollary follow: It turns out that principal's profit is decreasing at two points compared with the expected profit in the first-best solution. First, the output of type θ_1 is inefficient. Second, the information rent must be given to the efficient type. Consequently, since the inefficient type's output in general envy is less than the inefficient type's output in special envy, the wages with general envy become high. When general envy turns into specific envy as β increase, increasing the inefficient agent's output by an infinitesimal amount $d\beta$ increases allocative efficiency. We call the changes *allocation effect*. But as inefficient agent's output increases, both efficient and inefficient agent's compensations, w_0, w_1 must be increased for the standard outputs of adverse selection, which we call the *distribution effect*. Thus we obtain the results,

Proposition 2: *Optimal solutions in proposition 1 express the important complementary between the allocation and distribution effect which the agent has the envy toward principal's profits.*

The intuition lies with the proposition 2 that the cost of profit-sharing when $\beta = 1$ is larger risk borne by the agent than that by the agent when $\beta = 0$. The optimal contract does not trade off this cost and the outputs.

3.2 Envy Depends on Relative Income

Suppose now that the agent's envy increases with the difference in income between the principal and the agent. Again, we shall analyze that envy always makes behavior differ from what it would be in the absence of envy. To avoid repetition of arguments, we focus our discussion on the implications of letting envy depend on relative incomes rather than only on profits.

Given that the envy depends on relative income ($\chi = S(x_i) - w_i - w_i$), each agent's disutility function is defined $-\alpha(1-\beta)\hat{\chi}$ in envying the principal's incomes. After the agent discovers his type, each agent's interim participation constraints is given by

$$w_0 - \theta_0 x_0 - \alpha[S(x_0) - 2w_0] \geq -\alpha(1-\beta)[S(x_0) - w_0] \qquad (\mathrm{PC}_0^{\mathrm{r}})$$
$$w_1 - \theta_1 x_1 - \alpha[S(x_1) - 2w_1] \geq -\alpha(1-\beta)[S(x_1) - w_1] \qquad (\mathrm{PC}_1^{\mathrm{r}})$$

where $(\mathrm{PC}_0^{\mathrm{r}})$ and $(\mathrm{PC}_1^{\mathrm{r}})$ are efficient and inefficient agent's participation constraints that the contract must be guarantee agents' reservation utilities, respectively. Note that given the envy depends on relative incomes, the value of χ differs from that $\hat{\chi}$ when agent envies principal's relative income.

We thus led to optimize a reduced-form problem, which is written as

$$\max_{w_0, w_1, x_0, x_1} \nu[S(x_0) - w_0] + (1-\nu)[S(x_1) - w_1] \qquad \mathbf{Pr}$$
$$\text{subject to } (\mathrm{PC}_0^{\mathrm{r}}), (\mathrm{PC}_1^{\mathrm{r}}) \text{ and}$$
$$w_0 - \theta_0 x_0 - \alpha[S(x_0) - 2w_0] \geq w_1 - \theta_0 x_1 - \alpha[S(x_1) - 2w_1] \qquad (\mathrm{IC}_0^{\mathrm{r}})$$
$$w_1 - \theta_1 x_1 - \alpha[S(x_1) - 2w_1] \geq w_0 - \theta_1 x_0 - \alpha[S(x_0) - 2w_0] \qquad (\mathrm{IC}_1^{\mathrm{r}})$$

where the incentive compatibility constraint $(\mathrm{IC}_0^{\mathrm{r}})$ ensures that the efficient agent will not gain by announcing θ_1 and the incentive compatibility constraint $(\mathrm{IC}_1^{\mathrm{r}})$ is that the inefficient agent truthfully reports his private information when envy depends on relative incomes.

The optimal solution is obtained by maximizing the program. It is characterized as follows:

Proposition 3: *Suppose that agent is envious the principal's relative incomes. The optimal menu of contracts entails:*
(i) An upward output distortion for the efficient type with respect to the first best, $x_0 > x_0^{FB}$

$$S'(x_0) = \frac{1}{1+\alpha}\theta_0, \qquad (9)$$

and a downward output distortion for the inefficient type,

$$S'(x_1) = \frac{\theta_1 - \nu\theta_0}{1 - \nu(1+\alpha)} \qquad \text{if } \beta = 1 \qquad (10)$$

with specific envy, and

$$S'(x_1) = \frac{\theta_1(1+2\alpha) - \nu\theta_0(1+\alpha)}{(1+\alpha)[1+2\alpha-\nu(1+\alpha)]} \qquad \text{if } \beta = 0 \qquad (11)$$

with general envy.
(ii) When $\beta = 1$*, the efficient type receives a positive information rent and transfer given by*

$$w_0 = \theta_0 x_0 + \Delta\theta x_1 + \alpha[S(x_0) - 2w_0] \qquad (12)$$

the inefficient type gets also a positive transfer given by

$$w_1 = \theta_1 x_1 + \alpha[S(x_1) - 2w_1] \tag{13}$$

When $\beta = 0$, the efficient type receives a positive transfer given by

$$w_0 = \theta_0 x_0 + \alpha[S(x_0) - 2w_0 - (S(x_1) - w_1)] \tag{14}$$

the inefficient type gets a positive transfer

$$w_1 = \frac{\theta_1 x_1}{1+\alpha}. \tag{15}$$

Proof: See Appendix.

Proposition 3 states that optimizing with respect to outputs yields an upward distortion characterized in efficient type, $x_0 > x_0^{FB}$ when envy depends on relative incomes. As α becomes greater, the efficient type's output is larger than the first-best level of output. In the case of specific envy, when α continues to increase, the inefficient type is not attracted by the allocation given to the efficient type as long as $\mathrm{PC}_1^{\mathrm{r}}$ is binding and $\mathrm{IC}_1^{\mathrm{r}}$ remains non-binding. Since the agent has envy in the income of the principal, the efficient agent's wage may be lower than wages in case the agent has envy in the profits of the principal. Then, he want to make his output high and maintain a wage level. On the other hand, in order that principal want to lower the efficient agent's information rent, there is an incentive which is going to lower the level of x_1. Due to the fact that the efficient agent's output is larger than the first-best level, the inefficient type's output tends to be lowered further and it is going to save the information rent. Consequently, each production in the case agents have specific envy to relative incomes is attained. As for the efficient type's output, specific envy tightens inefficient type's participation constraint, the inefficient agent must not only get second-best transfer with envy but he must also receive some residual claimant for the principal's inefficient type's income in order that the principal must guarantee the inefficient agent's participation. With specific envy, we have $x_1 < x_1^{SB}$, where x_1^{SB} is defined in canonical output of adverse selection problem. As a result, specific envy now has a distribution and an allocative impact.

With general envy, the inefficient transfer is decreasing in α even though there is more inefficient type's output than that of specific envy. Since the efficient agent will have attained more than the first-best output, it is more desirable to have made $S(x_1)$ high and to make w_1 low, in order that the principal lower w_0 in the case of general envy. And since efficient type's output is larger than the first-best, it is desirable for his output to become small in the point of view of the principal. On the other hand, there exists a cutoff level $\hat{\alpha}$ so that, for all $\alpha > \hat{\alpha}$,

$$\frac{t_0}{t_1} < \frac{1+\alpha(2-\nu)}{\nu(1+\alpha)(2-\nu)} \Longleftrightarrow S^{'}(x_1) < S^{'}(x_1^{SB}) \Longleftrightarrow x_1 > x_1^{SB} \tag{16}$$

where x_1^{SB} is standard inefficient output of adverse selection and otherwise $x_1 < x_1^{SB}$ for all $\alpha < \hat{\alpha}$. For $\alpha > \hat{\alpha}$, the inefficient agent's wage w_1 increases, so that α becomes large. Consequently, when $\alpha > \hat{\alpha}$, then the efficient agent's output approaches above the value of first-best and his wage continues to increase. Because of the assumption made on $S^{'}(x) > 0, S^{''}(x) < 0$, it is clear that increasing $S(x_1)$ attains higher w_1 which make w_0 increase. However, when the value of $\alpha < \hat{\alpha}$, the inefficient agent's output is decrease such as $x_1 < x_1^{SB}$. As for this, the efficient agent's output approaches the value of first-best, so that α becomes small. Given that α is decreasing with $S(x_1)$, it is clear that the inefficient agent's wages decreases. Consequently, when $\alpha < \hat{\alpha}$, the efficient agent's output approaches the value of first-best, but his wage falls. This provides the following proposition.

Proposition 4: *Suppose that agent is envious the principal's incomes and $\beta = 0$. The agents' wages are increasing in α if and only if $\alpha > \hat{\alpha}$ and otherwise their wages are decreasing in α.*

Contrary to results of the proposition 2, when general envy turns into specific envy as β increases, decreasing the inefficient agent's output by an infinitesimal amount $d\beta$ reduces the allocative efficiency. Let us denote the wage when $\beta = j$ as $w_i^j, j = 0, 1$ and output as x_i^j. The agent's expected payoff is also decreased if wages w_i^0 is larger than w_i^1. That is

$$\begin{aligned} \alpha[S(x_1^0) - w_1^0] &> \Delta\theta x_1^1 \Longleftrightarrow w_1^0 > w_1^1 \\ \alpha[S(x_1^0) - 2w_1^1] &> \frac{\theta_1[x_1^1(1+\alpha) - x_1^0]}{1+\alpha} \Longleftrightarrow w_0^0 > w_0^1 \end{aligned} \tag{17}$$

where Eq. (17) means that wages of the efficient type decrease if the disutility of general envy exceeds an efficient agent's information rent, and wage of inefficient type also decreases if the disutility at the time of special envy is larger than the difference of production cost in the case of an inefficient agent. Otherwise wages increase and as long as general envy turns into specific envy as β increases reducing agents' outputs. Summarizing above the general envy's explanations yields the following result.

Lemma : *Suppose that agent is envious the principal's incomes. As general envy turns to specific envy, outputs are decreasing in wages if and only if (17) is satisfied and otherwise decreasing outputs makes wages induce high. Thus when (17) is violated, the principal has an incentive to produce quantities between more reduced below the second-best for the inefficient type and above the first best for the efficient type if and only if $\alpha < \hat{\alpha}$.*

When agent's envy depends on relative income, a reduction in the inefficient output increases the efficient wage if and only if $\alpha < \hat{\alpha}$. Therefore we know that when $\beta = 0$ and agent's envy depends on relative income, the allocation effect dominates the distribution effect when $\alpha > \hat{\alpha}$ and otherwise when $\alpha < \hat{\alpha}$. And when $\beta = 1$ and agent's envy depends on relative income, specific envy now has a distribution and an allocative effect. Thus when $\alpha > \hat{\alpha}$, proposition 4 and lemma express the important *trade-off* between allocation and distribution effect which the agent has the envy toward principal's incomes.

4 Concluding Remarks

We have found that first-best output can be still achieved by making the agent residual claimant for the principal's profit even though agent has envy toward principal. However, when the agent has envy toward the principal's incomes, first-best output can not be obtained. Thus comparison of the results obtained with specific and general envy shows that envy toward the principal's profit/incomes influences either wage or output.

Finally we discuss the assumptions taken with respect to the agent's reference groups. Suppose that unemployed agents compare themselves with principal's profits. In this case each unemployed agent's utility depends on that another agent takes the job. As before, outside option is thus endogenous, and the principal take account for this. For the principal's point of view, he provides information rent and residual claimant for the efficient type, maintaining the inefficient type's transfer still equals to his cost. However, if the agent has envy toward income of the principal, maintaining a residual claimant with efficient type, the inefficient agent's wage varies according to the extent of the quantity of production and the degree of envy.

Due to introducing concerns with envy into adverse selection, the optimal incentive contract structures often differ from those predicted by standard solutions canonical adverse selection problem. The precise details of optimal contract structure in the presence of aversion to envy or inequity await future research. The extent to which introducing dynamic relationship without commitment will alter results could be explored.

Appendix

To solve for the maximization of **Pr** under $\mathrm{PC}_i^{\mathrm{r}}$ and $\mathrm{IC}_i^{\mathrm{r}}$, we observe that $\mathrm{PC}_1^{\mathrm{r}}$ and $\mathrm{IC}_0^{\mathrm{r}}$ imply $\mathrm{PC}_0^{\mathrm{r}}$, and we momentarily ignore $\mathrm{IC}_1^{\mathrm{r}}$. We will check later that it is satisfied by the solution obtained. We therefore left two constraints, $\mathrm{PC}_1^{\mathrm{r}}$ and $\mathrm{IC}_0^{\mathrm{r}}$. Lagrangian of the principal's program

$$
\begin{aligned}
L = \nu[S(x_0) - w_0] + (1-\nu)[S(x_1) - w_1] \\
+\lambda[w_0 - \theta_0 x_0 - \alpha(S(x_0) - 2w_0) - w_1 + \theta_0 x_1 + \alpha(S(x_1) - 2w_1)] \\
+\pi[w_1 - \theta_1 x_1 - \alpha(S(x_1) - 2w_1) + \alpha(1-\beta)(S(x_1) - w_1)],
\end{aligned}
$$

where λ is the multiplier of $(\mathrm{IC}_0^{\mathrm{r}})$ and π is the multiplier of $(\mathrm{PC}_1^{\mathrm{r}})$.

The first-order conditions of this program can be expressed respectively as

$$\frac{\partial L}{\partial w_0} = -\nu + \lambda + 2\lambda\alpha = 0 \tag{A-8}$$

$$\frac{\partial L}{\partial w_1} = -(1-\nu) - \lambda - 2\lambda\alpha + \pi + 2\pi\alpha - \pi\alpha(1-\beta) = 0 \tag{A-9}$$

$$\frac{\partial L}{\partial x_0} = \nu S^{'}(x_0) - \lambda\theta_0 - \lambda\alpha S^{'}(x_0) = 0 \tag{A-10}$$

$$\frac{\partial L}{\partial x_1} = (1-\nu)S^{'}(x_1) + \lambda\theta_0 + \lambda\alpha S^{'}(x_1) - \pi\theta_1 - \pi\alpha S^{'}(x_1) + \pi\alpha(1-\beta)S^{'}(x_1) = 0 \tag{A-11}$$

Summing A-8 and A-9, we obtain

$$\pi(1+\alpha+\alpha\beta) = 1 \tag{A-12}$$

and thus $\pi > 0$. Using A-12 and inserting it into A-8 yields

$$\lambda = \frac{\nu}{1+2\alpha} > 0 \tag{A-13}$$

Therefore binding $\mathrm{IC}_0^{\mathrm{r}}$ implies $\mathrm{IC}_1^{\mathrm{r}}$.

Simplifying by using A-13 yields

$$S^{'}(x_0) = \frac{1}{1+\alpha}\theta_0 \tag{A-14}$$

$$S^{'}(x_1) = \frac{\theta_1(1+2\alpha) - \nu\theta_0(1+\alpha+\alpha\beta)}{(1+\alpha-\nu)(1+2\alpha) - \alpha[\alpha\nu(1+\beta) + 2\alpha\beta + \beta(1+\nu)]} \tag{A-15}$$

Thus, A-14 and A-15 yield (9), (10) and (11) in the proposition 3, respectively. Q.E.D.

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