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Peer Pressure with Inequity Aversion*

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To examine the effects of peer pressure on outputs under symmetric and asymmetric information, we define a peer pressure function representing psychological costs and incorporate it into the agent's utility function. Under symmetric information, an efficient agent who is averse to inequity (i.e., suffering from being ahead) produces less than he does without peer pressure whereas an inefficient agent suffering from being behind produces more such that the output gap between the two types of agents is lessened. Moreover, overproduction in total output will occur if the inefficient agent's disadvantage inequity aversion is greater than that of the efficient agent's. However, as the information structure becomes asymmetric, the overproduction disappears because the information rent paid to the efficient agent becomes too burdensome so that it countervails the active peer pressure effect. These results are consistent with previous findings from empirical and experimental studies.

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I. Introduction

Traditionally, individuals have been assumed to selfishly maximize their own payoffs. However, numerous empirical studies have considered various aspects of the impact of interpersonal comparisons on people and found substantial evidence

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that relative income and consumption are important determinants of individual well-being and behavior in society (Veblen, 1899; Duesenberry, 1949).[1] Recent experimental results (Camerer, 2003; Camerer *et al*., 2004; Gintis *et al*., 2005; Fehr and Schmidt, 1999; 2006; Bolton and Ockenfels, 2000) have revealed that the impact of fairness and inequity aversion depends on what workers compare. In this regard, one form of interpersonal effects is envy, which appears in many spheres of life.[2]

Labor market analysis has demonstrated the phenomenon wherein workers are more concerned about relative salary than about absolute salary (e.g., von Siemens, 2004, 2005; and Fehr and Schmidt, 1999; among others). In a survey study involving interviews with firm managers, Bewley (1999, p. 82) find that "the main function of internal pay structure is to ensure internal pay equity, which is crucial for good morale." Bandiera *et al*. (2005) report on personnel data from a fruit farm in the UK that switched its payment scheme from relative incentives to piece rates. The productivity of the average worker was at least 50 percent higher under piece rates than under relative incentives, and the authors attribute this productivity gap to social preference (i.e., workers internalize the externality that their effort imposes on others under relative incentives). For experimental evidence, Clark and Oswald (1996) and Brown *et al*. (2008), among others, emphasize that the role of the degree of happiness on income comparison depends on the position in an organization.

Several empirical/experimental studies and theoretical ones have revealed that social pressure forces individuals to exert similar effort levels, for example, in a team and in real society. This finding implies that informal interactions among group members make individuals to perform at an effort level which is similar norm established in their work group. From a theoretical point of view, Kandel and Lazear (1992) indicate that effort norms can be sustained by feelings of guilt or shame when individuals do not carry out their share of the group's work. Falk and Ichino (2006) and Mas and Moretti (2009) demonstrate in a controlled field experiment that the behavior of subjects working in pairs significantly differs from the behavior of subjects working alone.[3]

Peer pressure may raise effort levels in a group but it may also affect the agent's utility negatively because of the peer pressure. Researchers examine the concept of

[1] For an empirical and theoretical exposition of the utility interdependence, see Oswald *et al*. (2008).

[2] Easterlin (1995, 2001) demonstrated that at the country level, an increase in individual wages is closely related to the degree of residents' happiness. However, this correlation does not increase when the country grows richer over time. This outcome indicates that an individual's degree of happiness is related to his/her relative income level rather than to his/her absolute income level.

[3] Encinosa *et al*. (2007) find that intra-group effort comparisons among physicians matter in medical partnerships. Several lab experiments have linked peer pressure to improvements in team performance. In a laboratory study, Falk *et al*. (2002) demonstrate that the same individual contributes more to a public good in a group with high average contributions than in a group with a low contribution level.

psychological peer pressure experienced by each agent when comparing his or her effort level with that of others. Several lab experiments have focused on the effort level at which individual actions affecting the utility of others. Instead, from a theoretical point of view, the current study focuses on the incentive mechanism to incorporate peer pressure into the contract.[4] Particularly, to examine the effects of peer pressure on a screening model, we define a peer pressure function that represents psychological costs and incorporate it into the agent's utility function. Although certain features are borrowed from the existing literature, our model has the following three distinct features. First, our model allows for productivity differences among agents.[5]

Second, following Fehr and Schmidt (1999), we assume that each agent feels peer pressure when his or her output is not only below (i.e., disadvantage inequity) but also above (i.e., advantage inequity) that of other agents. In addition, we consider that agents are more sensitive to disadvantage inequity than to advantage inequity. Third, we assume that the individual's peer pressure, perceived from comparing others' output, is subject to an enforceable contract.

Theoretical studies have analyzed the effect of peer pressure on incentives (Kandel and Lazear, 1992; Barron and Gjerde, 1997; Hehenkamp and Kaarboe, 2006). They have dealt with cases where peer pressure can encourage additional "effort" from colleagues.[6] A paper closely related to our model is that of Hehenkamp and Kaarboe (2006), which argues that the principal can maintain the first-best level of effort and adjust incentives.[7] Masclet (2002) extends the team production game with an additional stage wherein inequity averse agents can punish their shirking colleagues. As in adverse selection, von Siemens (2011) assumes that agents concerned about inequity suffer a utility loss when they receive a material payoff lower than that of their colleagues, depending on whether the agents are concerned

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[4] In a laboratory setting, several researchers examine peer effects on performance when performance pay is introduced. Eriksson *et al*. (2009) analyze the influence of feedback about coworkers' productivity on individual performance when wages are paid by a piece-rate payment scheme. Rosaz *et al*. (2012) present the results from an experiment in which participants receive a piece-rate wage to perform a real-effort task.

[5] Our approach is different from Hansen (1997) and Rees et al. (2003) which investigated the peer pressure effect on change in productivity. For example, Hansen (1997) and Rees et al. (2003) investigate how group compensation affects individual worker's productivity when workers have unambiguous output measures. Hansen (1997) use average time (in minutes) spent per call as a proxy for productivity, whereas Rees et al. (2003) consider monthly telephone sales as an individual productivity measure. Accordingly, we introduce individual peer pressure, as perceived from an output comparison with others, into the model.

[6] Daido (2004, 2006) considers more specific peer pressure function than Hehenkamp and Kaarboe's (2006) model. According to Huck et al. (2002), agents are concerned about adherence to a social norm which emerges endogenously. However, Huck et al.'s. (2002) model includes multiple equilibria: choose high (resp. low) effort if others work more (resp. less).

[7] Later, we discuss several differences between their studies and ours.

about inequality in rents (i.e., wages minus costs). Given that we introduce peer pressure concerns into adverse selection, the optimal incentive contract structures often differ from those predicted by previous theoretical results and standard solutions of adverse selection or the moral hazard problem.

Considering the above literature, we define a peer pressure function as the psychological cost of an agent's feeling with respect to the output difference with other agents and incorporate it into his utility.[8] We explicitly consider the change in utility due to the peer pressure. Particularly, we consider the changes in production under different information settings. To establish a reference model of comparison, we analyze a full-information setting between principal and agent. We observe the changes in output at agent and aggregate levels from the case of no peer pressure. Then, we switch to an asymmetric-information setting and analyze the output change in the hidden information environment. We find the three characteristics as follows.

First, the effect of peer pressure reduces the production gap between efficient and inefficient types of agents. In the full-information setting, an efficient agent (i.e., suffers from being ahead) produces less than he would have done without peer pressure, whereas an inefficient agent (i.e., one who suffers from being behind) produce more than he would have done without such a pressure.

Second, overproduction at aggregate level occurs when the disadvantage from low production is hated by the inefficient agent more than the advantage from high production by the efficient agent. On the other hand, when the inequity aversion becomes symmetric, the overproduction disappears though the production gap between the two types still exists. In addition, if the advantage from high production is hated more by the efficient agent, then underproduction occurs. Moreover, the extent of the gap in asymmetric information between the two agents increases, and the extent of over or under production expands. The above discovery applies when the information is symmetric with the principal.

Third, we investigate change in output when information asymmetry is introduced. We find that the efficient types tend to produce more downwardly and the inefficient types tend to produce upwardly more, resulting in further reduction of the production gap between them. However, there is other force to reduce the production of the inefficient agent. As in typical screening model, principal intentionally distorts the production of the inefficient agent downward because of the information rent paid to the efficient agent. In short, the usual effect of the downward production distortion on the inefficient type, $\nu\Delta t/(1-\nu)$, in the ordinary screening model[9] works here. As a result, the total output level becomes the

[8] For identification, the principal is assumed a female and the agent is male.

[9] The term is a result of considerations of production efficiency gap (i.e., Δt) and distribution of each agent type (i.e., $\nu/(1-\nu)$).

same as that of no peer pressure case when information becomes asymmetric, despite the changes in the production of individual agent. If the principal with wage burden for peer pressure compensation becomes unable to observe the agents' type, promoting overproduction through peer pressure essentially becomes impossible. It is in sharp contrast to the overproduction driven by peer pressure in a symmetric information situation.

Our findings are consistent with various empirical and experimental results. Recent empirical/experimental work have indicated that average total output can either increase or decrease with peer pressure. This outcome is in line with our theoretical results. However, empirical research findings of total output increase or decrease in the presence of peer pressure must be considered with caution in view of our theoretical results.

This paper is organized as follows. Section 2 presents the basic peer pressure model. Section 3 considers the peer pressure model in a screening set-up. Section 4 discusses the empirical/experimental implications of peer pressure. Finally, Section 5 contains our concluding remarks.

II. Basic Model

Consider a risk-neutral principal facing a continuum of agents with measure one. The principal wants to delegate the production of x units of a good to an agent and pays for w. The value of x units of output to the principal is given by a strictly concave utility function $S(x)$ with $S'(x) > 0, S''(x) < 0$. To ensure production to take place but to make it finite, we also assume that $S'(0) = \infty$ and $\lim_{x \to +\infty} S'(x) = 0$.

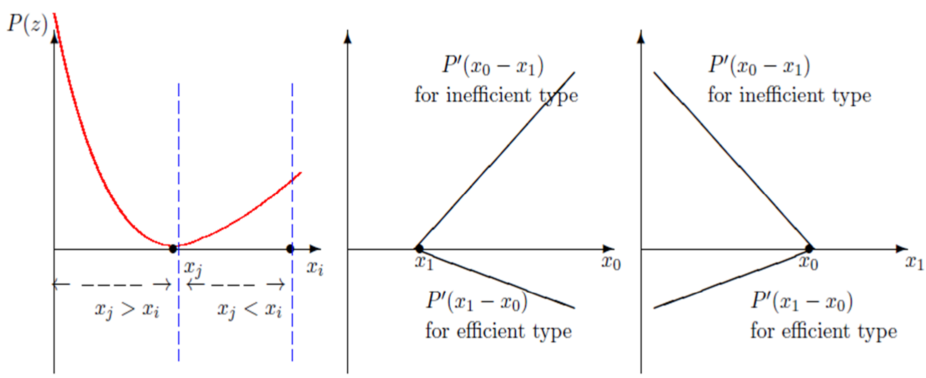
Regarding the production cost, two types of agents are present $T = \{t_0, t_1\}$ with $0 < t_0 < t_1$, where t_1 is marginal cost. Each agent has type-dependent linear cost function $C(x, t_0) = t_0 x$ or $C(x, t_1) = t_1 x$. Thus, type t_0 is the efficient agent, whereas type t_1 is regarded as the inefficient one. Efficient agents are distributed independently with probability v and inefficient ones with probability $1 - v$. Such distribution is regarded as common knowledge. When information asymmetry is introduced later, we assume that the realized agent types are not observable to the principal although the distribution is known. Agents are assumed to be risk neutral, so their utility function is defined as $U_i = w_i - x_i t_i$ before we consider peer pressure.

We adopt the peer pressure concept in Hehenkamp and Kaarboe (2006) and modify their concept as follows: Function $P(x_j - x_i)$ captures the peer pressure that each t_i agent producing x_i has against the other type t_j agent producing x_j. The peer pressure function depends on output spread, which is $x_j - x_i$. We assume the details of $P(x_j - x_i)$ as follows.

Assumption I: Suppose the peer pressure function $P(z)$, where $z \equiv x_j - x_i$, for $i, j = 0,1$. $P(z)$ is twice differentiable and satisfies (i) $P(0) = 0$, (ii) $P'(0) = 0$, (iii) $P''(z) \geq 0$ for $z \geq 0$ and $P''(z) > 0$ for $z < 0$, (iv) $P(z) > P(-z)$ and $P'(z) > 0 > P'(-z)$ for any $z > 0$, and (v) $|P''(-z)| < |P''(z)|$ for any $z > 0$.

Parts (i) and (ii) of Assumption I state that an agent does not feel peer pressure if his output is equal to the others. Part (iii) implies that agents feel peer pressure more as output spread increases. Parts (iv) and (v) indicate that an agent suffers from output inequity aversion more when his output level is relatively lower. The agent is more sensitive to the disadvantage inequity than to advantage inequity, that is, $|P''(-z)| < |P''(z)|$.[10] Note that part (v) is similar to Fehr and Schmidt's (1999) inequity aversion function. This assumption is described in Figure 1.

[Figure 1] Total (resp. Marginal) Peer Pressure Function with Inequity Aversion across z (resp. x_i)



On the basis of Assumption I,[11] let

[10] Choi (2009) incorporates the peer pressure function into the agent's utility, setting peer pressure at the same level regardless of whether the agent is conscious of it or not when his output level is below that of others. Huck and Rey Biel (2006) support the idea of "conformity preferences." Their setting is inconsistent with inequity aversion, but the authors argue that agents only care about choosing similar efforts.

[11] If we strictly follow Hehenkamp and Kaarboe (2006), then peer term should be $P(z) = P(x_j - \overline{x})$, instead of $P(x_j - x_i)v_j$. However, we take the latter for analytical simplicity, because the peer pressure term in the latter becomes $\frac{b_i v_j (x_j - x_i)^2}{2}$, but the term in the former becomes $\frac{b_i v_j^2 (x_j - x_i)^2}{2}$ with the square term of the density. We also check the robustness with $P(z) = P(x_j - \overline{x})$ regarding the disappearing overproduction phenomenon (see Proposition 3). Other extensions for considering peer pressure in this way involve studying the effectiveness of inducing competitive behavior among different types of consumers to increase a firm's sales or the effect of inducing competitive behavior

$$R_i(x_i, x_j) = w_i - t_i x_i - P(x_j - x_i)v_j \tag{1}$$

denote the agent i's overall utility with $P(x_j - x_i)$ multiplied by the weight (i.e., portion) of the other type, v_j. Thus, the degree of peer pressure depends on the distribution of the other type. For example, if no other type except for type t_0 agent exists, i.e., $v_1 = 0$, then type t_0 agent does not feel any peer pressure at all even if $x_0 \neq x_1$. Otherwise, the greater the proportion of the other type, the greater the psychological pressure felt about the output spread. Now, an agent's overall utility depends on weighted peer pressure term as well as wage minus its production cost. Note that Eq. (1) can capture the utility of a type-0 agent if he behaves as the other type (type 1), and vice versa. In this case, t_0 for $i = 0$ is the same but the other terms in Eq. (1) switch into w_1, x_1, v_0, and vice versa for the agent type j.

The model spans three periods. We examine each case where the agent type is known to the principal, and then is unknown in order. At period 1, agent type and its distribution are determined and the information will be known to principal. In an asymmetric-information setting, on the contrary, we assume that the principal only knows their distribution as she cannot observe the agent type directly.[12] At period 2, the principal proposes a menu of contracts $(x_i, w_i), i \in \{0,1\}$ respectively to each agent. We assume that the principal offers wage $w_0(w_1)$ in advance for the production of each agent $t_0(t_1)$. When the information on the agent type is asymmetric, the contracts are formed on the basis of an accurate belief over the distribution of the agent type. For the formation of the belief, we employ the Bayesian Nash equilibrium concept. At period 3, the agent chooses which contract to accept, if any. In this study, we only focus on a separating equilibrium where the principal proposes two different pairs $\{(x_0, w_0), (x_1, w_1)\}$ and an agent accepts distinct contracts depending on his type. The belief on agent type in the separating equilibrium is easily supported by the Bayesian Nash equilibrium concept (for additional discussions on the "menu of contracts," see Kubler *et al.*, 2008). In this way, each agent and the principal maximize his overall utility and her profit.

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between developed and developing countries on trade volume.

[12] From the canonical timing of adverse selection, agent utility depends on ability, but agent types entail private information such that an agent has to form the other agent's beliefs. Note that the term v_j is the percentage of agents of type t_j. As described in von Siemens (2005, pp. 8–9), in order for agents to compare their output with those of other agents, they must have a correct expectation of the other agents' types, that is, agents must know the information on their type in the course of production. If the agents' types are unknown, then an agent's utility depends on his/her belief about the other agents' types. For detailed explanation, see also von Siemens (2004, 2005).

III. Results

For simplicity, we denote the marginal cost difference between the two types, $t_1 - t_0$, by Δt. We also introduce the following assumption:

$$P'(z) - (1-v)P'(-z) < \Delta t, \quad z = x_0 - x_1., \tag{S}$$

where z is the difference in production between the two types of agents. Particularly, we describe z as the output spread (or production gap) from agent type t_1's perspective. $z = x_0 - x_1$, whereas $-z = x_1 - x_0$ is the output spread from the agent type t_0's perspective. The assumption (S) implies that the effect of the marginal cost difference dominates the aggregated effect of the two types' marginal peer pressure. To clarify terminology, we denote $vP'(z) - (1-v)P'(-z)$ as the average marginal peer pressure effect. The latter term, $-P'(-z)$ is a positive derivative value of peer pressure with respective to x_0, whereas $P'(z)$ is another derivative value for x_1. Then, each derivative value is weighted by the other type's proportion as the above.

3.1. Peer Pressure under Full Information

When no information asymmetry exists between the principal and agents, the principal can achieve efficient production by equating the principal's marginal value with each agent's marginal cost plus peer pressure. Thus, first-best output levels are given by

$$S'(x_0^{fb}) = t_0 - (1-v)P'(-z^{fb}) \text{ and } S'(x_1^{fb}) = t_1 - vP'(z^{fb}),$$
$$\text{where } z^{fb} = x_0^{fb} - x_1^{fb}. \tag{2}$$

The superscript fb denotes the first-best output level with peer pressure and no information asymmetry at the same time. From assumption (S), the optimal production levels are such that $S'(x_0^{fb}) < S'(x_1^{fb}) \Leftrightarrow x_0^{fb} > x_1^{fb}$. That is, the optimal production of an efficient agent is greater than that of an inefficient agent. Note that $P'(z) > 0 > P'(-z)$, where $z = x_0 - x_1$. Now, to achieve first-best production levels, the principal proposes the following take-it-or-leave-it offers to each type of agent: for $t = t_0 (t = t_1)$ type, she will propose $w_0^{fb} (w_1^{fb})$ for the production $x_0^{fb} (x_1^{fb})$, where $w_0^{fb} = t_0 x_0^{fb} - (1-v)P'(x_1^{fb} - x_0^{fb})$ and $w_1^{fb} = t_1 x_1^{fb} - vP'(x_0^{fb} - x_1^{fb})$.

For comparison, we introduce x_i^{FB} to denote an output level without the peer pressure effect. Then, $S'(x_1^{fb}) = t_1 - vP'(x_0 - x_1) > S'(x_1^{FB}) = t_0 \Leftrightarrow x_1^{fb} > x_0^{FB}$; $S'(x_0^{fb}) = t_0 - (1-v)P'(x_1 - x_0) > S'(x_0^{FB}) = t_0 \Leftrightarrow x_0^{fb} < x_0^{FB}$. With the peer pressure, the output level of an inefficient agent becomes greater, whereas the output level of an efficient agent becomes smaller.

3.1.1. Overproduction Possibility with Asymmetric Inequity Aversion

We introduce two specific forms of functions for peer pressure and for the social planner's utility. And we test if overproduction occurs. First, the peer pressure function is defined as follows:

$$P(x_i, x_j; b_i) = \frac{b_i (x_j - x_i)^2}{2}, \tag{3}$$

where $b_i > 0$ measures the marginal sensitivity of each agent i regarding peer pressure. We also introduce asymmetric inequity aversion among agents such that an agent with lower output suffers inequity aversion more than an agent with higher one by assuming $b_1 > b_0$. We describe such feature as asymmetric inequity aversion of disadvantage in the output spread. Thus, in our setting, we assume that disadvantage inequity is greater than advantage inequity. Second, we assume the social planner's utility function and marginal utility function as follows for tractability:

$$S(x) = cx - \frac{ax^2}{2} \quad \text{and} \quad S'(x) = -ax + c \quad \text{where} \quad a > 0 \quad \text{and} \quad c \geq 0\,. \tag{4}$$

For notational simplicity, the difference in outputs between the two agent types will be denoted by $\Delta x (= x_0 - x_1)$ in the following discussion.

Now, Eqs. (3) and (4) enable us to derive each type's output level and compare them with those from the case of no peer pressure. In addition, the total output level comparison between the presence and the absence of peer pressure is as follows:[13]

$$x_0^{fb} = \frac{1}{a}\left\{ c - \frac{(vb_1 + a)t_0 + (1-v)b_0 t_1}{vb_1 + (1-v)b_0 + a} \right\} < \frac{c - t_0}{a} = x_0^{FB}\,, \tag{5}$$

$$x_1^{fb} = \frac{1}{a}\left\{ c - \frac{vb_1 t_0 + ((1-v)b_0 + a)t_1}{vb_1 + (1-v)b_0 + a} \right\} > \frac{c - t_1}{a} = x_1^{FB}\,, \tag{6}$$

[13] To derive the first-best equilibrium with peer pressure under no asymmetry information with the principal, we solve the following maximization problem $\max_{x_i, w_i} \pi = cx_i - \frac{ax_i^2}{2} - w_i$ $s.t.\ w_i - t_i x_i - \frac{v_j b_i (x_j - x_i)^2}{2} = 0$, where $i \in \{0,1\}$.
The solution ultimately entails ascertaining $\begin{bmatrix} (1-v)b_0 + a & -(1-v)b_0 \\ -vb_1 & vb_1 + a \end{bmatrix} \begin{bmatrix} x_0 \\ x_1 \end{bmatrix} = \begin{bmatrix} c - t_0 \\ c - t_1 \end{bmatrix}$.

$$vx_0^{fb}+(1-v)x_1^{fb}=\frac{1}{a}\left\{c-\frac{v(b_1+a)t_0+(1-v)(b_0+a)t_1}{vb_1+(1-v)b_0+a}\right\}, \tag{7}$$

$$vx_0^{FB}+(1-v)x_1^{FB}=\frac{1}{a}\{c-vt_0+(1-v)t_1\}. \tag{8}$$

If $b_1=b_0$, then $vx_0^{fb}+(1-v)x_1^{fb}=vx_0^{FB}+(1-v)x_1^{FB}$. However, if $b_1<b_0$, then $vx_0^{fb}+(1-v)x_1^{fb}>vx_0^{FB}+(1-v)x_1^{FB}$. Otherwise, vice versa.[14]

First, we can see that the efficient type's output is lower with than without peer pressure, whereas the inefficient type's output is higher with than without peer pressure by comparing the output levels of the two agent types in Eqs. (5) and (6). This finding implies that, as expected, the efficient type reduces production with peer pressure, whereas the inefficient type increases production such that the production gap between the two types tends to reduce.

Second, we find that if $b_0=b_1$ in Eq. (7), then the total output levels are the same regardless of the presence of peer pressure. However, if the psychological aversion to disadvantage inequity is larger (i.e., $b_1>b_0$) or it becomes greater, then overproduction occurs and this phenomenon will be further intensified. On the contrary, if $b_0>b_1$, implying that the psychological aversion to advantage inequity is larger, then underproduction will arise. Moreover, the phenomenon will be further intensified as the gap between b_i values increases.[15] Interestingly, we find that the presence of peer pressure mainly plays a role in reducing the production gap between the two types. However, over-or under-production depends on the direction and size of aversion to inequity rather than the mere existence of the aversion. Our finding is summarized below as Proposition 1.

Proposition 1: *In a full-information setting, the production of an inefficient (efficient) agent becomes greater (smaller) with than without peer pressure. Therefore, the production gap between the two types becomes smaller with peer pressure. Furthermore, (i) the total output levels are the same regardless of the presence of peer pressure if* $b_1=b_0$ *(i.e., symmetric inequity aversion). However, (ii) if asymmetrically strong aversion to disadvantaged inequity exists (i.e.,* $b_1>b_0$*), then overproduction occurs. Should the aversion become stronger, then this phenomenon is further intensified. On the contrary, (iii) if* $b_0>b_1$*, implying that asymmetrically strong aversion to advantaged inequity (advantage in output spread) exists, then underproduction occurs. This phenomenon is further intensified as the gap between* $b_i s$ *increases*.

[14] The comparison between $vx_0^{fb}+(1-v)x_1^{fb}$ and $vx_0^{FB}+(1-v)x_1^{FB}$ is dependent upon the comparison between $\frac{v(b_1+a)t_0+(1-v)(b_0+a)t_1}{vb_1+(1-v)b_0+a}$ and $\frac{vt_0+(1-v)t_1}{1}$. Clearly, the comparison between the two terms depends on the following equation: $v(1-v)(b_1-b_0)(t_1-t_0)>0$ if $b_1>b_0$.

[15] Note that $x_0^{fb}>x_1^{fb}$ holds because of assumption (S).

An important finding is that the presence of peer pressure does not result in over- or under-production; rather, the direction and extent of inequity aversion asymmetry determines over- or under-production in the total output.

3.2. Peer Pressure under Asymmetric Information

We introduce asymmetric information between the agents and the principal. First, we consider each agent's participation constraints (i.e., individual rationality condition) as follows:

$$w_0 - t_0 x_0 - (1-v)P(x_1 - x_0) \geq 0, \qquad (PC_0)$$
$$w_1 - t_1 x_1 - vP(x_0 - x_1) \geq 0. \qquad (PC_1)$$

The contract guarantees each agent's reservation utility to become at least zero. Now, given asymmetric information, the principal must consider the following two incentive compatibility constraints as well as the above PC_i :

$$w_0 - t_0 x_0 - (1-v)P(x_1 - x_0) \geq w_1 - t_0 x_1 - vP(x_0 - x_1), \qquad (IC_0)$$
$$w_1 - t_1 x_1 - vP(x_0 - x_1) \geq w_0 - t_1 x_0 - (1-v)P(x_1 - x_0). \qquad (IC_1)$$

The incentive compatibility constraint (IC_0) ensures that the efficient agent (t_0) will not benefit from behaving as the other t_1 type. At the same time, the incentive compatibility constraint of agent (IC_1) also guarantees that the inefficient agent (t_1) truthfully reports his type rather than not, as is usual in screening problems.

Given the above agents' incentive compatibility and their participation constraints, the optimal program [P] of the principal now becomes

$$\max_{w_i, x_i} \ v[S(x_0) - w_0] + (1-v)[S(x_1) - w_1]$$
subject to (PC_i) and (IC_i), where $i \in \{0,1\}$.

The program [P] can also be expressed by using the functions in Eqs. (3) and (4) as the following [PP]:

$$\max_{w_i, x_i} \ v[S(x_0) - w_0] + (1-v)[S(x_1) - w_1],$$
$$w_0 - t_0 x_0 - \frac{(1-v)b_0(x_1 - x_0)^2}{2} \geq 0, \qquad (PC_0)$$
$$w_1 - t_1 x_1 - \frac{vb_1(x_0 - x_1)^2}{2} \geq 0, \qquad (PC_1)$$

$$w_0 - t_0 x_0 - \frac{(1-v)b_0(x_1 - x_0)^2}{2} \geq w_1 - t_0 x_1 - \frac{vb_1(x_0 - x_1)^2}{2}, \qquad (IC_0)$$

$$w_1 - t_1 x_1 - \frac{vb_1(x_0 - x_1)^2}{2} \geq w_0 - t_1 x_0 - \frac{(1-v)b_0(x_1 - x_0)^2}{2}. \qquad (IC_1)$$

In the above equations, we can see that (PC_0) automatically holds when both (IC_0) and (PC_1) works as follows:

$$w_0 - t_0 x_0 - \frac{(1-v)b_0(x_1 - x_0)^2}{2} > w_1 - t_0 x_1 - \frac{vb_1(x_0 - x_1)^2}{2}$$
$$> w_1 - t_1 x_1 - \frac{vb_1(x_0 - x_1)^2}{2} \geq 0.$$

Thus (PC_0) is not binding. Conversely, constraints (PC_1) and (IC_0) must be binding.

Let us prove this assertion through a contradiction. Suppose that (PC_1) is not binding. The principal can then decrease w_0 and w_1 by the same amount while keeping $w_0 - w_1$ constant so that she can increase her profit. Therefore, (PC_1) should be binding. (IC_0) is also binding. Otherwise, the principal can increase x_0 and her profit. Hence, (IC_0) should be binding. Now (IC_1) automatically holds if both (PC_1) and (IC_0) are binding. Thus (IC_1) is not binding. As a result, we only have to deal with the two binding constraints, (PC_1) and (IC_0). Now, substituting (PC_1) and (IC_0) into (PP), the program (PP) is simplified as follows:

$$\max_{x_i}\ v\left[S(x_0) - x_1(t_0 - t_1) - t_0 x_0 + \frac{(1-v)b_0(x_1 - x_0)^2}{2}\right]$$
$$+(1-v)\left[S(x_1) - t_1 x_1 - \frac{vb_1(x_0 - x_1)^2}{2}\right]. \qquad (9)$$

From the program [P], the following proposition can then be stated.

Proposition 2: *Suppose that the agent utility function in Eq. (1) satisfies Assumption I and (S). Under an asymmetric information setting, the optimal contracts in program [P] entails the following results ([i]–[iii]) and implication [iv]:*
(i) The optimal condition for both efficient agent and inefficient agent is given by

$$S'(x_0^*) = t_0 + (1-v)[P'(z^*) - P'(-z^*)],$$

$$S'(x_1^*) = t_1 + \frac{v}{1-v}\Delta t + v[P'(-z^*) - P'(z^*)], \tag{10}$$

where $z^* = x_0^* - x_1^*$, $z^* \neq z^{fb}$.[16] *In addition,* $P'(z^*) = b_1(x_0^* - x_1^*)$, $P'(-z^*) = b_0(x_1^* - x_0^*)$.

(ii) The efficient and inefficient agents receive, respectively,

$$w_0^* = t_0 x_0^* + \Delta t x_1^* + (1-v)P(x_1^* - x_0^*) \quad \text{and} \quad w_1^* = t_1 x_1^* + vP(x_0^* - x_1^*). \tag{11}$$

(iii) The truth-telling condition of $x_0^* > x_1^*$ *is*[17]

$$(1-v)[P'(z) - P'(-z)] < \Delta t. \tag{12}$$

(iv) The result (i) implies that the phenomenon of the reduced production gap between the two types of agents intensifies under information asymmetry at the individual agent level.

Proof: See the Appendix. Q.E.D.

For the efficient agent, under information asymmetry, Eq. (10) indicates that a downward output distortion is strengthened given the addition of $(1-v)P'(z^*) > 0$ to $(1-v)P'(-z)$, compared with $S'(x_0) = t_0 - (1-v)P'(-z)$ under symmetric information conditions in Eq. (2). On the contrary, for the inefficient agent, Eq. (9) shows that an upward output distortion is strengthened because of the addition $vP'(-z^*) < 0$ to $vP'(z)$, unlike $S'(x_0) = t_0 - vP'(z)$ under symmetric information. If we ignore the $\frac{v}{1-v}\Delta t$ in Eq. (10), we can conclude that the output level of the inefficient (efficient) agent becomes greater (smaller) with peer pressure. This outcome occurs as both types of agents consider their counterpart's psychological peer pressure as well as their own one due to incentive compatibility constraints. As a result, the effect of peer pressure itself is strengthened. If we just consider peer pressure effect, the efficient types should produce less and the inefficient types produce more compared with the case of symmetric information, resulting in a reduction of the production gap between the two types.

However, under information asymmetry, $\frac{v}{1-v}\Delta t$ in the ordinary screening model starts to work. It means that the effect of the downward production distortion on the inefficient type occurs and it also affects the production of the efficient types.

[16] Note that $z^{fb} = x_0^{fb} - x_1^{fb}$. z^* and x_i^* corresponds to the asymmetric information solution and z^{fb} and x_i^{fb} to the symmetric information solution.

[17] The truth telling condition from Eq. (12) implies that cost efficiency is assumed to dominate the psychological peer pressure effect.

Then, the final output level of the inefficient type is unclear given the off-setting downward output distortion of $\frac{v}{1-v}\Delta t > 0$ Without peer pressure, Eq. (10) should be driven as follows:

$$S'(x_0) = t_0\,,\quad S'(x_1) = t_1 + \frac{v}{1-v}\Delta t\,. \tag{13}$$

The above equation is a typical solution in a screening setting with no peer pressure. Note that current Eq. (10) additionally contains $(1-v)[P'(z^*) - P'(-z^*)]$ and $v[P'(-z^*) - P'(z^*)]$ terms. They represent the additional costs incurred to the principal from the existence of peer pressure among agents.

Compared with the compensation costs of peer pressure in Eq. (2) when the agent type is observed, we can see that the compensation cost to the principal in Eq. (10) increases, even if the self-selection is successfully done by the screening. Solving the two equations in Eq. (10) with respect to x_0 and x_1 yields the following x_0^* and x_1^* and total production $vx_0^* + (1-v)x_1^*$.[18]

$$x_0^* = \frac{1}{a}\left\{c - \frac{at_0 + (b_0+b_1)t_1}{a+(b_0+b_1)}\right\} < \frac{c-t_0}{a} = x_0^{w/o}\,, \tag{14}$$

$$x_1^* = \frac{1}{a}\left\{c - \frac{a(t_1 + \frac{v}{1-v}\Delta t) + (b_0+b_1)t_1}{a+(b_0+b_1)}\right\} > \frac{1}{a}\left\{c - \left(t_1 + \frac{v}{1-v}\Delta t\right)\right\} = x_1^{w/o}\,, \tag{15}$$

$$vx_0^* + (1-v)x_1^* = \frac{1}{a}\left\{c - \frac{a(vt_0 + (1-v)t_1 + v\Delta t) + (b_0+b_1)t_1}{a+(b_0+b_1)}\right\} = \frac{c-t_1}{a}\,, \tag{16}$$

where $\Delta t = t_1 - t_0$.

Note that x_1^* and $x_1^{w/o}$ are driven from Eq. (13). We can see that $x_0^{w/o} > x_0^* > x_1^* > x_1^{w/o}$. Particularly, the production of the inefficient type is greater with than

[18] F.O.Cs of [PP] in Eq. (9) with respect to x_0, x_1 respectively are summarized in the following matrix.

$$\begin{bmatrix} (1-v)(b_0+b_1)+a & -(1-v)(b_0+b_1) \\ -v(b_0+b_1) & v(b_0+b_1)+a \end{bmatrix}\begin{bmatrix} x_0 \\ x_1 \end{bmatrix} = \begin{bmatrix} c-t_0 \\ c-t_1-\frac{v}{1-v}\Delta t \end{bmatrix}.$$

Then, solving the above matrix yields x_0^* and x_1^*. The above matrix is also expressed in the following form:

$$S'(x_0^*) = t_0 + (1-v)(b_1+b_0)z^* \quad \text{and} \quad S'(x_1^*) = t_1 + \frac{v}{1-v}\Delta t - v(b_1+b_0)z^*\,.$$

In addition, Eq. (9) expresses w_0^* and w_1^* as $w_0^* = t_0x_0^* + \Delta t x_1^* + \frac{(1-v)b_0(x_0^*-x_1^*)^2}{2}$ and $w_1^* = t_1x_1^* + \frac{b_1v(x_0^*-x_1^*)^2}{2}$, respectively.

without peer pressure regardless of information structure. Comparison of x_1^* and $x_1^{w/o}$ in Eq. (15) reveals that the former is clearly larger the latter because of $(t_1 + \frac{v}{1-v}\Delta t) > t_1$. This result is related to the change in the information rent of the efficient type agent (i.e., $\Delta t x_1^*$).

Under information asymmetry, $\Delta t x_1^*$ is known to become information rent accruing to the efficient type, whereas no information rent accrues to the inefficient type. Furthermore, although efficient agents produce less than they can in the standard screening model, their ex-post information rent can increase when the output of the inefficient agent increases. We can summarize this in Lemma 1 as follows:

Lemma 1: *The efficient (inefficient) agent obtains a strictly positive (zero) ex post information rent,* $R_0^* = \Delta t x_1^* (R_1^* = 0)$. *Furthermore, information rent to the efficient agent is greater with peer pressure than without it.*

Proof: See the Appendix. Q.E.D.

Now, we compare total production between asymmetric and symmetric informational structure. Note that, if the information is symmetric and the inequity aversion is large at disadvantaged output spread (i.e., $b_1 > b_0$), the total output is greater with than without peer pressure. The presence of peer pressure also result in increased total production.[19] Nevertheless, when information becomes asymmetric, the effect of peer pressure on enhancing total output is lost. It is shown in Eq. (16). Furthermore the total production level itself becomes less than that in symmetric information cases. To help understand this puzzling phenomenon, it is worthwhile to consider the total production amount without peer pressure, and then compare it with the production amount in Eq. (16). The total output without peer pressure is derived as follows:

$$v x_0^{w/o} + (1-v) x_1^{w/o} = \frac{1}{a}[c - (v t_0 + (1-v) t_1 + v \Delta t)] = \frac{c - t_1}{a}. \tag{17}$$

The total output in the above traditional screening setting becomes the same as the total output in Eq. (16). Moreover, the value of $\frac{c-t_1}{a}$ in both equations is clearly smaller than $v x_0^{FB} + (1-v) x_1^{FB} = \frac{1}{a}[c - v t_0 + \ (1-v) t_1]$ in Eq. (8) with no information asymmetry as long as $\Delta t > 0$. These results imply that the disappearance of overproduction is mainly driven by the introduction of information asymmetry. These findings are summarized in Proposition 3 as follows:

[19] However, note that if the inequity aversion is symmetric (i.e., $b_1 = b_0$), this effect will be negated.

Proposition 3: *The total output level when information becomes asymmetric is the same as that of the no peer pressure case. The overproduction phenomenon completely disappears with information asymmetry. Moreover, such outcome is observed regardless of the degree of inequity aversion asymmetry and whether the total output volume becomes smaller compared with that under symmetric information.*

With information asymmetry, the change in an agent's production is canceled by that of their counterpart, and thus, the effect of peer pressure becomes negligible from the perspective of total production. Moreover, such result occurs for all possible variations in the size and the direction of aversion asymmetry. This finding is in sharp contrast to the effect of peer pressure on total production in the symmetric information case.

The reason for such observation is due to the effect of the inefficient type's distorted output reduction to reduce the information rent payment to the efficient type. This is well known effect in traditional screening model and this force is reproduced in our model. The effects of reducing production by the inefficient agent in order to decrease the information rent paid to his counterpart exactly countervail the overproduction possibility with peer pressure. As a result, with asymmetric information, the principal bears the increased wage burden for agents' peer pressure compensation but cannot enjoy the benefit of increasing total output.

IV. Implications for Relationship to the Literature

Previous experimental/empirical studies have presented different findings in total production given the presence of peer pressure. With this possibility in mind, we evaluate whether the total output increases or decreases with peer pressure settings under full and asymmetric information, respectively. We find that the total production increases with the presence of peer pressure if the principal can observe the different agent types, thereby causing the inefficient agent's output to increase more than the decrease of the efficient agent's output. This outcome is consistent with the following class of experimental/empirical study in which the output of inefficient agents increases from the effect of peer pressure.

Laboratory experiments from prior research shows that much of the peer effects in the workplace arise from the fact that low-productivity workers benefit from the work of high-productivity workers. Falk and Ichino (2006) and Mas and Moretti (2009) examine the impact of feedback on relative performance on effort in settings with a flat wage pay scheme. Both studies find significant positive peer effects. Mas and Moretti (2009) report that productivity increased when highly productive employees worked in an environment where they were compared with new employees. This finding shows peer pressure's positive effect on production from mutual monitoring, which is supported by our theoretical finding under symmetric information. Particularly, Falk and Ichino (2006) found a 10% increase in the pairs' output against a 1.4% increase in the individual effort. Our theoretical result from Propositions 1 is consistent with their empirical results. Moreover, Hansen (1997) and Rees *et al*. (2003) demonstrate that changes in individual productivity are negatively correlated with initial productivity, leading to less heterogeneity in output across workers. In this regard, having workers with different levels of productivity work as one group may increase the total output, thus supporting our theoretical results.

On the contrary, there are other contrasting empirical evidences. That is, the total production becomes smaller with peer pressure. For example, Guryan *et al*. (2009) find no evidence that the ability of playing partners affects the performance of professional golfers, contrary to recent evidence on peer effects. They provide several explanations for the contrasting findings, that is, workers seek to avoid responding to social incentives when financial incentives are strong, that the degree of susceptibility to social effects is heterogeneous among individuals, and that those who can avoid social effects are more likely to advance to elite professional labor markets. As for other evidence for decreasing total output production, Rosaz *et al*. (2012) find that peers may influence an individual's quitting decision through a comparison of one's own performance with that of co-workers, even when the incentive scheme is only based on absolute performance. In comparing oneself to a co-worker, an individual may feel discouraged and quit if the person performs less well and, consequently, earns relatively less than his or her coworker, thus leading to underproduction. Moreover, Bandiera *et al.* (2005) show that when a piece-rate pay scheme is in use and mutual monitoring is possible, negative spillovers between co-workers affect a worker's productivity.

For these negative effects of peer pressure, our Proposition 3 provides background of negligible or minimal peer pressure effect on the total output. If principal cannot observe the work's type, the change in an individual worker's production is canceled by that of their counterpart. And the reason for such disappearing overproduction is due to the effect of the inefficient worker's distorted output reduction caused by the principal to reduce information rent payment. Thus our model provides another reason for the uselessness of peer pressure.

Finally, Eriksson *et al*. (2009) find mixed evidence. They examine whether effects are present when the organization uses performance pay. Given that correct feedback is given continuously, which can be interpreted as communication by the principal of the agent type under full information, the result of Eriksson *et al*. (2009) allows us to identify the potential influence of the frequency of feedback on behavior. Eriksson *et al.* (2009) suggest that overall feedback does not improve performance. However, in both pay schemes, relative performance feedback reduces the quality of low performers' work.[20]

With our theoretical results, the result of previous empirical research—that the total output either increases or decreases in the presence of peer pressure—must be interpreted carefully. Our model assumes no change in productivity as we keep two types of agents with $t_1 (i = 0,1)$, as per usual in canonical adverse selection settings. Instead, we incorporate psychological peer pressure explicitly into the agents' utility functions, and then, examine if the introduction of peer pressure increases or decreases outputs at the individual and aggregate levels. By introducing the utility functions, our theoretical result in Lemma 1 shows that the inefficient agent's utility level with peer pressure is higher than the other type under full information. However, previous experimental/empirical works do not consider this point because the employees' utility level was not observed in their experiments. Furthermore, compared with the first-best levels of output with no peer pressure, the total output level changes depending on the degree of the psychological effect from peer pressure. Specifically, overproduction or underproduction is determined according to the magnitude of the psychological effects. In this sense, both occurrences of increase or decrease in total production in our study are consistent with the results of previous empirical/experimental research.

Finally, we demonstrate how the total output level alters according to the change in the information setting. Our setting in symmetric information may support overproduction under a certain degree of psychological effect, whereas asymmetric information may not. One limitation of this research is that our results may not be directly compared with that of previous experimental study, because peer pressure has never been examined as a form of principal-agent contract.

V. Concluding Remarks

In this study, we demonstrate peer pressure settings in which an agent exhibits inequity aversion if he or she incurs disutility from being either better or worse off than others. , we also assume that the agent's peer pressure from output comparison with others is subject to an enforceable contract. On the basis of recent experimental results, and by applying the concept of inequity aversion to the theoretical frame of adverse selection, optimal incentive policies often differ from those predicted by standard solutions of the canonical adverse selection problem.

Consequently, the efficient agent who is averse to inequity was found to produce

[20] Bandiera *et al.* (2010) find mixed evidence that the presence of a friend working nearby increases productivity, whereas working next to a non-friend co-worker has no impact. That is, relative to working only with non-friends, the average worker is 10% more productive if at least one of his or her abler friends is present and is 10% less productive if the person is the ablest among his or her friends.

less than the first-best level of output, whereas the inefficient agent produces more than the first-best level. In addition, overproduction of total output can occur when inefficient agents are more sensitive to disadvantage inequity relative to the efficient agents under a full-information setting. However, as the information setting becomes asymmetric, overproduction disappears regardless of the presence of peer pressure and the extent of inequity aversion asymmetry. Therefore, our theoretical results under certain condition are consistent with the findings of these empirical and experimental studies.

However, this study has a limitation in that only two types of agents are examined in our model. Future studies in this field will require comprehensive analysis of a more generalized and continuous type, filling in many points from the concept of peer pressure and social preferences in empirical/experimental and theoretical studies. For instance, incorporating all dynamic aspects of organizational problems holds promise. The precise details of an optimal contract structure in the presence of peer pressure also require further research.

Appendix

Proof of Proposition 2: To solve for the maximization of [P] under (PC_i) and (IC_i), (IC_1) is momentarily ignored. We check ex-post that the omitted constraint (IC_1) is strictly satisfied. We therefore have three constraints to consider, (PC_1), (PC_2), and (IC_0). From the program [P], the ability of the efficient agent to mimic the inefficient agent implies that the efficient agent's (PC_0) is always strictly satisfied. Indeed, (PC_1) and (IC_0) immediately imply (PC_0) to be held: i.e.,

$$w_0 - t_0 x_0 - (1-v)P(x_1 - x_0) > w_1 - t_0 x_1 - vP(x_0 - x_1) > w_1 - t_1 x_1 - vP(x_0 - x_1) \geq 0 .$$

Two constraints are therefore left: (PC_1) and (IC_0). Denoting the multiplier of the participation constraint (PC_1) by γ and the multiplier of the incentive constraint (IC_0) by λ, the Lagrangian equation of the principal's program can be written as

$$\begin{aligned} &L(x_i, w_i, x_0., \lambda, \gamma) \\ &\quad = v[S(x_0) - w_0] + (1-v)[S(x_1) - w_1] + \gamma[w_1 - t_1 x_1 - vP(x_0 - x_1)] \\ &\quad + \lambda[w_0 - t_0 x_0 - (1-v)P(x_1 - x_0) - w_1 + t_0 x_1 + vP(x_0 - x_1)] . \end{aligned}$$

Optimizing with respect to w_i yields

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

$$\frac{\partial L}{\partial w_1} = -(1-v) - \lambda + \gamma = 0 . \tag{A-2}$$

Summing (A-1) and (A-2), we obtain

$$\gamma = 1 > 0 ,$$

and thus the participation constraint (PC_1) is binding. Inserting $\gamma = 1$ into (A-2) yields

$$\lambda = v > 0 .$$

Therefore, (IC_0) is also binding. Now, replacing w_0 and w_1 in [P] by the previous two constraints simplifies the object function as the following [P^r]:

$$\max_{x_i} \pi = v[S(x_0) - t_1 x_1 - t_0(x_0 - x_1) - (1-v)P(x_1 - x_0)] \\ +(1-v)[S(x_1) - t_1 x_1 - vP(x_0 - x_1)] .$$

Optimizing with respect to x_i yields

$$\frac{\partial \pi}{\partial x_0} = v[S'(x_0) - t_0 + (1-v)P'(x_1 - x_0)] - (1-v)vP'(x_0 - x_1) = 0 , \quad \text{(A-3)}$$

$$\frac{\partial \pi}{\partial x_1} = v[[t_0 - t_1 - (1-v)P'(x_1 - x_0)] + (1-v)][S'(x_1) - t_1 + vP'(x_0 - x_1)] = 0 . \quad \text{(A-4)}$$

Rearranging (A-3) and (A-4), we obtain

$$S'(x_0^*) = t_0 + (1-v)[P'(x_0^* - x_1^*) - P'(x_1^* - x_0^*)] , \quad \text{(A-5)}$$

$$S'(x_1^*) = t_1 + \frac{v}{1-v}\Delta t + v[P'(x_1^* - x_0^*) - P'(x_0 - x_1)] . \quad \text{(A-6)}$$

Note that based on Eqs. (3) and (4), Eqs. (A-5) and (A-6) are expressed, respectively, as

$$S'(x_0^*) = t_0 + (1-v)(b_0 + b_1)z^* ,$$

$$S'(x_1^*) = t_1 + \frac{v}{1-v}\Delta t - v(b_0 + b_1)z^* , \text{ where } z^* = x_0 - x_1 ,$$

which correspond to Eqs. (8) and (10).

Lastly, we can ascertain the condition for $x_0^* > x_1^*$ as $(1-v)[P'(z) - P'(-z)] < \Delta t$ in (iv) from using Eqs. (A-5) and (A-6). Now, $x_0^* > x_1^*$ guarantees the truth-telling condition. Such outcome also means that cost efficiency still dominates the peer pressure effect. Using (IC_0) with binding and inserting it into (IC_1) yields

$$0 > \Delta t(x_1^* - x_0^*) .$$

Conversely, the solution of program (PP) can be obtained as below:

$$\max_{x_0, x_1} v\left[S(x_0) - x_1(t_0 - t_1) - t_0 x_0 + \frac{(1-v)b_0(x_1 - x_0)^2}{2} \right]$$

$$+(1-v)\left[S(x_1) - t_1 x_1 - \frac{vb_1(x_0 - x_1)^2}{2} \right].$$

Optimizing with respect to x_i yields

$$\frac{\partial \pi}{\partial x_0} = v[S'(x_0) - t_0 + (1-v)b_0(x_1 - x_0)] - (1-v)vb_1(x_0 - x_1) = 0$$

$$\Leftrightarrow S'(x_0^*) = t_0 + (1-v)(b_0 + b_0)z^*$$

$$\frac{\partial \pi}{\partial x_1} = (1-v)[S'(x_1) - t_1 + vb_0(x_0 - x_1)] - v[\Delta t + (1-v)b_0(x_0 - x_1)] = 0$$

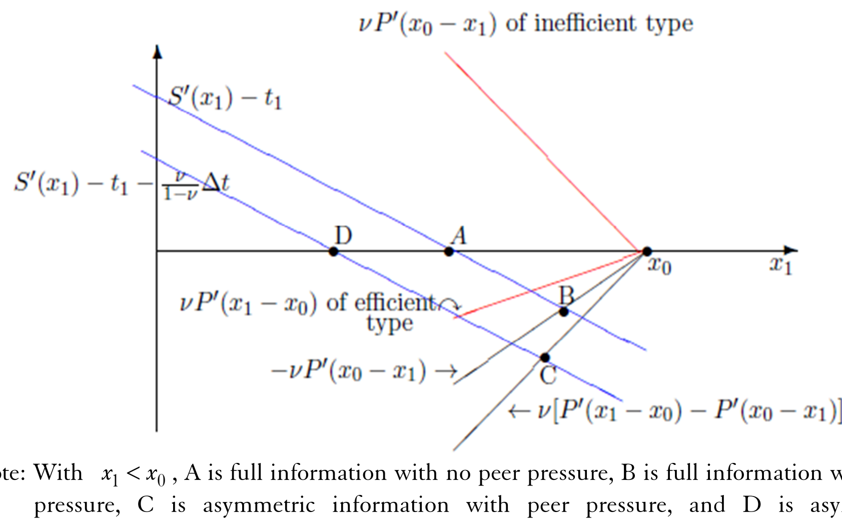
$$\Leftrightarrow S'(x_1^*) = t_1 + \frac{v}{1-v}\Delta t - v(b_0 + b_0)z^* \quad \text{where} \quad z^* = x_0^* - x_1^*.$$

Hence, we obtain $0 > \Delta t(x_1^* - x_0^*)$. Q.E.D.

Proof of Lemma 1:

The proof is clearly shown in Figure 2. After rearrangement, Eq. (10) can be expressed as $S'(x_1^*) - t_1 - \frac{v}{1-v}\Delta t = v[P'(-z^*) - P'(z^*)]$ and $S'(x_1^{fb}) - t_1 = vP'(z^{fb})$, respectively. Note that the shape of $S'(x_1)$ is downward sloping and that the sum of inequity aversion, $[P'(-z^*) - P'(z^*)]$, is negative and lower than $-P'(-z)$ according to part (iv) of Assumption I. Remember that $-z = x_1 - x_0$ and $z = x_0 - x_1$. Thus, x_1^* is derived at C and x_1^{fb} at B. In addition, x_1 from a typical adverse selection with no peer pressure term is derived at D. Now, comparison of x_1^* with x_1 in Figure 2 reveals that $x_1^* > x_1$, and thus the information rent is $\Delta t x_1^* > \Delta t x_1$.

[Figure 2]



Note: With $x_1 < x_0$, A is full information with no peer pressure, B is full information with peer pressure, C is asymmetric information with peer pressure, and D is asymmetric information without peer pressure.

One limitation in Figure 2 is that we cannot compare the magnitudes of x_1^{fb} and x_1^*. This is because of the countervailing effects between the increase in production according to the enhanced peer pressure in the information asymmetry case (i.e., $v[P'(-z^*)-P'(z^*)]<0$), and the decrease in production (i.e., $\frac{v}{1-v}\Delta t>0$) in order for the principal to reduce the information rent payment to the efficient type.[21]

Q.E.D.

[21] The final value of x_1^* will be determined according to v, b_0 and b_1 and, depending on their sizes, can be greater or smaller than x_1^{fb}. At this moment, we cannot determine which one is greater, and thus the change in the magnitude of output difference between full and asymmetric information, that is, z^* vs. z^{fb}, is difficult to compute.

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