Incentive Contracts with Disagreement*

Jaesoo Kim†

March 25. 2013

Abstract

This article examines incentive contracts when a principal and agents disagree on the agents' abilities. We analyze an agency problem with moral hazard where the principal contracts with two agents who might be overconfident or underconfident. The direction of disagreement alters the effectiveness of monetary incentives. The principal's optimal contract is joint performance evaluation with the overconfident agents and relative performance evaluation with the underconfident agents. Moreover, the principal finds it profitable to have disagreement, whether the agents are overconfident or underconfident. We further discuss how our framework can be extended to make disagreement endogenous by considering the principal's project choice, recruiting and matching.

JEL: D2, J3, L2, M5

Keywords: Incentives, contracts, disagreement, heterogeneous beliefs

*I thank Subir Chakrabarti, Henry Mak, Steven Russell, and Michael Waldman for helpful comments.
†Department of Economics, Cavanaugh Hall 511A, 425 University Boulevard, IUPUI, Indianapolis, IN 46202. Email: jaeskim@iupui.edu

1 Introduction

There are many situations in which the contracting parties have disagreement on the agents' abilities or the operating environments. The contracting parties may have different prior beliefs when faced with the same information. An executive may disagree with employees about the corporate strategies even when the employees have provided the executive with all the market information. An external lender may disagree with an entrepreneur about the value of projects or the entrepreneur's ability.

To study the interaction between disagreement and incentive structures, we extend the standard moral hazard model in which the principal offers an incentive contract to induce the agents to carry out a task. The likelihood that the task succeeds is determined not only by the agents' unobservable effort but their abilities on the task. The agents may have different beliefs about their abilities than the principal. The agents are allowed to be either overconfident or underconfident compared to the principal in the sense that they can have a more optimistic or more pessimistic view on the likelihood of the success of the tasks.

When the principal contracts with only one agent, an increase in the agent's confidence is always preferred by the principal. It is because the agent's overconfidence makes him recognize the power of incentives more acutely, and hence willing to work at a lower compensation. Thus, not surprisingly, disagreement is not necessarily desirable for the principal's interest. Only the agent's overconfidence can be exploited in a profitable way. However, the introduction of a second agent changes the problem in a significant way. In the two-agent case, the disagreement in incentive contracts has two notable consequences. First, the principal's compensation scheme is sharply different depending on whether the agents are overconfident or underconfident. The optimal incentive contract follows joint performance evaluation (hereafter JPE) for the overconfident agents, whereas relative performance evaluation (hereafter RPE) is used for the underconfident agents. Second, not only the agents' overconfidence but also their underconfidence can make the principal better off. Thus, the disagreement can be an effective means of providing incentives and thereby reducing the agency problem.

The intuition for these results is as follows. With two agents, the incentives can be provided as a mix of two devices: compensation for joint performance and compensation for relative performance. The principal's optimal mix of the two is determined by balancing the trade-off between the principal's relative price of the two and the agents' relative responsiveness to the two. The balance is in turn dependent on the different beliefs among the contracting parties. In particular, when the agents are overconfident (underconfident), they are more likely to believe that their partner will perform well (badly) and hence that they receive compensation for joint (relative) performance more often. Therefore, the principal can take advantage of the disagreement by providing JPE (RPE) to the overconfident (underconfident) agents. Interestingly, the principal can reduce the agency cost even with the underconfident agents compared to the agents who hold the same level of confidence with the principal.

We further investigate the implications of our results with respect to organizational design. For example, when the principal and the agents have different beliefs on a certain decision with two alternatives, should the principal choose the agent-preferred decision or not? This question is deeply related to the principal's leadership and her choice of incentive structures. Second, we can ask whether the principal prefers to hire the overconfident or underconfident agents. Last, when both parties can have a distribution of beliefs, we examine the matching outcome. Hence, we look at the endogenous emergence of disagreement and explain why disagreement is so common in every organization. In answering these questions, it will be highlighted that the relative merits of RPE and JPE under disagreement plays a key role.

Former GE CEO Jack Welch was known for championing internal competition. He was one of the most famous practitioner of forced ranking system. He was also known as an optimist.[1] We believe that his overconfidence is deeply related to his management style, in particular, his choice of RPE. On the contrary, Former Southwest CEO James Parker kept all of their employees and started a profit-sharing program for employees after 9/11, while many other airlines cut their workforce by up to 20 percent. His leadership and Southwest's corporate culture is known for employee satisfaction and its ′employees come first′ policy.[2] This case can be also understood in our model. When the principal has a democratic leadership style

[1] See Welch (2003) and CNNMoney, "Internal competition at work: Worth the trouble?", January 25, 2012. See also CBS, "What is forced ranking?", March 20, 2007.

[2] See Parker (2007) and Businessweek, "At Southwest, the Culture Drives Success", February 21, 2008.

in which she encourages employees' creativity and innovation, our model implies that profit-sharing as JPE can be the optimal incentive scheme. Although systematic empirical evidence is not provided in our paper, we believe that our analysis generates testable implications for the relationship between management style and incentive structure.

The key element of the model is that the contracting parties disagree. Disagreement is different from a dispute or conflict. In our model, the contracting parties have their own subjective beliefs on the quality of the task. Although they have different priors, they do not update their beliefs when they become aware of the difference.[3] They simply agree to disagree. Studies that consider the heterogeneous beliefs include Harsanyi (1967), Morris (1995), Fang and Moscarin (2005), Eliaz and Spiegler (2006), and Van den Steen (2005, 2010), and Che and Kartik (2009) among many others.

In particular, several papers study the effect of the different prior beliefs on incentive contracts. (Goel and Thakor 2008; Santos-Pinto 2008; de la Rosa 2012) A common result is that hiring the overconfident (underconfident) agents is beneficial (harmful) to the principal. This article makes three contributions to the literature: (i) the incentive scheme follows JPE with the overconfident agents and RPE with the underconfident agents, (ii) the disagreement can be desirable in a principal-agent relationship even when the agents are underconfident, and (iii) the disagreement is naturally emerging from organizational management such as project choice and recruiting, and the matching between the principal and the agents.

Our first contribution is closely related to the literature that has studied the merits of JPE and RPE. (Green and Stocky 1983; Mookherjee 1984; Itoh 1991; Che and Yoo 2001; Kvaloy and Olsen 2006, Kim 2012) To the best of our knowledge, our model first points out that the disagreement between the contracting parties may determine the emergence of JPE and RPE as the optimal incentive scheme. The second contribution is reminiscent of Santos-Pinto (2008) and de la Rosa (2012). They also show that the principal can take advantage of the pessimistic beliefs of the agents. However, they consider the case where there is no agency problem, whereas we find that the agent's pessimism can be made use of by the principal even in the presence of

[3] One important source of the disagreement is that people tend to have overly positive self-assessments. Numerous studies in experimental economics and social psychology have documented that people are overconfident. See Baker et al. (1988), Buehler et al. (1994) and Josephs and Hahn (1995) among many others.

moral hazard. Last, since both overconfidence and underconfidence of the agents can reduce the agency cost, we study which bias can be better utilized by the principal's managerial decisions.

The remainder of the paper is organized as follows. Section 2 lays out the basic model. Section 3 characterizes the incentive contracts. We begin with the benchmark case in which the principal contracts with one agent. Then, we study the two-agent case and present the main results. In Section 4, we make the disagreement endogenous by considering three important issues: project choice, recruiting, and matching. Section 5 concludes.

2 Model

Consider that a principal employs a risk averse agent(s) to perform a task. The outcome of the task can be either success or failure, $x \in \{S, F\}$. The outcome depends on two things: the agent's effort and the agent's ability. The agent's effort $e \in \{0, 1\}$ cannot be observed by the principal as in a standard moral hazard model.[4] The agent's cost function is given by $C(e) = ce$. That is, the agent's work, $e = 1$, incurs a utility cost c, whereas shirking, $e = 0$, does not incur such a cost. The agent has an outside option which is given by $\overline{u} \geq 0$.

The agent's ability $Q \in \{G, B\}$ can be interpreted interchangeably as the quality of the task. $Q = G$ (B) stands for the high (low) ability agent or the good (bad) quality of the task. The agent's ability is not verifiable by a third party and hence not contractible. The agent's ability is beyond anyone's control and is exogenously determined. The principal and the agent have their own subjective beliefs about the likelihood of $Q = G$. In other words, they hold different prior beliefs. Note that this is not private information. As stressed in the Introduction, they do not update their beliefs when they find someone who holds a different belief. It is common knowledge that the principal's belief on $Q = G$ is θ_P, whereas the agent's belief is θ_A. Accordingly, their beliefs on $Q = B$ are $1 - \theta_P$ and $1 - \theta_A$, respectively.[5]

[4] For analytical tractability, we take this simple setup with binary output and binary effort as in Che and Yoo (2001), Kvaloy and Olsen (2006) and many others. In particular, the binary effort model allows us to abstract from the principal's problem of choosing the optimal effort level. However, this can be easily relaxed to a continuous effort model. This extension does not change our main results.

[5] Later each contracting party's belief will be determined endogenously once we consider the principal's project choice, recruiting decision, or endogenous matching between the principal and the agents.

For the task to be successfully accomplished, the agent's ability must be good and the agent should exert effort as well. Thus, the agent's perceived probability of success is $p(e;\theta_A) = \theta_A e$ and the principal's perceived probability of success is $p(e;\theta_P) = \theta_P e$, where $\theta_A \in (0,1)$ and $\theta_P \in (0,1)$. We allow θ_P to be greater than or less than θ_A. When $\theta_P < \theta_A$, the agent will be referred to as overconfident or more optimistic than the principal. Likewise, when $\theta_P > \theta_A$, the agent will be called underconfident or more pessimistic.[6]

Since the principal can observe the realization of the agent's outcome, the principal offers an incentive contract that will be contingent on the outcome of the task. Thus, when only one agent is considered, the contract stipulates two different transfers, $\mathbf{v}^1 \equiv (v^S, v^F) \in R^2$. The agent receives v^S in the case of $x = S$ and v^F in the case of $x = F$. Then, the risk averse agent's expected payoff is:

$$U(e;\theta_A) = p(e;\theta_A)u(v^S) + (1 - p(e;\theta_A))u(v^F) - ce. \tag{1}$$

with $u'(\cdot) > 0$, $u''(\cdot) < 0$, $u(0) = 0$ and $u'(0) = \infty$.[7]

When the principal wants to hire two agents, $i = 1, 2$, the principal confronts the four different situations and offers a contract $\mathbf{v}^2 \equiv (v_i^{SS}, v_i^{SF}, v_i^{FS}, v_i^{FF}) \in R^4$, where $v_i^{x_i x_j}$ represents the transfer given to agent i in each situation, $x_i \in \{S, F\}$ and $x_j \in \{S, F\}$. Both agents succeed with probability $p(e_1;\theta_A)p(e_2;\theta_A)$, agent 1 succeeds but agent 2 fails with $p(e_1;\theta_A)(1-p(e_2;\theta_A))$, agent 2 succeeds but agent 1 fails with $(1 - p(e_1;\theta_A))p(e_2;\theta_A)$, and neither agent succeeds with $(1-p(e_1;\theta_A))(1-p(e_2;\theta_A))$. Without loss of generality, we restrict attention to the symmetric case. Agent i's expected payoff is:

$$\begin{aligned} U_i(e_i, e_j;\theta_A) &= p(e_i;\theta_A)p(e_j;\theta_A)u(v^{SS}) + p(e_i;\theta_A)(1 - p(e_j;\theta_A))u(v^{SF}) \\ &\quad +(1 - p(e_i;\theta_A))p(e_j;\theta_A)u(v^{FS}) + (1 - p(e_i;\theta_A))(1 - p(e_j;\theta_A))u(v^{FF}) \\ &\quad -ce_i \end{aligned} \tag{2}$$

[6] Most papers focus on the case that agents are overconfident. However, our model allows the case that the principal can be more optimistic than the agent, i.e., the underconfident agent. This is important because entrepreneurs and managers, who can be thought of as the principal in our model, are found to be unrealistically optimistic about their business prospect and future performance.

[7] The assumption $u'(0) = \infty$ guarantees an interior solution, thereby simplifying the analysis without affecting the results.

We assume that the agents share the same belief on θ_A. This assumption can be justified by the fact that the agents share similar information and knowledge compared to the principal.[8]

Following the literature, $\mathbf{v}^2$ is referred to joint performance evaluation if $(v^{SS}, v^{FS}) > (v^{SF}, v^{FF})$ and relative performance evaluation if $(v^{SS}, v^{FS}) < (v^{SF}, v^{FF})$.[9] An agent's effort generates positive externalities to his partner under JPE, while negative externalities under RPE. For instance, when an agent succeeds the task, his compensation is either v^{SS} or v^{SF} depending on whether his partner succeeds or fails. Hence, when $v^{SS} > v^{SF}$, the partner's good performance makes the agent better off. On the other hand, when $(v^{SS}, v^{FS}) = (v^{SF}, v^{FF})$, it can be easily seen that $U_i(e_i, e_j; \theta_A)$ is reduced to $U(e; \theta_A)$. That is, the compensation scheme is individual performance evaluation (hereafter, IPE).

Finally, in what follows, we assume that the agent's work is highly important. Hence, the principal always induces effort from the agents. This assumption can be relaxed with no impact on the results. In this way, we do not need to specify the principal's payoff function. The principal's objective is minimizing the expected payment to the agents based on her belief, θ_P.

The timing of the game is as follows. In the first stage, the principal offers a contract to agent(s), who can accept or reject it. When two agents are considered, if one of the agents rejects the offer, then the game is reduced to the one-agent case. In the second stage, if the contract is accepted by both, the agents decide whether to work or not simultaneously. As a result of effort, in the third stage, the outcome of the task is realized and the agent(s) receives payments as stipulated in the contract.

3 Incentive Contract

One agent. As a benchmark case, we first consider the case with one agent.[10] Since the principal always induces the agent's effort, the principal's objective is to minimize the total payments to the agent, $\Psi^1 \equiv p(e = 1; \theta_P)v^S + (1 - p(e = 1; \theta_P))v^F = \theta_P v^S + (1 - \theta_P)v^F$. The

[8] This is not a necessary assumption for the results that follow, as long as the difference in their beliefs is not large. In addition, the principal never wants to hire agents with different beliefs. See Proposition 6.

[9] The inequality indicates weak inequality of each component and strict inequality for at least one component.

[10] Most papers look at the first-best outcome as a benchmark case; however, it is not our main interest. We want to compare the one-agent case and the two-agent case in the presence of moral hazard. One can refer to de la Rosa (2012) to see the first-best outcome in a similar setup.

minimum-payment contract solves:

$$\min_{v^S, v^F} \theta_P v^S + (1-\theta_P) v^F$$

subject to

$$(i)\ \ \theta_A(u(v^S) - u(v^F)) \geq c \tag{3}$$

$$(ii)\ \theta_A u(v^S) + (1-\theta_A)u(v^F) - c \geq \overline{u} \tag{4}$$

$$(iii)\ \ v^S, v^F \geq 0. \tag{5}$$

The first constraint (3) is the incentive compatibility constraint that requires the agent to exert effort, $U(e = 1; \theta_A) \geq U(e = 0; \theta_A)$. As usual, if the agent is indifferent between work and shirk, we assume that he prefers to work as a tie-breaking rule. It is intuitive that the higher the agent's belief, the less stringent the constraint is. That is, the lower-powered incentives $u(v^S) - u(v^F)$ can induce the agent's effort. The second constraint (4) is the participation constraint which guarantees that the agent accepts the contract in equilibrium, $U(e = 1) \geq \overline{u} \geq 0$. Last, the agent is protected by the limited liability constraints which do not allow the transfer to be negative.[11]

Proposition 1 *(a) The optimal contract is characterized as:*

if $\theta_A \leq \widehat{\theta}$, $v^S = \dfrac{c}{\theta_A} + \overline{u}$ *and* $v^F = \overline{u}$,

if $\theta_A > \widehat{\theta}$, v^S *and* v^F *satisfy* $\dfrac{u'(v^F)}{u'(v^S)} = \dfrac{\theta_A/(1-\theta_A)}{\theta_P/(1-\theta_P)}$ *and* $\theta_A u(v^S) + (1-\theta_A)u(v^F) = c + \overline{u}$,

where $\frac{u'(\overline{u})}{u'(c/\widehat{\theta}+\overline{u})} = \frac{\widehat{\theta}/(1-\widehat{\theta})}{\theta_P/(1-\theta_P)}$. *(b) As* θ_A *rises, the principal's expected payment decreases.*

Proof. In the appendix. ■

The optimal contract is illustrated in Figure 1 (a). When θ_A is small, strong incentives are

[11] In fact, the limited liability constraints are not necessary for the presence of moral hazard because the agent is risk averse. They do not affect the results in Proposition 1, 2, and 3. However, we prefer to keep them because we will later look at the case where the agents are risk neutral. See Corollary 4.

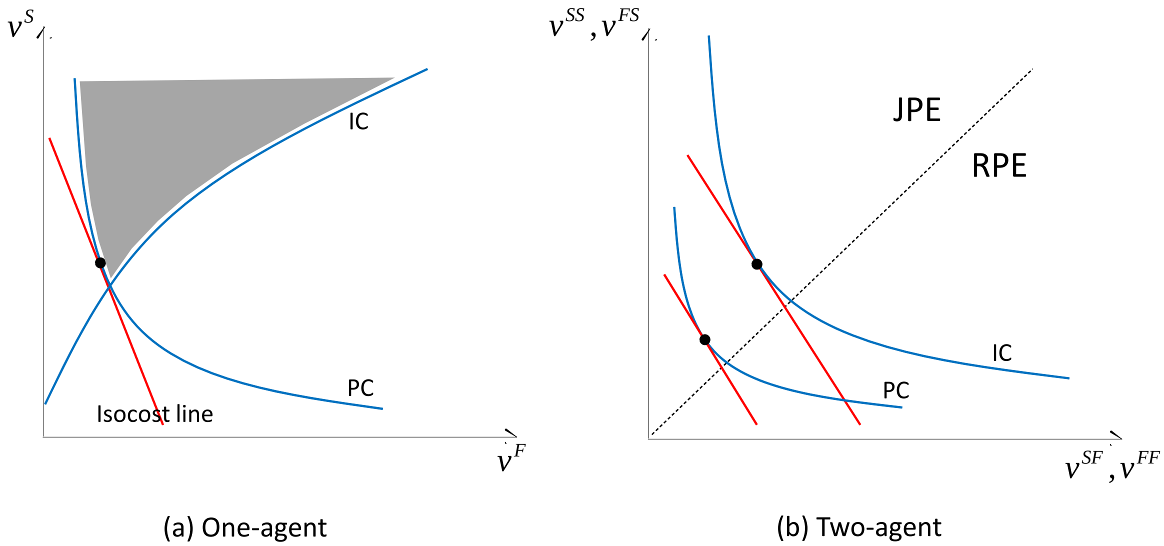

Figure 1: Optimal Contract. In the one-agent case, (a) illustrates the case where only the participation constraint is binding due to high θ_A. As θ_A gets smaller, both constraints will bind at the kinked point. In the two-agent case, (b) illustrates the reduced case where the incentive constraint is only $\theta_A^2(u(v^{SS}) - u(v^{FS})) + \theta_A(1-\theta_A)(u(v^{SF}) - u(v^{FF})) \geq c$.

needed to induce effort. Hence, both constraints (3) and (4) bind. In this case, the optimal compensation can be readily found as the solution of the two constraints. When θ_A is large, only the participation constraint (4) binds simply because the agent is confident enough. Thus, the optimal compensation can be found by comparing the slope of the isocost line and that of the participation constraint:

$$\frac{1-\theta_P}{\theta_P} = \frac{(1-\theta_A)}{\theta_A}\frac{u'(v^F)}{u'(v^S)} = -\left.\frac{dv^S}{dv^F}\right|_{U(e=1)=\overline{u}}. \tag{6}$$

The isocost line is the locus of wage combinations along which expected payment is constant. The LHS of (6) is the slope of the isocost line. On the other hand, the RHS of (6) is the slope of the participation constraint. Interestingly, when only the participation constraint is binding (θ_A is large), higher-powered incentives are provided for a more optimistic agent: v^S/v^F is increasing in θ_A.[12]

[12] In a more general setup, de la Rosa (2012) shows that the effect of θ_A on the power of incentives, $u(v^S) - u(v^F)$ is non-monotonic. Similarly, in our model, it is easy to check that v^S/v^F is decreasing in θ_A when the both constraints are binding (θ_A is small).

In the one-agent case, the principal's expected payment is decreasing with the agent's belief or confidence. The agent's underconfidence always increases the agency cost. This is simply because higher-powered incentives are needed for the underconfident agent to exert effort. This result can be easily seen in the following:

$$\frac{\partial \Psi^1}{\partial \theta_A} = -(\lambda_1 + \lambda_2)(u(v^S) - u(v^F)) < 0.$$

This can be obtained by applying the envelope theorem to the principal's minimization problem. λ_1 and λ_2 are the Lagrange multipliers attached to the incentive compatibility constraint (3) and the participation constraint (4) respectively. Whether each constraint is binding or not, the principal's expected payment is decreasing in θ_A, because the principal can save a little bit of $u(v^S) - u(v^F)$. It immediately implies that the principal prefers to hire the overconfident agent. However, we will see that the principal may benefit even from the underconfidence of the agents in the two-agent case.

Two agents. Next, we consider the case with two agents. The principal's expected payment to each agent is now written as $\Psi^2 \equiv p(e_i = 1; \theta_P)p(e_j = 1; \theta_P)v^{SS} + p(e_i = 1; \theta_P)(1 - p(e_j = 1; \theta_P))v^{SF} + (1 - p(e_i = 1; \theta_P))p(e_j = 1; \theta_P)v^{FS} + (1 - p(e_i = 1; \theta_P))(1 - p(e_j = 1; \theta_P))v^{FF}$. Thus, the contract solves:

$$\min_{v^{SS}, v^{SF}, v^{FS}, v^{FF}} \theta_P^2 v^{SS} + \theta_P(1 - \theta_P)v^{SF} + \theta_P(1 - \theta_P)v^{FS} + (1 - \theta_P)^2 v^{FF}$$

subject to

$$(i) \quad \min \left\{ \begin{array}{c} \theta_A^2(u(v^{SS}) - u(v^{FS})) + \theta_A(1 - \theta_A)(u(v^{SF}) - u(v^{FF})), \\ \theta_A(u(v^{SF}) - u(v^{FF})) \end{array} \right\} \geq c \quad (7)$$

$$(ii) \ \theta_A^2 u(v^{SS}) + \theta_A(1 - \theta_A)u(v^{SF}) + \theta_A(1 - \theta_A)u(v^{FS}) + (1 - \theta_A)^2 u(v^{FF}) - c \geq \overline{u} \quad (8)$$

$$(iii) \quad v^{SS}, v^{SF}, v^{FS}, v^{FF} \geq 0. \quad (9)$$

As in the one-agent case, the principal minimizes the expected payment to the agents with three constraints: incentive compatibility constraint, participation constraint, and limited liability constraint. The incentive compatibility constraint (7) is derived from the simultaneous choice of effort by the agents:

$$U_i(e_i = 1, e_j = 1; \theta_A) \geq U_i(e_i = 0, e_j = 1; \theta_A),$$

$$U_i(e_i = 1, e_j = 0; \theta_A) \geq U_i(e_i = 0, e_j = 0; \theta_A) \text{ for } i = 1, 2 \text{ and } i \neq j.$$

Intuitively, we would expect that the first constraint is stricter under RPE. Recall that RPE results in negative externalities. Hence, the incentive to work is weakened because the other agent's effort is unfavorable. Similarly, the second constraint is stricter under JPE because the other agent's effort is favorable.[13] Also, the participation constraint (8) ensures each agent's acceptance of the contract, i.e., $U_i(e_i = 1, e_j = 1; \theta_A) \geq \overline{u}$. The following proposition characterizes the optimal contract.

Proposition 2 *If the agents are overconfident (underconfident) relative to the principal, i.e., $\theta_P < \theta_A$ ($\theta_P > \theta_A$), then the JPE (RPE) scheme is preferred:*

$$\text{as } \theta_P \lesseqgtr \theta_A, \; v^{SS} \gtreqless v^{SF} \text{ and } v^{FS} \gtreqless v^{FF}.$$

Proof. In the appendix. ■

First of all, when there is no disagreement among the contracting parties, i.e., $\theta_P = \theta_A$, the optimal compensation scheme is individual performance evaluation, which has been already characterized by Proposition 1. In this standard setting with the common beliefs, the principal does not have incentives to create an interdependent compensation structure because it increases each agent's risk exposure.[14] However, the disagreement changes the optimal compensation scheme in a significant way.

[13] We believe that the simultaneous choice of effort is a reasonable setting, but it is not necessary. When the agents choose their effort sequentially, the problem is indeed reduced and simpler to analyze without changing our main results. Since the second mover can observe the first mover's effort choice, we do not need the latter part, $\theta_A(u(v^{SF}) - u(v^{FF})) \geq c$, in (7).

[14] Relating to this point, it is well-known in the literature that RPE is optimal when there exists a common

When the principal deals with the underconfident, i.e., $\theta_P > \theta_A$, the principal prefers RPE. The underconfident agents believe that they will receive v^{SF} (v^{FF}) relative to v^{SS} (v^{FS}) more frequently vis-á-vis the principal. The reason is that the underconfident agents underestimate their own abilities in the principal's point of view. Knowing this fact, the principal find it less costly to provide RPE. For example, consider the case of $\theta_P = 0.9$ and $\theta_A = 0.7$. The principal believes that she has to give v^{SS} with probability 0.81 and v^{SF} with probability 0.09, whereas the agents believe that they receive v^{SS} with probability 0.49 and v^{SF} with probability 0.21. In this case, v^{SF} is more effective relative to v^{SS} in motivating the agents. On the other hand, when the agents are overconfident, i.e., $\theta_P < \theta_A$, the principal adopts JPE. In this case, the overconfident agents expect to receive v^{SS} (v^{FS}) relative to v^{SF} (v^{FF}) more often than the principal expects to pay. Hence, JPE is less costly to the principal. This is the intuition for the fact that the optimal contract regime is dependent on the agents' over- or underconfidence.

We look at the incentive compatibility constraints as a sufficient condition for both agents choosing work. However, as in most papers, we can focus on Nash equilibrium of the simultaneous effort choice game as a necessary condition. This corresponds to the case where we drop the latter part $\theta_A(u(v^{SF}) - u(v^{FF})) \geq c$. This approach is useful for the presentation as follows. Since both (7) and (8) bind, they can be solved together and can be rewritten as

$$(i)' \quad \theta_A u(v^{SS}) + (1-\theta_A)u(v^{SF}) = \overline{u} + \frac{c}{\theta_A} \tag{10}$$

$$(ii)' \quad \theta_A u(v^{FS}) + (1-\theta_A)u(v^{FF}) = \overline{u}. \tag{11}$$

Then, the contract minimizes the payment subject to (10) and (11). Indeed, the principal face the two separate problems. She chooses the optimal combination of v^{SS} and v^{SF} to satisfy the incentive compatibility constraint. She also choose the optimal combination of v^{FS} and v^{FF} to meet the participation constraint. As illustrated in Figure 1-(b), when we compare the slope of

shock affecting both agents' performance. In this case, RPE reduces each agent's risk exposure by filtering out the common shock.

the isocost line and that of each constraint, we obtain:

$$\frac{1-\theta_P}{\theta_P} = \frac{(1-\theta_A)}{\theta_A}\frac{u'(v^{SF})}{u'(v^{SS})} = \left.\frac{dv^{SS}}{dv^{SF}}\right|_{U_i(e_i=1,e_j=1)=U_i(e_i=0,e_j=1)} \tag{12}$$

$$= \frac{(1-\theta_A)}{\theta_A}\frac{u'(v^{FF})}{u'(v^{FS})} = -\left.\frac{dv^{FS}}{dv^{FF}}\right|_{U_i(e_i=1,e_j=1)=\overline{u}}. \tag{13}$$

This result shows how organizational incentive structures can be shaped by disagreement between contracting parties. Whether organizations reward joint performance or relative performance is determined by which party is more or less confident. When CEOs or managers are overconfident relative to their employees, our model predicts that they are more likely to promote internal competition to incentivize workers. On the other hand, when workers are overconfident, organizations may provide team-based rewards.

Proposition 3 *The principal's expected payment decreases in θ_A when $\theta_P < \theta_A$, while if θ_A is not too small, it increases in θ_A when $\theta_P > \theta_A$.*

Proof. In the appendix. ■

Another important result is that the agents' underconfidence does not necessarily increase the agency cost. This is sharply different from the one-agent case. Perhaps surprisingly, contracting with the underconfident agents can be better for the principal than with the agents with homogeneous beliefs, as long as the agents' beliefs are not too low. The intuition is as follows. Recall that the principal dealing with two agents is now able to create two types of incentives: one for joint performance and one for relative performance. The disagreement creates a discrepancy between the principal's relative price of the two incentives and the agents' relative responsiveness to the two incentives. The discrepancy allows the principal to optimally mix the two incentives at a lower price.

This argument can be understood in the following:

$$\frac{\partial \Psi^2}{\partial \theta_A} = -\lambda_1\left[u(v^{SS}) - u(v^{SF}) + c/\theta_A^2\right] - \lambda_2\left[u(v^{FS}) - u(v^{FF})\right].$$

Again, λ_1 and λ_2 are the Lagrange multipliers attached to (10) and (11). The sign of the above is determined by whether the wage scheme is JPE or RPE. Under JPE, i.e., $(v^{SS}, v^{FS}) > (v^{SF}, v^{FF})$, the expected payment is decreasing in θ_A. On the other hand, under RPE, i.e., $(v^{SS}, v^{FS}) < (v^{SF}, v^{FF})$, the expected payment is increasing in θ_A unless it is not too small. Thus, the both types of bias, overconfidence or underconfidence, can be exploited by the principal.[15]

It is worthwhile to point out how our finding is different from the two closest papers: de la Rosa (2012) and Santos-Pinto (2008). First, unlike ours, de la Rosa (2012) studies the model with one principal and one agent and shows the result that the principal's expected profit increases in the agent's level of pessimism as well as optimism. But, in his model, this result holds only when no effort is implemented. Next, Santos-Pinto (2008), like ours, studies the model with one principal and multiple agents. This paper also shows the similar result in the case where effort is observable and contractible. That is, in both cases, when there is no incentive issue and hence no moral hazard, the agent's pessimism can be desirable in the principal's point of view. However, in our model, we show that the negatively biased beliefs of the agents can be beneficial in the presence of moral hazard.[16]

4 Economic Implications

The previous analysis shows that the principal can benefit from the disagreement with the agents, in particular, even when the agents are underconfident. The agents' biased beliefs can reduce the agency cost regardless of whether it is positive or negative. Then, a natural question

[15] Figure 1 (b) can illustrate this result. Suppose that the principal and the agents have identical beliefs, i.e., $\theta_P = \theta_A$. (12) and (13) immediately imply that the optimal incentive scheme is IPE ($v^{SS} = v^{SF}$ and $v^{FS} = v^{FF}$). Hence the isocost line is tangent to the both incentive compatibility constraint and participation constraint along the 45 degree line. Now, consider that the agents have different beliefs than the principal. Then, both constraints rotate counter-clockwise when the agents are overconfident, whereas they rotate clockwise when the agents are underconfident. In both case, the isocost line must shift down to be tangent to both constraints. This is the reason why the agency cost can be lower not only with the overconfident agents but also with the underconfident agents.

[16] Santos-Pinto (2008) also looks at the case that the agents hold mistaken beliefs about their co-workers while they have correct beliefs about their own abilities. In this setup, he shows that the principal prefers to use an interdependent incentive scheme. Compared to this, our model is concerned with the disagreement between the principal and the agents, and clearly shows how RPE reduces the agency cost even with the underconfident agents.

is which bias can be exploited more effectively by the principal. This question is also equivalent to asking the relative merits of JPE or RPE.

For example, the agents' beliefs in their abilities can be endogenous to the principal's project choice. Also, the principal may be able to distinguish agents with overconfidence from those with underconfidence. In this case, which group of agents does the principal want to hire? Similarly, when the principal and agents have heterogeneous beliefs, what would be a matching outcome. This section investigates these questions as the implications of our main results.

For further analysis, we simplify our model by assuming that the value of the outside option is zero, i.e., $\overline{u} = 0$, and that the agents are now risk neutral, i.e., $u(v) = v$.[17] This simplification provides the following transparent results.

Corollary 4 *Suppose $\overline{u} = 0$ and $u(v) = v$. With $\theta_P < \theta_A$, the JPE scheme is $v^{SS} = \frac{c}{\theta_A^2}$ and $v^{SF} = v^{FS} = v^{FF} = 0$. The principal's expected payment is $\Psi^2 = \frac{\theta_P^2}{\theta_A^2}c$. On the other hand, with $\theta_P > \theta_A$, the RPE scheme is $v^{SF} = \frac{c}{\theta_A(1-\theta_A)}$ and $v^{SS} = v^{FS} = v^{FF} = 0$. The principal's expected payment is $\Psi^2 = \frac{\theta_P(1-\theta_P)}{\theta_A(1-\theta_A)}c$.*

The zero value of the outside option enables us to ignore the participation constraint (8), which immediately implies $v^{FS} = v^{FF} = 0$. The agents' risk neutrality allows us to find the principal's expected payments to the agents in a closed form. As $u(v) = v$, both the isocost line and the incentive compatibility constraint are linear, so that we must have a corner solution.[18] The solutions can be found directly from (7). The principal's expected payment with JPE is decreasing in θ_A, while with RPE it is increasing in θ_A as long as θ_A is greater than 1/2. For the rest of the paper, we restrict consideration to the relevant case of $\theta_A \geq 1/2$.

4.1 Project Choice

Consider that the contracting parties' beliefs are now endogenously influenced by the principal's decision. Suppose that the principal has to make a choice from the set $D \in \{X, Y\}$ before

[17] Note that since there exist the limited liability constraints, the moral hazard problem is still present.

[18] When $\theta_P = \theta_A$, the isocost line coincides with the incentive compatibility constraint. As a result, the optimal contract is not unique in this case.

proposing a contract. The principal's decision is perfectly observable. Whether the decision is correct or not is dependent on the state variable $S \in \{X, Y\}$. The principal and the agents disagree on S. The principal's subjective belief on $S = X$ is $\mu \in (0.5, 1)$ while the agents believe that $S = Y$ with μ. That is, the principal is biased in favor of X, whereas the agents are biased towards Y with the same intensity.

Next, the probability of having $Q = G$ is given by

$$\Pr(Q = G) = \Pr(D = S) + \Pr(D \neq S)(1 - \alpha), \text{ where } \alpha \in (0, 1).$$

The correct decision makes the high ability agent with probability 1, while the wrong decision makes the high ability agent with probability $1-\alpha$. The wrong decision decreases the probability of $Q = G$ by α. That is, α captures the importance of the decision. For example, as $\alpha \to 1$, the correct decision has to be made because the wrong decision does not allow us to have $Q = G$. However, as $\alpha \to 0$, it does not matter whether the decision is correct or wrong because the probability of $Q = G$ becomes 1

When X is chosen, we obtain each contracting party's belief on the agents' ability as $\theta_P = \mu + (1-\mu)(1-\alpha)$ and $\theta_A = 1 - \mu + \mu(1-\alpha)$. On the other hand, when Y is chosen, their beliefs are reversed as $\theta_P = 1 - \mu + \mu(1-\alpha)$ and $\theta_A = \mu + (1-\mu)(1-\alpha)$. Note that the disagreement is increasing in α in both case because $|\theta_P - \theta_A| = (2\mu - 1)\alpha$. According to Proposition 2, the principal offers the RPE contract with $D = X$ because it turns that $\theta_P > \theta_A$. Likewise, the principal offers the JPE contract with $D = Y$ because it turns that $\theta_P < \theta_A$.

Proposition 5 *$D = Y$ if $\alpha > \widehat{\alpha}$, whereas $D = X$ if $\alpha < \widehat{\alpha}$. The principal implements the agent-preferred project if the importance of the decision is large enough, and vice versa.*

Proof. In the appendix. ■

When the effect of the decision is relatively large, the principal chooses to follow the agents' preference in the project choice. On the other hand, when the effect of the decision is relatively small, the principal follows her own preference. The trade-off regarding the principal's project choice is between JPE and RPE. Under JPE with $D = Y$, the agents perceive that the tasks are complementary and so are their beliefs.[19] Hence, as θ_A rises, the benefit of JPE increases at an increasing rate. This can be seen by the fact that the probability of receiving v^{SS}, i.e., θ_A^2, is convex. On the other hand, RPE with $D = X$ makes the tasks substitutes in the agents' perspective. As θ_A falls, the benefit of RPE increases at a decreasing rate. Similarly, this can be seen by the probability of receiving v^{SF}, i.e., $\theta_A(1 - \theta_A)$, being concave. As a result, when α is large, and so is $|\theta_P - \theta_A|$, JPE dominates RPE, and vice versa.

The result sheds light on the principal's leadership style and organizational incentive structures. When α is large and hence the disagreement is large, the principal is more likely to have participative or democratic leadership in the sense that the agent-preferred project is implemented. At the same time, the prevailing incentive structure is promoting and rewarding team performance. In contrast, when α is small, the principal's leadership is more authoritarian or autocratic because she is more likely to enforce her own ideas and her preferred project. This autocratic leadership entails competitive incentive structures. These findings are consistent with Jack Welch and James Parker's leadership and many other informal observations. It is common that many organizations are internally competitive under an autocratic leader, whereas collaborative culture is more likely to be built under a democratic leader.

4.2 Recruiting

Suppose there are two types of agents: those who are underconfident and those who are overconfident, i.e., $\theta_A \in \{\theta_L, \theta_H\}$, where $\theta_L < \theta_P < \theta_H$. A group of agents share a more optimistic belief, θ_H, while the other group shares a more pessimistic belief, θ_L. When the principal needs to recruit two agents, she has three different options: hiring both with θ_H, both with θ_L, or one with θ_H and the other one with θ_L. Then, interesting questions are whether the principal prefers to recruit a team of agents with identical beliefs or with heterogeneous beliefs and whether she wants to hire both with overconfidence or both with underconfidence.

[19] Kim (2012) shows that the agents perceive that their tasks are complements under JPE, whereas the tasks are perceived as substitutes under RPE. In our model, note that

$$\frac{\partial U_i}{\partial e_j} = \theta_A \left[\theta_A e_i (v^{SS} - v^{SF}) + (1 - \theta_A e_i)(v^{FS} - v^{FF}) \right].$$

The sign of this tells us whether the tasks are (gross) complements or (gross) substitutes, which is in turn determined by whether the compensation scheme is JPE or RPE.

Proposition 6 *(a) The principal never hires agents with heterogeneous beliefs. (b) The principal prefers to hire the optimistic agents if* $\theta_P < \widehat{\theta} \in (\theta_L, \theta_H)$, *whereas she prefers to hire the pessimistic agents if* $\theta_P > \widehat{\theta}$, *where* $\widehat{\theta} = \frac{\theta_H^2}{\theta_L(1-\theta_L)+\theta_H^2}$.

Proof. In the appendix. ■

The intuition for the first result is as follows. When a team is composed of agents with heterogeneous beliefs, the IC constraint for the underconfident agent is always binding in the principal's minimization problem. This implies that the principal can relax the IC constraint by replacing the underconfident agent with the overconfident agent. It seems obvious that the principal prefers the overconfident agent to the underconfident agent. However, Proposition 2 suggests, interestingly, that it may not be always true that a team with overconfident agents is preferred to a team with underconfident agents.

When the principal contracts with two overconfident agents, Corollary 3 tells us that her expected payment with JPE is $\frac{\theta_P^2}{\theta_H^2}c$. On the other hand, when the principal contracts with two underconfident agents, her expected payment with RPE is $\frac{\theta_P(1-\theta_P)}{\theta_L(1-\theta_L)}c$. Hence, we find the cutoff value of the principal's belief, $\widehat{\theta}$, above which (below which) the principal hires the underconfident agents (overconfident agents). The result is simple to understand. Recall that the agency cost is increasing in $\theta_A < \theta_P$ and decreasing in $\theta_A > \theta_P$. Hence, roughly speaking, If the principal's belief is close to the overconfident agents, she prefers to hire the underconfident agents, and vice versa.

4.3 Endogenous Matching

As an application, we also consider matching between the principal and the agents. In particular, we look at the case where the principal and each agent's belief takes two values - high or low, i.e., θ_P, $\theta_A \in \{\theta_L, \theta_H\}$ where $\theta_H > \theta_L$. The matching equilibrium should be efficient as usual. Since we know from Proposition 5 that contracting with heterogeneous agents can be Pareto improved, the matching requires the homogeneous agents. Also, recall that the participation constraint is binding in our simplified setting. Hence, we can take the negative of the principal's expected payment as joint surplus of the principal-agent pair.

The matching equilibrium is straightforward in this simple model only with two types of beliefs. Proposition 2 says that the principal is better off with the agents who hold different beliefs on the quality of the task than those who have the same beliefs. As a consequence, we obtain the negative assortative matching results. In other words, the principal with $\theta_P = \theta_H$ matches with the agents with $\theta_A = \theta_L$, while the principal with $\theta_P = \theta_L$ matches with the agents with $\theta_A = \theta_H$.

Proposition 7 *When θ_P, $\theta_A \in \{\theta_L, \theta_H\}$ where $\theta_H > \theta_L$, negative assortative matching results.*

However, if we consider the case that a distribution of beliefs is continuous, or more than two types, the matching equilibrium is not so obvious. We define the "surplus function",

$$\sigma(a,b) = \max\left\{0, -\mathcal{P}(a,b) - \frac{1}{2}\left(-\mathcal{P}(a,b) - \mathcal{P}(a,b)\right)\right\},$$

where the principal's expected payment is denoted by $\mathcal{P}$. Then, the surplus function in each JPE and RPE case is written as:

$$\begin{cases} \sigma(\theta_P, \theta_A)_{\theta_P < \theta_A} = \max\left\{0, \left(1 - \frac{\theta_P^2}{\theta_A^2}\right) c\right\} > 0, \\ \\ \sigma(\theta_P, \theta_A)_{\theta_P > \theta_A} = \max\left\{0, \left(1 - \frac{\theta_P(1-\theta_P)}{\theta_A(1-\theta_A)}\right) c\right\} > 0. \end{cases}$$

Also, it is straightforward to check that $\sigma(\theta_P, \theta_A)_{\theta_P < \theta_A}$ satisfies weak increasing differences (WID) inequalities, whereas $\sigma(\theta_P, \theta_A)_{\theta_P > \theta_A}$ satisfies weak decreasing differences (WDD) inequalities. Now, according to Proposition 10 and 11 in Legros and Newman (2002), the matching between the principal and the overconfident agents is positive assortative, while the matching with underconfident agents is negative assortative. Thus, in our model, the matching pattern is endogenous to the principal's choice of the compensation scheme. The full analysis of this problem is beyond the scope of the paper, but will be an interesting project.

The matching outcome in our model is different from Van den Steen (2005) which shows that the beliefs of the manager and the employees are more aligned. There is an important reason for why our model predicts heterogeneous matching unlike in Van den Steen (2005). The principal can use the monetary incentives to take advantage of the disagreement in our model, whereas the monetary incentives are not a main concern in his model. In some sense, the difference is obvious and intuitive. When disagreement can be handled in a desirable way, the heterogeneous matching will prevail. On the other hand, as in Van den Steen (2005), when agents are willing to work harder for firms that espouse a vision they agree with, the homogeneous matching will occur.

5 Conclusion

This article studies an optimal contract between a principal and multiple agents who have different beliefs on the agents' abilities or the quality of the task. The article provides a new rationale for the adoption of JPE and RPE as a result of disagreement and highlights that disagreement can reduce the agency cost. Several recent articles have shown that the agent's overconfidence can be profitable in the principal's perspective. However, this article finds that not only overconfidence but underconfidence of the agents can be advantageous to the principal. We have further studied how disagreement emerges from managerial decisions and endogenous matching between contracting parties.

Disagreement is often regarded as something negative and disobedient to authority in organizations, and hence increases agency problems. Van den Steen (2007) formalizes this idea in a principal-agent setting where the agent has high intrinsic or extrinsic motivation. He shows that the disagreement with high-powered incentives may increase the agent's disobedience, which is costly to the principal's interest. In contrast, our paper argues that the open disagreement can be exploited by the principal through elaborate incentive schemes. We believe that two views on disagreement are not necessarily opposing, but are showing two different sides of the same thing and hence complementary in understanding how incentives interact with disagreement in organizations. While the cost of disagreement is disobedience, the benefit of it is a lower cost of incentive provision.

6 Appendix

6.1 Proof of Proposition 1.

Proof. The Lagrangian of the problem is:

$$\begin{aligned}\mathcal{L} &= \theta_P v^S + (1-\theta_P)v^F \\ &\quad -\lambda_1 \left[\theta_A(u(v^S) - u(v^F)) - c\right] \\ &\quad -\lambda_2 \left[\theta_A u(v^S) + (1-\theta_A)u(v^F) - c - \overline{u}\right].\end{aligned}$$

The limited liability constraints are irrelevant given the assumption $u'(0) = \infty$. The first-order conditions are:

$$\frac{\partial \mathcal{L}}{\partial v^S} = \theta_P - (\lambda_1 + \lambda_2)\theta_A u'(v^S) = 0, \tag{14}$$

$$\frac{\partial \mathcal{L}}{\partial v^F} = (1-\theta_P) + (\lambda_1\theta_A - \lambda_2(1-\theta_A))\, u'(v^F) = 0, \tag{15}$$

$$\frac{\partial \mathcal{L}}{\partial \lambda_1} = \theta_A(u(v^S) - u(v^F)) - c \geq 0, \quad \lambda_1 \frac{\partial \mathcal{L}}{\partial \lambda_1} = 0, \tag{16}$$

$$\frac{\partial \mathcal{L}}{\partial \lambda_2} = \theta_A u(v^S) + (1-\theta_A)u(v^F) - c - \overline{u} \geq 0, \quad \lambda_2 \frac{\partial \mathcal{L}}{\partial \lambda_2} = 0. \tag{17}$$

When θ_A is large enough and thus $\lambda_1 = 0$, (14) and (15) yield

$$\frac{u'(v^F)}{u'(v^S)} = \frac{\theta_A/(1-\theta_A)}{\theta_P/(1-\theta_P)},$$

which characterizes the solution together with the participation constraint. Thus, we must have $v^S > v^F > 0$. However, as a fall in θ_A makes the incentive compatibility constraint bind, $\lambda_1 > 0$. In this case, solving (16) and (17) together, we get $v^S = \frac{c}{\theta_A} + \overline{u}$ and $v^F = \overline{u}$. Hence, we find the cutoff $\widehat{\theta}$ such that $\frac{u'(\overline{u})}{u'(c/\widehat{\theta}+\overline{u})} = \frac{\widehat{\theta}/(1-\widehat{\theta})}{\theta_P/(1-\theta_P)}$. Since the LHS is greater than 1 due to $u(\cdot) < 0$, we must have $\widehat{\theta} > \theta_P$.

Next, let us show that the effect of a change in θ_A on the principal's expected payment.

Using the envelope theorem,

$$\frac{\partial \mathcal{L}}{\partial \theta_A} = \frac{\partial \Psi^1}{\partial \theta_A} = -(\lambda_1 + \lambda_2)(u(v^S) - u(v^F)) < 0.$$

Thus, the principal's total payment to the agent is decreasing in θ_A. ■

6.2 Proof of Proposition 2.

Proof. The Lagrangian of the problem is written:

$$\begin{aligned} \mathcal{L} &= \theta_P^2 v^{SS} + \theta_P(1-\theta_P)v^{SF} + \theta_P(1-\theta_P)v^{FS} + (1-\theta_P)^2 v^{FF} \\ &\quad -\lambda_1 \left[\theta_A^2(u(v^{SS}) - u(v^{FS})) + \theta_A(1-\theta_A)(u(v^{SF}) - u(v^{FF})) - c\right] \\ &\quad -\lambda_2 \left[\theta_A \left(u(v^{SF}) - u(v^{FF})\right) - c\right] \\ &\quad -\lambda_3 \left[\theta_A^2 u(v^{SS}) + \theta_A(1-\theta_A)u(v^{SF}) + \theta_A(1-\theta_A)u(v^{FS}) + (1-\theta_A)^2 u(v^{FF}) - c - \overline{u}\right] \end{aligned}$$

The limited liability constraints are irrelevant given the assumption $u'(0) = \infty$. The first-order conditions are:

$$\frac{\partial \mathcal{L}}{\partial v^{SS}} = \theta_P^2 - \theta_A^2(\lambda_1 + \lambda_3)u'(v^{SS}) = 0, \tag{18}$$

$$\frac{\partial \mathcal{L}}{\partial v^{SF}} = \theta_P(1-\theta_P) - \theta_A\left[\lambda_1(1-\theta_A) + \lambda_2 + \lambda_3(1-\theta_A)\right] u'(v^{SF}) = 0, \tag{19}$$

$$\frac{\partial \mathcal{L}}{\partial v^{FS}} = \theta_P(1-\theta_P) - \theta_A\left[-\lambda_1\theta_A + \lambda_3(1-\theta_A)\right] u'(v^{FS}) = 0, \tag{20}$$

$$\frac{\partial \mathcal{L}}{\partial v^{FF}} = (1-\theta_P)^2 - \left[-\lambda_1\theta_A(1-\theta_A) - \lambda_2\theta_A + \lambda_3(1-\theta_A)^2\right] u'(v^{FF}) = 0, \tag{21}$$

$$\frac{\partial \mathcal{L}}{\partial \lambda_1} = \theta_A^2(u(v^{SS}) - u(v^{FS})) + \theta_A(1-\theta_A)(u(v^{SF}) - u(v^{FF})) - c \geq 0, \quad \lambda_1 \frac{\partial \mathcal{L}}{\partial \lambda_1} = 0, \tag{22}$$

$$\frac{\partial \mathcal{L}}{\partial \lambda_2} = \theta_A\left(u(v^{SF}) - u(v^{FF})\right) - c \geq 0, \quad \lambda_2 \frac{\partial \mathcal{L}}{\partial \lambda_2} = 0, \tag{23}$$

$$\frac{\partial \mathcal{L}}{\partial \lambda_3} = \theta_A^2 u(v^{SS}) + \theta_A(1-\theta_A)u(v^{SF}) + \theta_A(1-\theta_A)u(v^{FS}) + (1-\theta_A)^2 u(v^{FF}) - c - \overline{u} \geq 0, \quad \lambda_3 \frac{\partial \mathcal{L}}{\partial \lambda_3} = 0. \tag{24}$$

Comparing (22) and (23), we need to consider the following four cases: (i) $\lambda_1 = 0$ and $\lambda_2 = 0$, (ii) $\lambda_1 = 0$ and $\lambda_2 > 0$, (iii) $\lambda_1 > 0$ and $\lambda_2 = 0$, and (iv) $\lambda_1 > 0$ and $\lambda_2 > 0$.

Let us consider case (i): $\lambda_1 = 0$ and $\lambda_2 = 0$. Neither (22) nor (23) is likely to bind when θ_A is large enough. In this case, (18) and (19), similarly, (20) and (21) can be solved simultaneously. We have:

$$\frac{u'(v^{SF})}{u'(v^{SS})} = \frac{u'(v^{FF})}{u'(v^{FS})} = \frac{\theta_A/(1-\theta_A)}{\theta_P/(1-\theta_P)}. \tag{25}$$

Note that as $\theta_P < \theta_A$, we must have $v^{SS} > v^{SF}$ and $v^{FS} > v^{FF}$, JPE.

Now consider case (ii): $\lambda_1 = 0$ and $\lambda_2 > 0$. This case is likely when θ_A is rather small. We must have

$$u(v^{SS}) - u(v^{FS}) > u(v^{SF}) - u(v^{FF}). \tag{26}$$

From (18) and (20), we get $\frac{u'(v^{FS})}{u'(v^{SS})} = \frac{\theta_A/(1-\theta_A)}{\theta_P/(1-\theta_P)}$, which must be greater than 1 for $v^{SS} > v^{FS}$. Thus, only $\theta_P < \theta_A$ is feasible, because $u''(\cdot) < 0$. JPE is still the optimal compensation scheme as follows. From (20) and (21), we have $\frac{u'(v^{FF})}{u'(v^{FS})} = \frac{\frac{\lambda_3\theta_A(1-\theta_A)}{\lambda_3(1-\theta_A)^2-\lambda_2\theta_A}}{\theta_P/(1-\theta_P)}$, which can be shown to be greater than $\frac{\theta_A/(1-\theta_A)}{\theta_P/(1-\theta_P)}$. It implies that $v^{FS} > v^{FF}$. In turn, we must have $v^{SS} > v^{SF}$ for (26) to hold.

Consider case (iii): $\lambda_1 > 0$ and $\lambda_2 = 0$. Thus,

$$u(v^{SS}) - u(v^{FS}) < u(v^{SF}) - u(v^{FF}). \tag{27}$$

Solving (22) and (24) together, we obtain (10) and (11):

$$(i)' \quad \theta_A u(v^{SS}) + (1-\theta_A)u(v^{SF}) = \overline{u} + \frac{c}{\theta_A} \tag{28}$$

$$(ii)' \quad \theta_A u(v^{FS}) + (1-\theta_A)u(v^{FF}) = \overline{u}. \tag{29}$$

As a consequence, the principal's problem can be reduced to be minimizing the expected payment subject to two constraints (10) and (11). Note that the choice of v^{SS} and v^{SF} and that of v^{FS} and v^{FF} are separable. Comparing the slope of the isocost and that of each constraint, we obtain (25) again. For (27) to hold, we should have RPE, and only $\theta_P > \theta_A$ is feasible.

Last, consider case (iv): $\lambda_1 > 0$ and $\lambda_2 > 0$. We must have

$$u(v^{SS}) - u(v^{FS}) = u(v^{SF}) - u(v^{FF}). \tag{30}$$

It is evident from the first two cases that (25) must hold. As a result, we obtain $v^{SS} = v^{SF}$ and $v^{FS} = v^{FF}$. For (30) to hold, this case turns out to be IPE. This is valid only when $\theta_P = \theta_A$. ■

6.3 Proof of Proposition 3.

Proof. From the proof of Proposition 2, we know $\lambda_1 = 0$ under JPE. Using the envelope theorem, we get

$$\begin{aligned} \frac{\partial \mathcal{L}}{\partial \theta_A} &= -\lambda_2 \left[u(v^{SF}) - u(v^{FF}) \right] \\ &\quad -\lambda_3 \left[\begin{array}{c} 2\theta_A \left(u(v^{SS}) - u(v^{SF}) \right) + (1 - 2\theta_A) \left(u(v^{FS}) - u(v^{FF}) \right) \\ +u(v^{SF}) - u(v^{FF}) \end{array} \right]. \end{aligned} \tag{31}$$

Note that each term attached to λ_2 and λ_3 is negative under JPE ($v^{SS} > v^{SF}$ and $v^{FS} > v^{FF}$). Thus, the principal's expected payment is decreasing in θ_A under JPE.

Similarly, since we know $\lambda_2 = 0$ under RPE, the envelope theorem gives

$$\begin{aligned} \frac{\partial \mathcal{L}}{\partial \theta_A} &= \frac{\partial \Psi^2}{\partial \theta_A} = -2\theta_A(\lambda_1 + \lambda_3) \left[\left(u(v^{SS}) - u(v^{SF}) \right) - \left(u(v^{FS}) - u(v^{FF}) \right) \right] \\ &\quad -\lambda_3 \left(u(v^{FS}) - u(v^{FF}) \right) \\ &\quad -(\lambda_1 + \lambda_3) \left[\left(u(v^{SF}) - u(v^{FF}) \right) \right] \end{aligned} \tag{32}$$

Note that first two terms are always positive under RPE ($v^{SS} < v^{SF}$ and $v^{FS} < v^{FF}$), while the third term is negative. It can be seen by (26) that the first term is negative. One can also notice that $\theta_A > 1/2$ is a sufficient condition for $\frac{\partial \mathcal{L}}{\partial \theta_A}$ to be positive. Therefore, we can conclude that if θ_A is not too small, the principal's expected payment is increasing in θ_A under RPE. ■

6.4 Proof of Proposition 5.

Proof. The principal's expected payment in each case is written as:

$$\mathcal{P}_{D=X}(\alpha) = \frac{\mu + (1-\mu)(1-\alpha)}{1-\mu+\mu(1-\alpha)}\frac{1-\mu}{\mu} \quad \text{and} \tag{33}$$

$$\mathcal{P}_{D=Y}(\alpha) = \left(\frac{1-\mu+\mu(1-\alpha)}{\mu+(1-\mu)(1-\alpha)}\right)^2. \tag{34}$$

Note that $\mathcal{P}_{D=X}(\alpha)$ is increasing in α, whereas $\mathcal{P}_{D=Y}(\alpha)$ is decreasing. When we evaluate the expected payment at $\alpha = 0$, it is $\frac{1-\mu}{\mu}$ with $D = X$, whereas it is 1 with $D = Y$. When evaluating the expected payment at $\alpha = 1$, it is 1 with $D = X$, whereas it is $\left(\frac{1-\mu}{\mu}\right)^2$ with $D = Y$. As a result, we have

$$\lim_{\alpha\to 0}\mathcal{P}_{D=X}(\alpha) = \frac{1-\mu}{\mu} < 1 = \lim_{\alpha\to 0}\mathcal{P}_{D=Y}(\alpha) \text{ and}$$

$$\lim_{\alpha\to 1}\mathcal{P}_{D=X}(\alpha) = 1 < \left(\frac{1-\mu}{\mu}\right)^2 = \lim_{\alpha\to 1}\mathcal{P}_{D=Y}(\alpha).$$

This implies that there should be a unique $\widehat{\alpha}$ such that $\alpha \lesseqgtr \widehat{\alpha}$ as $\mathcal{P}_{D=X}(\alpha) \lesseqgtr \mathcal{P}_{D=X}(\alpha)$. ■

6.5 Proof of Proposition 6.

Proof. Suppose the principal hires two agents with heterogeneous beliefs. With $\overline{u} = 0$ and $u(v) = v$, we know that $v^{FS} = v^{FF} = 0$. The IC for the overconfident agent is $\theta_H\theta_L v^{SS} + \theta_H(1-\theta_L)v^{SF} \geq c$, while the IC for the underconfident agent is $\theta_H\theta_L v^{SS} + \theta_L(1-\theta_H)v^{SF} \geq c$. Note that the latter IC must be binding. Also, note that the latter IC can be relaxed by replacing the underconfident agent with the overconfident agent, i.e., $\theta_H^2 v^{SS} + \theta_H(1-\theta_H)v^{SF} \geq c$. This implies that the principal always prefers a team of overconfident agents to a team of heterogeneous agents. ■

References

[1] Baker, George P., Michael C. Jensen, and Kevin J. Murphy. 1988. Compensation and incentives: Practice vs. Theory. *Journal of Finance* 43: 593- 616.

[2] Buehler, Roger., Dale Griffin, and Michael Ross. 1994. Exploring the planning fallacy: why people underestimate their task completion times. *Journal of Personality and Social Psychology* 67: 366-381.

[3] Che, Yeon-Koo, and Navin Kartik. 2009. Opinions as incentives. *Journal of Political Economy* 117: 815-860.

[4] Che, Yeon-Koo, and Seung-Weon Yoo. 2001. Optimal incentives for teams. *American Economic Review* 91: 525-541.

[5] de la Rosa, Leonidas E., 2011. Overconfidence and moral hazard. *Games and Economic Behavior* 73: 429-451.

[6] Eliaz, Kfir. and Ran Spiegler. 2006. Contracting with diversely naive agents. *Review of Economic Studies* 73: 689-714.

[7] Fang, Hanming. and Giuseppe Moscarin. 2005. Morale hazard, *Journal of Monetary Economics* 52: 749-777.

[8] Goel, Anand. M. and Anjan V. Thakor. 2008. Overconfidence, CEO selection, and corporate governance. *Journal of Finance* 63: 2737-2784.

[9] Green, Jerry R. and Nancy L. Stokey. 1983. A comparison of tournaments and contracts. *Journal of Political Economy* 91: 349-364.

[10] Harsanyi, John C. 1967. Games with Incomplete Information Played by "Bayesian" Players, I-III, Management Science 14: 159-182.

[11] Hermalin, Benjamin E. 2013. Leadership and corporate culture. *Handbook of Organizational Economics* edited by Robert Gibbons and John Roberts.

[12] Itoh, Hideshi. 1991. Incentives to help in multi-agent situations, *Econometrica* 59: 611-636.

[13] Josephs, Robert A. and Eugene D. Hahn. 1995. Bias and accuracy in estimates of task duration. *Organizational Behavior and Human Decision Processes* 61: 202-213.

[14] Kvaloy, Ola. and Trond E. Olsen. 2006. Team incentives in relational employment contracts. *Journal of Labor Economics* 24: 139-169.

[15] Kim, Jaesoo. 2012. Endogenous leadership in incentive contracts. *Journal of Economic Behavior & Organization* 82: 256-266.

[16] Morris, Stephen. 1995. The common prior assumption in economic theory. *Economics and Philosophy* 11: 227-253.

[17] Mookherjee, Dilip. 1984. Optimal incentive schemes with many agents. *Review of Economic Studies* 51: 433-446.

[18] Parker, James F. 2007. Do the right thing: how dedicated employees create loyal customers and large profits. Pearson Prentice Hall

[19] Prendergast, Canice. 1999. The provision of incentives in firms. *Journal of Economic Literature* 37: 7-63.

[20] Santos-Pinto, Luís. 2008. Positive self-image and incentives in organisations. *Economic Journal* 118: 1315-1332.

[21] Van den Steen, Eric. 2005. Organizational beliefs and managerial vision. *Journal of Law, Economics, and Organization* 21: 256-283.

[22] Van den Steen, Eric. 2007. The cost of incentives under disagreement: can an employee be too motivated? Unpublished manuscript.

[23] Van den Steen, Eric. 2010. Interpersonal authority in a theory of the firm. *American Economic Review* 100: 466-490.

[24] Welch, Jack. 2003. Jack: Straight from the gut. Business Plus.