Optimal Incentive Contracts, Common Uncertainty, and Intrinsic Value

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This paper concerns the optimal use of incentive contracts in a multiple agent situation where moral hazard problems are issues. This paper proposes to investigate (1) the effect of common uncertainty on expected contract cost of different contract types (an Individual contract, a Team-based contract, a Relative performance contract), (2) the effect of common uncertainty on the principal's preference over the different contract types under different levels of common uncertainty, and (3) the intrinsic value of using relative performance information on agents' efforts. Taking the standard agency paradigm where a principal can improve his welfare by achieving better risk-sharing without altering agents' incentives to take the desired action, this paper hypothesizes that (1) the expected contract cost of a Team-based contract would increase, while that of a Relative performance contract would decrease as the level of common uncertainty increases, (2) there exists a critical value of the common uncertainty such that a Team-based contract is preferred by the principal when the level of common uncertainty is below the critical value and a Relative performance contract is preferred by the principal when the level of the common uncertainty is above the critical value, and (3) neither the level of common uncertainty nor the contract type would change the agents' effort levels, Hypotheses are to be tested in two computer-assisted experiments with 80 MBA students. In experiment I, 60 MBA students are required to act as managers and make production decisions. 20 subjects are assigned to one of three contract groups and matched as a pair. Subjects under an Individual contract are compensated only based on their individual performance. While subjects under a Team-based contract are compensated based on both performances of subjects, subjects under a Relative performance contract are compensated based on relative performance to other subject's performance. In experiment II, 20 MBA students are required to act as principals to choose an incentive contract among three incentive contracts given a common uncertainty. There are 10 levels of common uncertainty, and common uncertainty is manipulated by providing conditional contingency tables on their effort choice. Subjects' risk and effort preferences are induced by utilizing Berg et al technique (1986).

INTRODUCTION AND BACKGROUND

It is well observed that modern firms evaluate and compensate their workers through various performance evaluation schemes such as the team-based contract and the relative performance evaluation contract. Workers are evaluated and compensated based on the team performance in the team-based contract, while they are evaluated and compensated based on their relative performance to others' in the relative performance evaluation contract. While a team-based contract induces cooperation among workers, a relative performance contract induces competitions among workers. Modern firms are reorganizing their workers into workgroups so that workers are to cooperate each other within a workgroup and to compete with other workgroups as a group (Hayes et al, 1988; Young et al, 1993).

Researchers have been interested in investigating these special forms of incentive contracts because the above observed phenomena make a puzzle; neither the team-based contract nor the relative performance contract are consistent with the principle of the responsibility accounting, which states that a worker should be evaluated and compensated only on the basis of those factors that he/she is responsible for and controls over. Particularly, researchers have been trying to identify the conditions under which incentive contract is beneficial to the corporations and when is not. Matsumura and Shin (2006) provided empirical evidence that the financial performance increased with an incentive plan with relative performance measures and that under that plan, the degree of common uncertainty is positively associated with the profitability. Gong et el (2011) reported empirical evidence of the explicit use of the relative performance evaluation within the related peer groups in executive compensation contracts. Hannan et el (2008) experimentally investigated the effects of disseminating relative performance feedback in tournament and individual performance compensation plans. Hannan et el (2013) investigated, in an experiment, how relative performance information affects agent performance and allocation across tasks in a multi-task environment. Based on behavioral theories, they predicted and provided evidence that relative performance information induces both a motivation effect which increases efforts and a distortion effect which distorts effort allocations across tasks away from the firm-preferred allocations.

On the other hand, analytical agency researchers have identified that the common environmental uncertainty which workers in modern organizations face as one key factor to determine the optimal use of these incentive contracts (Ramakrishnan and Thakor, 1991; Holmstrom, 1991; Itoh, 1991, 1992). The results of this line of research show that as the level of common uncertainty increases, the benefit of employing the team-based contract would decrease, while that of a relative performance contract would increase, and predict that there exists a critical value of the common uncertainty such that firms prefer the team-based contract when the level of common uncertainty is below the critical value and firms prefer the relative performance contract when the level of the common uncertainty is above the critical value.

This paper is motivated to illustrate the conditions under which performance evaluation scheme is beneficial to corporations and when is not. Also this paper aims to experimentally test the optimality of an incentive contract under such conditions.

Another motivation of this paper is to provide further evidence on the intrinsic value of using the relative performance information. While standard agency theory does not formally incorporate the behavioral factors into explaining the agents' incentives to exert efforts, Frederickson (1992) suggested that both economic variables and behavioral factors be considered to better understand the motivational effects of using relative performance information on agents' behaviors. Based on the social influence theory, he asserted that comparing agents' performances has intrinsic value to a principal; that is, the saliency of the comparisons affects agents' motivation. He hypothesized that since the saliency of comparisons increases as the degree of common uncertainty increases, agents exert more efforts and that since a relative performance evaluation contract is more salient to agents, agents with a relative performance contract exert more efforts than those with an individual contract. In a laboratory experiment with 36 MBA students, he investigated the effects of common uncertainty and two contract types (an individual contract and a relative performance evaluation contract) on agents' efforts. He found that subjects with a RPE contract significantly increased their efforts as the degree of common uncertainty increased, but not subjects with an individual contract [Finding 1] and that subjects with a RPE contract exerted more efforts than subjects with an individual contracts [Finding 2]. Although he provided insightful findings which suggest that both economic variables and behavioral variables are important determinants of driving human behaviors, current research raises some concerns on his development of economic predictions.

First of all, his design does not allow us to interpret his Finding 2 unambiguously. His Finding 2 supports both his economic hypothesis 2 and his competing behavioral hypothesis 6 (*agents' effort levels are higher with the RPE contract than with the [individual contract]*). His economic hypothesis 2 was driven based on the contracting approach where a principal can improve his welfare by providing the agent with greater incentives to exert efforts without altering risk-sharing (foot note 20 and discussions in section 1) through using relative performance information. However, since this prediction is same as that in competing behavioral theory prediction, we cannot distinguish whether economic theory or competing behavioral theory confirms agents' behaviors. Under this design, the behavioral theory prediction does not achieve its' competing objectives: investigation of the intrinsic value of RPI in contracting. In order to circumvent this design problem, this paper aims to provide a different approach where a principal can improve his welfare by achieving better risk-sharing without altering agent's incentives to take desired effort level such that agents will take same effort level across the contract types. This approach will provide the sharp distinction between two competing theories with regard to the effect of contract types on agent's effort.

In addition, although his economic predictions were derived from an analytical agency model, neither his model was rigorously well-grounded nor his economic hypotheses were proved analytically. First of all, while he designed linear payoff functions, his experimental design does not justify the rationale of using linear contracts. Since he assumed and experimentally induced that agents be risk averse, the payoff function is to be convex in his experiment. The use of this particular form of incentive contract should be justified.[1] Second of all, since he did not well define common uncertainty mathematically, he did not provide a formal analytical model and rigorous analyses such as comparative analysis. His proofs were based on speculations and computer simulations for his experimental models. Moreover, his model does not incorporate any standard constraints such as "individual rationality" and "incentive comparability". That is to say, he just solved unconstrained optimization problems instead of standard constrained optimization problems through computer simulations. As a consequence of misspecifications in his experimental models, computer simulations showed that the agents' expected utility increases as the common uncertainty increases. However, this is not the way the incentive contracts are designed. Standard agency research suggests that ex-ante, a principal designs an incentive contract such that risk averse agents receive exactly same expected utility as their constant reservation utility for any foreseen uncertainty (Holmstrom,1979; Baiman, 1982; Grossman and Hart, 1983).

In summary, based on the standard agency research paradigm where a principal can improve his welfare by achieving better risk-sharing without altering agents' incentives to take the desired effort levels, this research is motivated to provide more precise and rigorous economic predictions which can be distinguishable from the behavioral predictions, thus it aims to reexamine the intrinsic value of using relative performance evaluation information.

The remainder of this proposal is organized as follows. The next section explains the theory and develops the hypotheses. Section 3 describes the proposed laboratory experiments. Section 4 explains the data analysis procedures. Section 5 concludes this proposal.

THEORY AND HYPOTHESES DEVELOPMENT

The models in this proposal are adapted from the models developed by Ramakrishnan and Thakor (1991) and modified to develop the experimental hypotheses.

The Basic Principal Agent Model

Consider a single period situation where a principal hires two economic agents. At the beginning of the period, the principal negotiates an incentive contract with each agent. This contract induces the agent to take desired action that, along with the realization of a random variable representing an exogenous source of noise in the production process, determines the output from the task at the end of the period.

Production process is independent in the sense that the output of task derived from each agent's production process does not depend upon the action taken by other agent. However, output of task may be conditionally correlated in the sense that the realization of an exogenous random variable in each agent's production process may not be independent.

For simplicity, any task output can take only one of two dichotomous values, "acceptable quality (A)" and "unacceptable quality (U)". Agents are risk averse and identical, and each has a von Neumann-

Morgenstern utility function over wealth, represented by U(), with U'()>0, and U"()<0. Agents have disutility for efforts. That is, if W represents the agent's feasible action space, and w the agent's effort, then the agent's total utility is (with m representing wealth) J(m,w) = U(m) - V(w), with V(w)>0, V"(w)>0, $\forall$ w $\in$ W.

Let π be the task output of agent. The probability function of π is given by Prob[π = A/w] = q(w), and Prob[π = U /w] = 1- q(w), with q'(w)>0, q"(w)<0, $\forall$ w $\in$ W. The agent's incentive contract is a function, θ:{A,U} -> R, that pays the agent a dollar amount Z if π = A and X if π = U. Define U(Z) = z and U(X) = x. Throughout, lowercase letters denote utilities and capitals represent the corresponding dollar payoffs. Thus, J(θ, w) = q(w)z + (1-q(w))x - V(w).

Now we characterize joint distribution of the outputs of two tasks managed by two agents. Given an exogenous ϕ (Phi) correlation coefficient[2], the probability structure for outputs can be written as;

$$P_{AA} = \phi\sqrt{q1(1-q1)q2(1-q2)} + q1q2$$
$$P_{AU} = (1-q2)q1 - \phi\sqrt{q1(1-q1)q2(1-q2)}$$
$$P_{UA} = (1-q1)q2 - \phi\sqrt{q1(1-q1)q2(1-q2)}$$
$$P_{UU} = (1-q1)(1-q2) + \phi\sqrt{q1(1-q1)q2(1-q2)}$$

Since agents have same production process characterized as q (w), a probability of producing acceptable quality of output, when a principal wants to induce the same effort level (w*) for each agent, then the above expression can be rewritten as;

$$P_{AA} = q(w^*)(1-q(w^*))\phi + q^2(w^*)$$
$$P_{AU} = q(w^*)(1-q(w^*))(1-\phi)$$
$$P_{UA} = q(w^*)(1-q(w^*))(1-\phi)$$
$$P_{UU} = (1-q(w^*))(1-q(w^*) + q(w^*)\phi)$$

Assume that the principal is risk neutral toward the agent's compensation. Define t() be inverse function of U(). t() exists since U()is strictly increasing and continuous on R and hence invertible. Moreover, t'()>0 and t"()>0. The output produced can be observed by both principal and the agents, but agent's action is not observable ex post to the principal, agent's compensation can be only based on output of the task. Since the agents have disutility for effort and a principal cannot observe the agent's exerted effort, with risk averse agents, a principal must design an incentive contract to induce the agents to take the desired actions by the principal.

Suppose the principal wants each agent to take a desired action (w*)[3]. This action is arbitrarily chosen and hence need not be optimal for the contract[4]. For any exogenously given common uncertainty (ϕ), the principal must design the incentive contract (θ) such that (1) the agent receives at least the reservation expected utility (denoted as R) when he or she takes the principals' desired action (Individual Rationality constraint) and (2) the desired action, w*, must be agent's dominant strategy to the given incentive contract (Incentive Compatibility constraint)[5].

Effect of Common Uncertainty on Optimality of Incentive Contracts

A principal can design the incentive contracts which induce agents to take the desired effort level as follows;

1) an Individual contract; the agents are compensated solely based on his or her task output.

2) a Team-based contract; the agents as a team are compensated based on team performance.
3) a Relative performance contract; the agents are evaluated and compensated relative to other agent's performance.

An Individual Contract

In an individual contract, a principal keeps the agents independent and compensate each agent independently of other agent' performance. We refer to the outcome in this case as the "second best" solution. The principal will solve the following optimization problem;

$$\underset{x,z}{\text{Minimize}} \quad EC(I, w^*, \phi) = q(w^*)t(z) + [1-q(w^*)]t(x)$$

$$\text{s.t.} \quad q(w^*)z + [1-q(w^*)]x - V(w^*) \geq R \qquad \text{(IR)}$$

$$q'(w^*)(z-x) - V'(w^*) = 0 \qquad \text{(IC)}$$

The optimal solution of the above problem can be characterized as follows;

(I1) Let the pair (x*,z*) represent the optimal solution to the above problem. Using standard technique, this solution can be shown to be;

$$z^* = R + V(w^*) + [1-q(w^*)]V'(w^*)[q'(w^*)]^{-1}$$
$$x^* = R + V(w^*) - q(w^*)V'(w^*)[q'(w^*)]^{-1}$$

If w* is observable ex post, the principal could achieve the first best solution by paying each agent t[R + V(w*)] dollars if w = w* is observed and nothing otherwise. Thus, with first best solution, the principal would pay t[R + V(w*)] dollars to each agent.

(I2) Since t() is convex function, the expected contract cost per agent of the second best is strictly greater than the first best expected contract cost;

$$q(w^*)t(z^*) + [1-q(w^*)]t(x^*) > t\,\{q(w^*)z^* + [1-q(w^*)]x^*\}$$

(I3) Using the Envelope Theorem, we now have

$$\frac{d\ EC(I, w^*, \phi)}{d\,\phi} = 0$$

deriving the Hypothesis 1;

(H1) Ceteris paribus, with an Individual contract, increasing the level of common uncertainty will not affect the expected contract cost.

The rationale behind Hypothesis 1 is straight forward; Since the level of common uncertainty is not included in an Individual contract, it does not play any role to achieve better risk-sharing, thus, increasing the level of common uncertainty will not change the expected contract cost.

A Team-Based Contract

In a Team-based contract, the principal let two agents form a team so that they can cooperate in the performance of their tasks and in pooling their payoffs and sharing them. As a team, an agent will receive C dollars when both agents produce acceptable qualities, receive B dollars when the outcomes are mixed (one acceptable and one unacceptable quality), and receive A dollars when two agents produce unacceptable outcomes. We assume that the agents can perfectly monitor each other. The principal wants each agent to take the desired action w*. Given any exogenous common uncertainty, the principal solves the following optimization problem with respect to a, b, c;

$$\text{Min} \quad EC(T, w^*, \phi) = [q(1-q)\phi + q^2]t(c) + 2q(1-q)(1-\phi)t(b) + (1-q)(1-q+q\phi)t(a)$$

$$\text{s.t} \quad [q(1-q)\phi + q^2]c + 2q(1-q)(1-\phi)b + (1-q)(1-q+q\phi)a - V \geq R \qquad \text{(IR)}$$

$$q'(1-2q)\phi(c-2b+a) + 2q'[q(c-b)+(1-q)(b-c)] - V' = 0 \qquad \text{(IC)}$$

The optimal solution of the above problem can be characterized as follows;

(T1) For any ϕ, IC constraint has to be satisfied, thus

$$b = \frac{a+c}{2} \text{ and } q'[q(c-b)+(1-q)(b-c)] = \frac{V'}{2}$$

(T2) Subject to T1, IR constraint becomes

$$qc + (1-q)a = V + R$$

(T3) $c > b > a$

(T4) For $\phi = 0$, expected contract cost is strictly greater than first best expected contract cost;

$$\begin{aligned} EC(T, w^*, 0) &= q[qt(c) + (1-q)t(b)] + (1-q)[qt(b) + (1-q)t(a)] \\ &> qt(qc + (1-q)b) + (1-q)t(qb + (1-q)a) \\ &> t(q^2c + 2q(1-q)b + (1-q)^2a) \\ &= t(V + R) \end{aligned}$$

(T5) For $\phi = 1$, optimization problem becomes identical to that in the second best, thus expected contract cost is same as the second best;

$$EC(T, w^*, 1) = EC(I, w^*, \phi) = \text{second best expected contract}$$

(T6) Subject to T1, using the Envelop Theorem, we now have

$$\frac{d\, EC(T, w^*, \phi)}{d\phi} = q(1-q)[t(c) + t(a) - 2t(\frac{a+c}{2})] > 0$$ and drive Hypothesis 2 as follows;

(H2) Ceteris paribus, with a Team-based contract, increasing the level of common uncertainty will increase the expected contract cost.

The rationale behind Hypothesis 2 is as follows; Since agents are compensated based not only on his outcome but also on other agent's outcome, they are mutually insuring each other and exposing themselves less risk. Therefore, a principal can design a Team-based contract such that it satisfies original constraints and reduces the risk premium. However, as common uncertainty increases, the variation between two agents' output decreases, the variation of joint output increases, thus, gains from mutual coinsurance decrease, agents become exposed to more risk, and finally a principal has to pay more risk premium to agents to induce the desired action.

A Relative Performance Contract

In a Relative performance contract, the principal keep the agents independent in terms of their production process, but let them compete in a rank-order tournament. Thus, an agent's performance is evaluated relative to other agent's performance. An agent will receive Z dollars when both agents produce the acceptable outcomes, receive Y1 dollars when he produces an acceptable output while the other agent produces the unacceptable output, receive Y2 dollars when the other agent produces acceptable quality while he or she produces an unacceptable quality outcome, and receive X dollars when both agents produce the unacceptable outcomes. The principal wants each agent to take the desired action w*. Given any exogenous common uncertainty, the principal solves the following optimization problem with respect to z, y1, y2, x ;

$$\text{Min} \quad EC(R,w^*,\phi) = [q(1-q)\phi + q^2]t(z) + q(1-q)(1-\phi)t(y1) + q(1-q)(1-\phi)t(y2) + (1-q)(1-q+q\phi)t(x)$$

$$\text{s.t} \quad [q(1-q)\phi + q^2]z + q(1-q)(1-\phi)y1 + q(1-q)(1-\phi)y2 + (1-q)(1-q+q\phi)x - V \geq R \qquad \text{(IR)}$$

$$q'(1-2q)\phi(z-y1-y2+x) + q'[q(2z-y1-y2)+(1-q)(y1+y2-2x)] - V' = 0 \qquad \text{(IC)}$$

The optimal solution of the above problem can be characterized as follows;

(R1) For any ϕ, IC constraint has to be satisfied, thus

$$z - y1 - y2 - x = 0 \text{ and } z - y2 = y1 - x = \frac{V'}{q'}$$

(R2) Subject to R1, IR constraint becomes

$$qz + (1-q)x = V + R$$

(R3) y1 > z > x > y2

(R4) $EC(R,w^*,0) = EC(I,w^*,0)$ = second best expected contract cost

(R5) $EC(R,w^*,1) = t(V+R)$ = first best expected contract cost

(R6) Subject to R1,R3, using the Envelop Theorem, we now have

$$\frac{d\,EC(R,w^*,\phi)}{d\phi} = q(1-q)[t(z)-t(y1)-t(y2)+t(x)] < 0$$ and derive Hypothesis 3 as follows;

(H3) Ceteris paribus, with a relative performance contract, increasing the level of common uncertainty will reduce the expected contract cost.

The rationale behind Hypothesis 3 is as follows; as the level of common uncertainty increases, the informativeness of relative performance information increases and it becomes valuable to a principal.

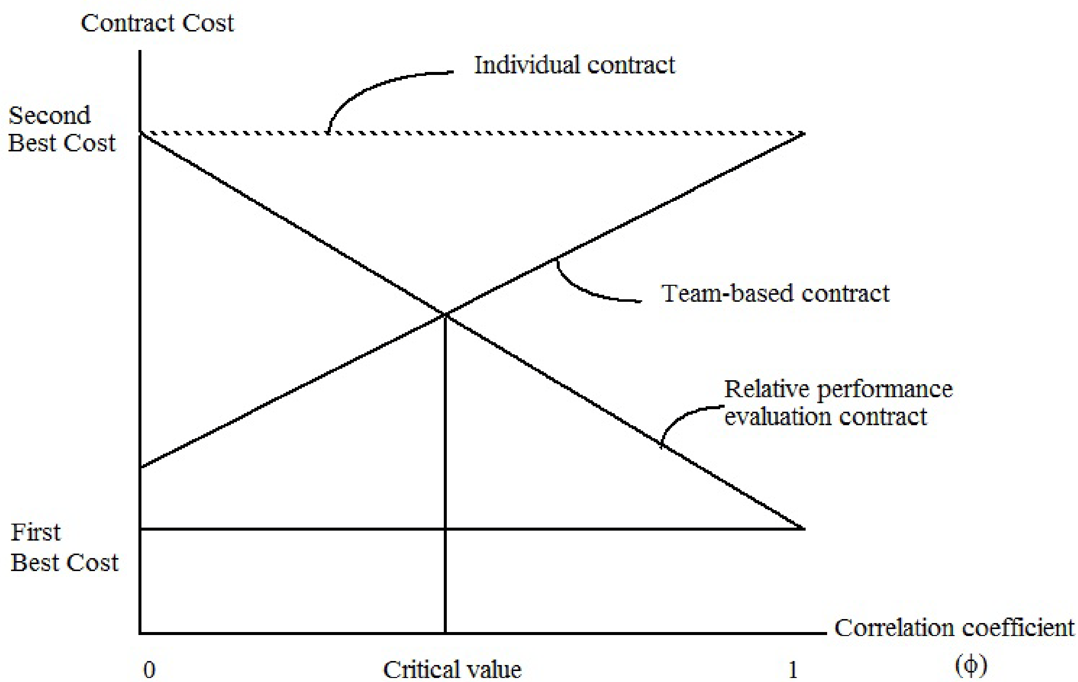
Since she is more able to filter the common uncertainty and to infer the action taken by the agents, this enforced monitoring ability enables her to force agents to take the desired action with less contract cost.

Finally, (T4), (T5), (T6), (R4), (R5), and (R6) jointly implies that there exist ϕ_c such that $EC(T,w^*, \phi) \leq EC(R,w^*, \phi)$ for $\phi \leq \phi_c$ and $EC(T,w^*, \phi) > EC(R,w^*, \phi)$ for $\phi > \phi_c$. Thus, we derive Hypothesis 4 as follows;

(H4) There exist a critical value of the common uncertainty such that a Team-based contract is preferred by the principal when the level of common uncertainty is below the critical value and a Relative performance contract is preferred by the principal when the level of the common uncertainty is above the critical value.

Figure 1 summarizes the above hypotheses.

FIGURE 1



Intrinsic Value of Relative Performance Information

Two economic predictions are made as follows;

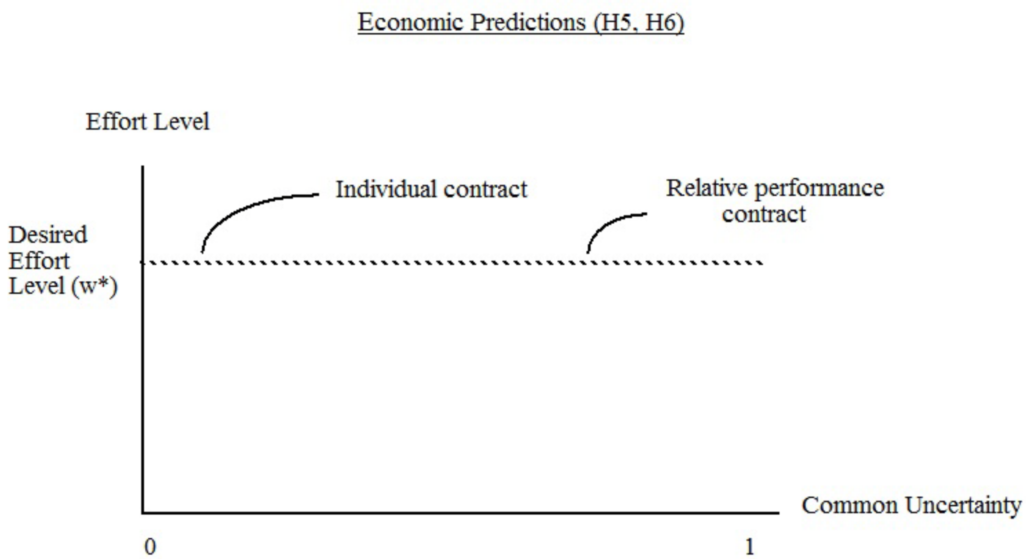
(H5) Ceteris paribus, agents' effort levels are same across the levels of common uncertainty.

(H6) Ceteris paribus, agents' effort levels are same across the contract types (an Individual contract and a Relative performance evaluation contract).

The rationale behind the Hypothesis 5 is as follows; Since agents face the common uncertainty, a principal can improve his welfare by filtering agents' risk exposure to the common uncertainty without altering agents' incentives to take the desired effort level. Thus, in an optimal incentive contract, the level of common uncertainty does not alter agents' incentives to take the desired level of effort. The rationale behind the above Hypothesis 6 is as follows; since a principal designs an incentive contract to induce agents to take the desired level of effort such that the desired level of effort must be agents' dominant strategy to any given contract for any level of common uncertainty, the agents' effort levels are same across the contract types.

Figure 2 depicts these hypotheses.

FIGURE 2
EFFECT OF COMMON UNCERTAINTY AND CONTRACT TYPES ON AGENT EFFORT



Based on Frederickson's predictions, three competing behavioral hypotheses are to be tested.

(H7) Ceteris paribus, as the degree of common uncertainty increases, agents are expected to exert more efforts.

(H8) Ceteris paribus, agents with a Relative performance evaluation contract are expected to exert more efforts than those with an Individual performance contract.

(H9) Ceteris paribus, as the degree of common uncertainty increases, agents with a Relative performance evaluation contract are expected to exert more efforts than those with an individual contract.

The rationale behind Hypothesis 7, which is equivalent to Frederickson's H4 and H5, is as follows; since the saliency of comparisons increases as the common uncertainty increases, agents are expected to exert more efforts as the common uncertainty increases.

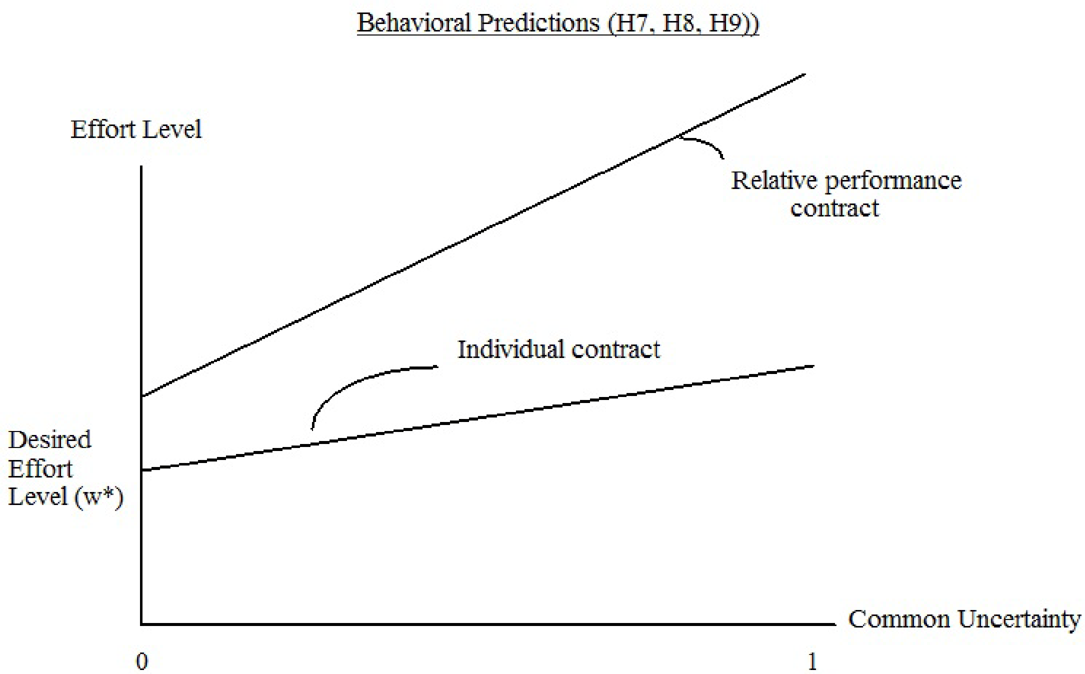
The rationale behind Hypothesis 8, which is equivalent to Frederickson's H6, is as follows; since the saliency of comparisons is greater with a Relative performance contract, agents with a Relative performance contract are expected to exert more efforts than those with an Individual contract.

The rationale behind Hypothesis 9, which is equivalent to Frederickson's H7, is as follows; since the saliency of comparisons is greater with a Relative performance contract, agents in a relative performance contract are expected to respond more sensitively to changes in common uncertainty. Thus, agents with a

Relative performance contract are expected to exert more efforts than those with an Individual contract as the common uncertainty increases.

Figure 3 depicts these hypotheses.

FIGURE 3
EFFECT OF COMMON UNCERTAINTY AND CONTRACT TYPES ON AGENT EFFORT



EXPERIMENTS

Two experiments are to be conducted, Experiment I examines the agents' response to the different levels of common uncertainty under the different performance evaluation schemes (Hypothesis 1 through 3) and the intrinsic value of using the relative performance information (Hypothesis 5 through 9). Experiment II examines the principals' preference over the different performance evaluation schemes under the different levels of common uncertainty (Hypothesis 4).

Experiment I

Subjects and Design

A laboratory experiment with 60 MBA students is going to be conducted to test hypotheses. A 10 X 3 factorial design is going to be obtained by crossing 10 levels of common uncertainty with 3 types of contracts (an Individual contract, a Team-based contract, a Relative performance contract). 20 subjects will be randomly assigned to each contract. Every subject will be tested under all 10 levels of common uncertainty.

Task

Under each contract type, the level of common uncertainty will be given in a random sequence to the subjects. Facing an experimentally introduced common uncertainty, subjects are responsible for producing one unit of goods in a computerized exercise. The outcome (acceptable quality or unacceptable quality) of production is a joint function of a subject's effort (i.e., economic resource) and a realized state of nature. The subject's effort is valuable to the experimenter in a sense that it increases the likelihood of getting the acceptable quality of goods[6]; however, it is also valuable to subjects in a sense that exerting efforts derives the disutility of the subjects. Therefore, subjects' tasks are to decide on how many economic resources they will exert for producing one unit of the experimental goods. After subjects made production decision, the automated production process stochastically determines the quality of the experimental goods. For each outcome, subjects will be compensated with the experimental commodity (say, Lira) based on the contract given to them.

Risk and Effort Preferences

Subjects' risk and effort preferences will be experimentally induced by utilizing the Berg et al (1986) technique. With this technique, experimental commodities are converted into the probability of winning a preferred prizes via a two-prize lottery, and this transformation induces a subject's preference function for the experimental commodities.

In conformance with the agency literature (Holmstrom, 1979; Baiman, 1982; Holmstrom, 1982; Grossman and Hart, 1983; Ramakrishnan and Thakor, 1991), the subject's utility function is assumed to be additively separable in compensation and effort. Based on this assumption, the probability of winning the preferred prize is determined in two steps. First, utility for compensation will be induced[7]. Subjects will earn the experimental Liras through their contracts[8], and these compensations will be transformed into degrees in the prize wheel. With the induced utility function for compensation, subjects are induced to prefer more experimental compensations (Liras) to less; however, subjects are induced to have diminishing marginal utilities for compensations. Second, disutility for effort will be induced.[9] The number of experimental commodities (economic resources) subjects decided to exert, W , will be transformed into the degrees through the disutility function for effort. With the induced disutility for effort, subjects are induced to prefer less effort to more. Moreover, subjects are induced to have increasing marginal disutilites for efforts. Therefore, the subject's total degrees of winning a preferred prize in a lottery wheel is obtained by deducting degrees associated with effort from the degrees associated with compensation. The winning area on the prize wheel is the area from zero degree to the subject's total degree. When the wheel's spinner stops in the win area, the subject receives a preferred prize, otherwise, gets a less preferred prize.[10]

Independent Variables

The ϕ correlation coefficient is used in this experiment because experimental outcomes consist of two dichotomous outcomes (acceptable quality vs. unacceptable quality). 6 levels out of 10 levels of common uncertainty (varying from zero correlation to perfect correlation by 10%) will be given to the subjects in a random sequence for each experimental round [i.e. within subject design][11]. The subject will receive the information on the correlation coefficient (the degree of common uncertainty) and the computer screen will provide the conditional contingency table on agents' effort choice.

20 subjects will be randomly assigned to one of 3 contract experimental groups (an Individual contract, a Team-based contract, a Rank-order tournament contract). A subject in the Individual contract group will be told that his or her performance will be evaluated solely based on his or her own outcomes; a subject will receive Z Liras for acceptable quality of his own outcome, otherwise receive X Liras. A subject in the Team-based contract will be told that he or she will be compensated based on joint outcome of a team; a subject will receive C Liras when both of the team members produced acceptable qualities, receive B Liras when the outcomes are mixed (one acceptable and one unacceptable quality), and receive A Liras for two unacceptable outcomes. A subject in the Rank-order tournament contract group will be told that his or her performance will be evaluated relative to others' performance; a subject will receive T Liras when he produces an acceptable output while the other subject in a pair produces the unacceptable output, receive S Liras when both subjects produce the acceptable outcomes, receive R Liras when both subjects produce the unacceptable outcomes, and receive Q liras when the opponent in a match pair produced acceptable quality while he or she produced an unacceptable quality outcome.

Dependent Variables

Principal's expected contract cost under a common uncertainty is obtained by averaging out the experimental compensations (Liras) paid to the subjects over the observations.

Subject's effort is measured as an economic resource (W) the subject decided to exert in order to produce the one unit of experimental goods.

Experimental Procedures

The experiment will consist of five parts. The first part introduces the experimental exercise. The second part explains how subjects would be compensated. The third part will serve as a practice session under the complete set of experimental rules. The fourth session will be the actual experimental session. In the fifth session, a questionnaire concerning demographic data and information about experimental manipulations is collected.

Following steps illustrate the main experimental procedures.

1. 20 subjects will be randomly assigned to each contract type experimental groups and they will be informed of their production function which is uniform across all subjects and their contracts.
2. Then, the experiment will run 10 rounds (3 practice rounds in the third part and 7 real rounds in the fourth part).
3. At the beginning of each round, subjects will be randomly matched as a pair, thus we will have 10 pairs in each round[12].
4. One round will consist of 6 sessions for 6 levels of common uncertainty; 6 levels of common uncertainty out of 10 levels will be randomly selected and provided to subjects in a random sequence.
5. Under a common uncertainty, subjects are asked to decide on their effort levels.
6. Given effort level supplied by the subject, the outcome(good quality or bad quality) of production is stochastically determined.
7. For each outcome, subjects received the experimental compensations through their assigned contracts.
8. The experimental commodities (compensations and efforts) will be the transformed into probability of winning a preferred prize utilizing the induced utility function.
9. The lottery is conducted and the payment is determined and recorded in the computer memory.
10. At the end of each round, there will be drawing about which section will be chosen to pay.[13]
11. The final experimental payments will be given to subjects at the end of 10th round by summing up the payment of the last 7 rounds.

Experiment II

Subjects and Design

A laboratory experiment with randomly assigned 20 MBA students is going to be conducted to test Hypothesis 4. This experiment consists of 10 rounds (3 practice rounds and 7 real rounds). One factor (common uncertainty) design is going to be obtained by manipulating 10 levels of common uncertainty. Every subject will be tested under all 10 levels of common uncertainty.

Task

Each principal subject is going to be informed of production environment and each contract which is identical contract developed in Experiment 1. Then, the level of common uncertainty will be given in a random sequence to the subjects. Facing an experimentally introduced common uncertainty, subjects are responsible for choosing one of 3 types of contract in a computerized exercise. After choosing one incentive contract, the computer program automatically produces the experimental outcomes. The outcome (acceptable quality or unacceptable quality) of production is a joint function of a pre-specified effort[14] (i.e., economic resource) and a realized state of nature. After the automated production process stochastically determines the quality of the experimental goods, For each outcome, the contracting cost (Lira) is calculated through subject's choice of a contract. Subject's experimental compensation is calculated by deducting it from a constant experimental commodity.[15]Thus, principal subjects are induced to maximize their compensations by minimizing contract cost.

Subject's Risk Preference

Subjects' risk preference will be experimentally induced by utilizing the Berg et al (1986) technique. With this technique, each subject's experimental compensation is converted into the probability of winning a preferred prizes via a two-prize lottery, and this transformation induces a subject's preference function (i.e. risk neutrality) for the experimental commodities. With the induced utility function for compensation, subjects are induced to prefer more experimental compensations (Liras) to less and subjects are induced to have constant marginal utilities for compensations. The subject's total degrees of winning a preferred prize in a lottery wheel is obtained by converting the experimental compensation into the degrees. The winning area on the prize wheel is the area from zero degree to the subject's total degree. When the wheel's spinner stops in the win area, the subject receives a preferred prize, otherwise, gets a less preferred prize.[16]

Independent Variables

Principal subjects are informed of ϕ (Phi) correlation coefficient between the agent's production environment. 6 levels out of 10 levels of common uncertainty (varying from zero correlation to perfect correlation by 10% interval) will be given to the subjects in a random sequence for each experimental round.

Dependent Variable

After subjects are informed of the common uncertainty of two production process, subjects are asked to choose one out of 3 contract experimental groups (an Individual contract, a Team-based contract, a Relative performance contract). Same manipulations of three contracts in Experiment 1 are to be given to principal subjects.

Experimental Procedures

The experiment will consist of five parts. The first part introduces the experimental exercise. The second part explains how subjects would be compensated. The third part will serve as a practice session under the complete set of experimental rules. The fourth session will be the actual experimental session. In the fifth session, a questionnaire concerning demographic data and information about experimental manipulations is collected.

Following steps illustrate the main experimental procedures.

1. 20 subjects will be randomly assigned to the principal group and they will be informed of the production function and each type of contracts.
2. Then, the experiment will run 10 rounds (3 practice rounds in the third part and 7 real rounds in the fourth part).
3. One round will consist of 6 sessions for 6 levels of common uncertainty; 6 levels of common uncertainty out of 10 levels will be randomly selected and provided to subjects in a random sequence.
4. Under a common uncertainty, subjects are asked to choose one type of performance evaluation scheme.
5. Given the common uncertainty, the outcome(good quality or bad quality) of production is stochastically determined.
6. For each outcome, contract cost is calculated through the contract chosen by the subjects and subject's experimental compensation is obtained by subtracting contract cost from a constant experimental commodity.

7. The experimental compensations (Liras) will be the transformed into probability of winning a preferred prize utilizing Bergs et al (1986) technique to induce the risk neutrality.
8. The lottery is conducted and the payment is determined and recorded in the computer memory.
9. At the end of each round, there will be drawing about which section will be chosen to pay[17].
10. The final experimental payments will be given to subjects in cash at the end of 10th round by summing up the payment of the last 7 rounds.

DATA ANALYSIS

The effect of the level of common uncertainty on agents' effort level (Hypothesis 5, 7) , the effect of contract types on agent's effort level (Hypothesis 6,8), and the interaction effect between contract types and the level of common uncertainty on agents' effort (Hypothesis 9) will be examined through repeated measure MANOVA analysis technique.

The effect of the level of common uncertainty on contract cost with an Individual contract (Hypothesis 1), with a Team-based contract (Hypothesis 2), and with a Relative performance contract (Hypothesis 3) will be examined through regressing the level of common uncertainty on the contract cost. The regression models and expected signs are as follows[18];

A. Individual contract :

Contract cost = $\beta_0 + \beta_1$ Common uncertainty ; $\beta_0 > 0$, $\beta_1 = 0$

B. Team-based contract :

Contract cost = $\beta_2 + \beta_3$ Common uncertainty ; $\beta_2 > 0$, $\beta_3 > 0$

C. Relative performance contract :

Contract cost = $\beta_4 + \beta_5$ Common uncertainty ; $\beta_4 > 0$, $\beta_5 < 0$

The effect of common uncertainty on principals' choice of incentive contract type (Hypothesis 4) will be examined by conducting sequentially two statistical tests of independence of distributions.[19]First, the Karl Pearson test (Chi-square test) of independence of distributions is conducted to examine whether there exist an association between common uncertainty and principals' preference of a contract type. Upon rejection of the null hypothesis that there does not exist any association, multiple pair-wise comparisons for independence of distribution is conducted to examine the principal preference of a contract type when the level of common uncertainty is above or below the critical value.

Conclusions

Summary

This paper concerns the optimal use of incentive contracts in a multiple agent situation where moral hazard problems are issues. This paper proposes to investigate (1) the effect of common uncertainty on expected contract cost of different contract types (an Individual contract, a Team-based contract, a Relative performance contract), (2) the effect of common uncertainty on the principal's preference over the different contract types under different levels of common uncertainty, and (3) the intrinsic value of using relative performance information on agents' efforts.

Taking the standard agency paradigm where a principal can improve his welfare by achieving better risk-sharing without altering agents' incentives to take the desired action, this paper hypothesizes that (1) the expected contract cost of a Team-based contract would increase, while that of a Relative performance contract would decrease as the level of common uncertainty increases, (2) there exists a critical value of the common uncertainty such that a Team-based contract is preferred by the principal when the level of common uncertainty is below the critical value and a Relative performance contract is preferred by the principal when the level of the common uncertainty is above the critical value, and (3) neither the level of common uncertainty nor the contract type would change the agents' effort levels, Hypotheses are tested in two computer-assisted experiments with 80 MBA students. In experiment I, 60 MBA students are required to act as managers and make production decisions. 20 subjects are assigned to one of three contract groups and matched as a pair. Subjects under an Individual contract are compensated only based on their individual performance. While subjects under a Team-based contract are compensated based on both performances of subjects, subjects under a Relative performance contract are compensated based on relative performance to other subject's performance. In experiment II, 20 MBA students are required to act as principals to choose an incentive contract among three incentive contracts given a common uncertainty. There are 10 levels of common uncertainty, and common uncertainty is manipulated by providing conditional contingency tables on their effort choice. Subjects' risk and effort preferences are induced by utilizing Berg et al technique (1986).

Limitations and Future Research Directions

In the experiments, subjects' risk and effort preference are induced. Two concerns about this operation arise. First of all, is this operation powerful and successful enough to induce subjects behave as if they had induced preferences. This operation is crucial to achieve the consistency and internal validity of the experiment. However, the complex tasks such as the one in this experiment may impede risk attitude inducement (Selto and Cooper, 1990). Secondly, suppose this operation turns out to successful one, the consistency and internal validity of the experiment may have been achieved. However, the external validity of this experiment may be weak. There is no guarantee that the actual economic agents have the induced preferences and that we could observe at least qualitatively equivalent phenomena in a real world.

In addition, using MBA students as subject may reduce the external validity to the extent that the experiment does not control the diversity of MBA students, in terms of gender, age, job experience, and cultural background.

In a Team-based contract, we made a little bit of strong assumption; the effort levels the each agent takes can be observable ex post to each agent, thus, the agents are allowed to perfectly monitor each other. However, the free riding problem in a multiple-agent organization has been well recognized because of the inability of perfect monitoring (Alchian and Demsetz, 1972). Gains from a Team-based incentive contract will decrease when the members in a team cannot perfectly monitor the other's activities. Team-members are better able to monitor each other when they share high degree of common uncertainty than when they share low degree of common uncertainty. Thus, increasing the degree of common uncertainty would result in mixed effect on contracting cost of a Team-based contract; decreasing gains from mutual insurance vs. increasing gains from mutual monitoring. Future research will investigate the effect of relaxation of this perfect monitoring assumption in a Team-based contract.

In a Relative performance contract, no production interaction is assumed. Relaxation of this assumption brings a different picture of the Relative performance contract. In a relative performance contract, when an agent can influence the other agent's performance, they try to reduce the probability of other agents' getting good performance measures. In order to prevent this "sabotage" by the agents, pay compression between the winner and the loser may be preferable (Lazear, 1989). However, this pay scheme will weaken the tie between pay and performance, thus reduce the agents' incentives to take desired action. Thus, future research will explore the effect of the extent of the production interaction in a Rank-order tournament contract.

Finally, since our model is a two-agent and two-state model, it does not capture much of real world phenomena. Thus, future research will expand current model to a multiple agent and finite state model so that it captures the richness of real world phenomena.

ENDNOTES

1. Holmstrom and Milgrom (1987) developed a dynamic model under which linear pay schemes are optimal. In their model, they showed that there exists an optimal linear contract if outcome of a task is normally distributed and an agent with constant risk aversion controls the drift rate of a stochastic process of

performance measures over time, and his action at each time can be conditioned on the observation of his current position in that process. However, Frederickson's experimental design does not satisfy these conditions.

2. ϕ (Phi) correlation coefficient is an ordinary correlation coefficient between two dichotomous variables. This ϕ (Phi) correlation coefficient provides information on the association between two dichotomous variables. This magnitude of association, $\phi 2$, is obtained by squaring the Phi correlation coefficient. We can interpret that $\phi 2$ % of the variations in one dichotomous variable can be explained by another dichotomous variable. High ϕ (Phi) correlation coefficient implies that the source of variations in performance across agents is small and that two agents face the high degree of common uncertainty. Therefore, the ϕ (Phi) correlation coefficient between the subject's production environment represents the degree of common uncertainty which the agents face. The ϕ correlation coefficient is used in this experiment because joint outcomes of the two agent's production process consist of two dichotomous outcomes (acceptable quality vs. unacceptable quality).
3. We are interested in improving principal's welfare by achieving better risk sharing without altering agents' incentives to take desired action.
4. We will hold w* fixed throughout. In comparing two incentive contracts, we will use the same w* for both arrangement. Even though w* may not be optimal for either arrangement, if a principal experience lower expected contracting with one contract, it must be superior one since w* is arbitrarily chosen.
5. The first order approach is valid here since the Grossman and Hart (1983) CDFC condition is met.
6. The specific functional form of probability for getting the acceptable quality of goods has not been decided yet. However, it will satisfy the two assumptions (1) the more effort a subject exerts, the more likely he or she gets the acceptable quality ($q' > 0$) and (2) the probability function has diminishing probability of producing the acceptable quality ($q'' < 0$).
7. The specific functional form of utility for compensation has not been decided.
8. The specific compensation rule has not been determined.
9. The specific functional form of disutility for effort has not been decided.
10. The prizes are not determined yet.
11. The reasons of randomly selecting the treatments are as follows. First, this design will reduce the subjects' fatigue or boredom for the experiment. Second, this random treatment effect design rather than fixed treatment effect will increase the external validity of this experiment.
12. Since we can obtain 100 pairs from 20 subjects, not a single subject will be paired with the same subject with he/she was previously paired).
13. The reasoning behind this manipulation is that it would reduce the subject's randomization decision behavior or simple exploration behavior, thus inducing them to make best decision for each level of common uncertainty. Also, this procedure would not necessarily impose additional financial risk on subjects.
14. This desired effort level has not been determined yet, however, this desired effort will satisfy the Incentive compatibility and Individual rationality constraints of agents in experiment 1. Thus, it is to be identical effort level which is desired by the principal in Experiment 1.
15. This constant experimental commodity has not been determined yet, however, it is assumed to be same as expected output of production.
16. The prizes are not determined yet.
17. The reasoning behind this manipulation is that it would reduce the subject's randomization decision behavior or simple exploiting behavior, thus inducing them to make best decision making on effort. Also, this procedure would not necessarily impose any financial risk on subjects.
18. These Hypotheses also can be tested through the trend analysis (Marasculio and Serlin, 1988, PP 458-460).
19. These statistical procedures are well described in Chapter 26 in Marasculio and Serlin.

REFERENCES

Alchian, A., and H. Demsetz. (1972). Production, Information Costs, and Economic Organization, American Economic Review, pp.777-795.

Baiman, S., and Demski, J. (1980). Economically optimal performance evaluation and control systems. *Journal of Accounting Research* 18 (supplement): 184-220.

Baiman, S. (1982). Agency research in managerial accounting: a survey. *Journal of Accounting Literature* 1: 154-213.

Berg, I., D. Lane, J. Dickhaut, and J. O'Brien. (1986). Controlling preferences for lotteries on units of experimental exchange, *The Quarterly Journal of Economics*, 281-306.

Demski and Sappington. (1984). Optimal Incentive Contracts with Multiple Agents, *Journal of Economic Theory* 33, 152-171.

Dye, R. (1992). Relative Performance Evaluation and Project Selection, *Journal of Accounting Research*, 27-52.

Frederickson, J. (1992). Relative Performance Information: The Effects of Common Uncertainty and Contract Type on Agent Effort, 647-699.

Gibbons, R., and K. Murphy. (1990). Relative performance evaluation for chief executive officers, *Industrial and Labor Relations Review* 43, Special Issue, 30-S - 51-S.

Gong, G., L. Li, J. Shin. (2011). Relative Performance Evaluation and Related Peer Groups in Executive Compensation Contracts, *The Accounting Review*, Vol. 86, No. 3, 1077-1043.

Green, J, and N. Stokey. (1983). A Comparison of Tournaments and Contracts, *Journal of Political Economy* 91, 349-364.

Grossman, S. and O. Hart. (1983). An analysis of the principal-agent problem. *Econometrica* 51, 7-45.

Groves, T. (1973). Incentives in Teams, *Econometrica*, 617-631.

Hannan, R., R. Krishnan, A. Newman. (2008). The Effects of Disseminating Relative Performance Feedback in Tournament and Individual Performance Compensation Plans, *The Accounting Review*, Vol. 83, No. 2, 893-913.

Hannan, R., G. Mcphee, A. Newman, and I. Tafkov. (2013). The Effect of Relative Performance Information on Performance and Effort Allocation in a Multi-Task Environment, *The Accounting Review*, Vol. 88, No. 2, 553-575.

Hayes, R., S. Wheelwright, and K. Clark. (1988). Dynamic Manufacturing, New York: Free Press.

Holmstrom, B. (1979). Moral hazard and observability, *Bell Journal of Economics* 10, 74-91.

Holmstrom, B. (1982). Moral Hazard in Teams, *The Bell Journal of Economics* 13, 1982. 324-340.

Holmstrom, B. and P. Milgrom. (1987). Aggregation and linearity in the provision of intertemporal incentives, *Econmetrica* 55, 303-28.

Holmstrom, B. and P. Milgrom. (1990). Regulating trade among agents, *Journal of Institutional and Theoretical Economies* 146, 85-195.

Holmstrom, B. and P. Milgrom. (1991). Multitask principal-agent analyses: Incentive contracts, asset ownership, and job design, *Journal of Law, Economics, and Organizations*, 24-52.

Itoh, H. (1991). Incentives to Help in Multi-agent Situations, *Econometrica* 59, 616-636.

Itoh, H. (1992). Cooperation in Hierarchical Organizations: An Incentive Perspective, *Journal of Law, Economics, and Organizations* 8, 321-345.

Janakiraman, S., R. Lambert, and D. Larcker. (1992). An Empirical Investigation of the Relative Performance Evaluation Hypothesis, 53-69.

Lazear, E., and R. Sherwin (1989). Rank-Order Tournaments as Optimum Labor Contracts, *Journal of Political Economy*, 841-864.

Moolherjee, D. (1984). Optimal Incentive Schemes with Many Agents, Review of Economic Studies, 433-446.

Nalebuff, B., and J. Stiglitz. (1985). Prizes and Incentives: Towards a General Theory of Compensation and Competition, *The Bell Journal of Economics*, 21-43.

Ramakrishnan, R. and A. Thakor. (1991). Cooperation versus Competition in Agency, *Journal of Law, Economics, and Organization* 7, 248-281.

Selto, F. and J. Cooper (1990). Control of risk attitude in experimental accounting research, *Journal of Accounting Literature* 9, 229-264.

Varians, H. (1990). Monitoring agents with other agents, *Journal of Institutional and Theoretical Economies* 146, 153-174.

Young, , S., J. Fisher, and T. Lindquist. (1993). The effects of intergroup competition and intragroup cooperation on slack and output in a manufacturing setting, *The Accounting Review* 68, 466-481.