The Employment Relationship versus Independent Contracting: On the Organizational Choice and Incentives

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Abstract

This paper studies a firm's choice between employing a worker and using an independent contractor to carry out a task. If the firm hires a worker, all residual rights reside with the firm. In contrast, when the firm deals with an independent contractor, it cannot interfere with the way the task is undertaken. The firm's future actions may impose non-pecuniary costs to the worker, and as a result the worker requires an ex-ante compensation. The firm can economize on the up-front cost by hiring an independent contractor. Independent contracting is a commitment device which ensures that the principal will not intervene

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in the future. However, when the firm has superior private information that is relevant to the execution of the task, the firm faces a trade-off between paying lower costs by hiring an independent contractor and keeping the option of value-enhancing intervention in employment relationship.

1 Introduction

In the provision of intermediate inputs or services, a …rm can either hire labor to produce within the …rm, or subcontract with another …rm to deliver the …nished product. In many contexts, the choice is determined by the relative cost of these two types of transaction. These costs include not only the cost of hiring, …ring, and training, but also the transaction costs associated with bargaining, contracting, and monitoring performance. The transaction costs are zero if the agents are fully informed and the contracts are complete and enforceable. In this case, the organization of production is irrelevant since e¢ciency can be achieved in both cases. If, however, the transaction takes place in an imperfect environment, the transaction costs will di¤er depending on the organizational structure. As it has been argued by Coase [3] and Williamson [15], di¤erent organizational forms emerge in the market economy in order to minimize these costs. Similarly, when a …rm decides whether to organize production as an employment relationship or as independent contracting, it considers the transaction costs associated with each of them.

An organizational structure is a set of rules that govern a relationship. Each organization adopts di¤erent rules which, in turn, in‡uence in a different manner incentives of the agents. In this paper, we study two ways of organizing production: in-house production, which we refer to as the employment relationship, and independent contracting. These two organizational structures di¤er in terms of the allocation of ownership rights over physical assets (Grossman and Hart [5], Klein, Crawford and Alchian [8]), the monitoring instruments used in the relationship (Khalil and Lawarrée [9]), and the compensation (Alchian and Demsetz [1], and Holmstrom [6]).[1] However, the fundamental distinction between the employment relationship and independent contracting is the allocation of residual control rights over production. As noted by Coase [3], and Simon [14], in the employment relationship, the employer has the authority to direct the activities of the employee. This observation has often been criticized on the grounds that the sources of this authority remain unexplained.[2] However, Masten [11] argues that there is

[1] Holmstrom and Milgrom [7] provide an analysis of how these choices are intertwined in the …rm's decision.

[2] For example, Alchian and Demsetz [1], and Jensen and Meckling [10] disagree with the view that the …rm has superiority in terms of authority. The former argues that transactions are organized within a …rm as a result of technological inseparabilities which require team production. The latter views the …rm as the nexus of contractual relationship,

a clear di¤erence in the legal treatment of the employment relationship and the independent contracting because of the allocation of the authority among the parties. On legal grounds, these two types of transaction are perceived as being di¤erent in terms of obligations, sanctions, and procedures governing the exchange.[3] In this paper, we analyze how di¤erences in the allocation of authority in‡uence the …rm's choice between the employment relationship and independent contracting.

The use of the authority in the employment relationship is redundant in an environment where complete contracts can be written. Since the initial contract speci…es the obligations of each party in every conceivable state of the nature, there is no need for ex-post interventions in the relationship. We assume, however, that writing comprehensive contracts is not feasible due to high transaction costs (see Coase [3], Klein, Alchian and Crawford [8], and Williamson [15]). Thus, when an unexpected contingency arises the initial contract must specify what is to be done. One way to accomplish this is by assigning residual control rights to the parties (as in Grossman and Hart [5]) in the initial contract. Alternatively, the …rm[4] can choose either the employment relationship, so that she retains the residual control rights, or independent contracting, so that she forgoes these rights which are given to the contractor.[5]

The model is an extension of the classical principal-agent model. The …rm (principal) contracts with a risk-neutral agent to carry out a project. The principal cannot observe the agent's action, which can be thought of, as his exerted e¤ort level. Therefore, she has to o¤er him an incentive contract

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rejecting any advantages or limitations that arise from internal organization.

[3] The following quote from Masten ([11], p.158) supports this view:

> Upon entering an employment relationship, for example, every employee accepts an implied duty to "yield obedience to all reasonable rules, orders, and instructions of the employer"...
>
> ... whereas, "an ' independent' contractor is generally de…ned as one who in rendering services exercises an independent employment or occupation and represents his employer only as a results of his work and not as the means whereby it is to be done"...

[4] Throughout the paper we will refer to the …rm/principal as "she" and the employer/contractor/agent as "he".

[5] In this paper we are not, modelling the ex-post bargaining problem. We assume that the …rm has all the bargaining power, hence in the equilibrium of the bargaining game, the …rm pays the worker his reservation utility and receives the residual.

to induce him to choose the e¢cient level of e¤ort. After the agent chooses an e¤ort level, both the principal and the agent receive private signals of the project's future pro…tability. It is under the discretion of the party with the control rights to take an action conditional upon the signal he/she observes. These actions not only a¤ect the distribution of pro…ts but also impose a non-pecuniary cost to the agent. We assume that neither the signal nor the action is contractible. Therefore, the initial contract only speci…es how the production is organized. In other words, if the employment relationship is chosen, the principal has the right to decide the second stage action based on the private signal she receives. On the other hand, if independent contracting is chosen, the agent makes this decision based on his information. The principal's problem in an employment relationship is to design a contract that will induce the agent to exert the optimal e¤ort level in the …rst stage. In independent contracting, she also wants to align the agent's incentives regarding the second stage action with her incentives.

In addition to the moral hazard problem, in the employment relationship, there also exist a commitment problem. Since the principal cannot commit ex-ante to a second stage decision, she may have to compensate the agent for the unexpected intervention. The …rm can economize on the up-front cost by hiring an independent contractor. If there is no informational asymmetry over the signals received, then the principal prefers independent contracting over the employment relationship. Independent contracting can be viewed as a commitment device that ensures that in the future the principal will not intervene in the production. As it has been discussed earlier by Williamson [15], the inability of the parties to intervene selectively may be the cause of organizing production in the market rather than internally. When we introduce an informational asymmetry, and in particular, as the agent's information is inferior to the principal's information, the bene…ts from having residual control rights outweighs the cost of compensating the agent. Thus, the employment relationship is the preferred organizational form.

Our model improves the employment relationship model developed by Simon [14], by adding the moral hazard problem. Simon [14] compares the employment relationship, where the employer has the ‡exibility to postpone decisions regarding production until after the uncertainty is resolved, to contingent contracting. His model, however, ignores the moral hazard problem that may exist in the employment relationship. Even though the principal has given the authority to direct the agent's actions in the employment relationship, some dimensions of his actions, such as the e¤ort he exerts, cannot be monitored and therefore cannot be contracted upon. We use a principal-agent model to describe the employment relationship in order to emphasize the impact of the contractual incompleteness that exists in relationships involving human capital. Our model is also related to Grossman and Hart [5]. Their paper examines the relationship between the two firms and the allocation of residual control rights over physical assets when there is contractual incompleteness. Our paper can be viewed as an application of the incomplete contracts framework to an employment relationship. While they study the role of ownership over physical assets, we study the role of authority over human assets. We define authority as the residual control rights over the production process and analyze its implications in a principal-agent setting. Their model focuses on the hold-up problem, and consequently on the distortions that arise in relationship-specific investments, in an environment where contracts are incomplete in every respect. In this model we focus on the contracting problems when there is partial incompleteness.

The remainder of the paper is organized as follows: section 2 presents the basic model. The pareto efficient contract is analyzed in section 2.1, the employment relationship is presented in section 2.2 and the independent contracting is presented in section 2.3. Section 3 analyzes the model where normality of all random variables is assumed. The pareto optimal contract is analyzed in section 3.1. In section 3.2 the employment relationship is discussed for two cases; when the principal can commit to an intervention rule and when she cannot. Section 3.3 presents the optimal contract in independent contracting. The organizational forms are compared in section 4. Conclusions are presented in section 5.

2 The Basic Model

We consider a principal-agent relationship in which the principal contracts with the agent to carry out a one-time project. The project generates profit π which is partly determined by the agent's actions. After they sign a contract the agent chooses his effort level which is assumed to take two values $e \in \{e_L, e_H\}$ with $0 < e_L < e_H$. Before profits realized, both parties privately observe a noisy signal s of profit. The distribution of s is determined by e and given by the function $G(s \mid e)$. We assume that $G(s \mid e_H)$ first order stochastically dominates $G(s \mid e_L)$.

After the private signals are received, the party with control rights chooses an action A which affects the distribution of future profits. In the simplest form we can assume that there are two possible actions available to the party with residual control rights.; "intervene" and "not intervene", i.e.: $A = \{I; NI\}$. Intervention, which can be in the form of partial liquidation of firm's assets, reorganization of production or redirection of the project, reduces the project's risk. Let $F(\pi \mid s; e) = F_A(\pi \mid s; e)$ denote the conditional probability distribution function of profits conditional on signal s, effort e, and action A. We make the following assumption:

Assumption 1:[6] For each $s \in \Re$, there exists $\hat{\pi}(s)$ such that

$$F_I(\pi \mid s; e) < F_{NI}(\pi \mid s; e) \quad \text{for} \quad \pi(s) < \hat{\pi}(s)$$

and

$$F_I(\pi \mid s; e) > F_{NI}(\pi \mid s; e) \quad \text{for} \quad \pi(s) > \hat{\pi}(s)$$

The assumption implies that for each signal s, intervening is safer than not intervening, which has fatter lower and upper tails.

We assume that none of the variables, e, s or A are contractible. The non-contractibility of e requires the principal to offer an incentive contract to the agent in order to induce him to exert high levels of effort. This contract can only be written contingent on the verifiable realized profits. Moreover, the non-contractibility of s and A necessitates the allocation of residual control rights in the initial contract, which in turn, determines the organizational form chosen.[7] In the employment relationship, these rights are given to the employer (the principal) and in independent contracting they are assigned to the contractor (the agent). Essentially the party with the residual control rights, after observing the signal, decides which action, $A = \{I; NI\}$ should be taken.

Both the principal and the agent are assumed to be risk neutral. The agent has reservation utility U_0. The agent's utility function is additively separable, $H(w(\pi); e) = w(\pi) - v(e) - \delta\tau(A)$, where $w(\pi)$ is the compensation scheme, $v(e)$ measures agent's disutility for choosing action e and it

[6] See Dewatripont and Tirole [4].

[7] Notice that if either s or A were is contractible then we can either write the initial contract contingent upon the signal observed or the action taken. In other words, if s is contractible, it is feasible for the principal to offer a contract in the following form. The agent is paid a linear compensation and the cost of intervention δ, if s is less than a particular cutoff point. Otherwise he will only receive the linear compensation. On the other hand if s is not contractible but A is, then we can made the additional payment of δ contingent upon the action I being chosen.

is increasing, strictly convex, and twice differentiable. In addition to the disutility of effort, there is also a nonpecuniary cost δ; incurred by the agent in the event of intervention, regardless of who initiated the decision to intervene. Finally $\tau(A)$ is an indicator function where it takes the value 0 if there is no intervention and 1 if there is an intervention. δ can be thought as the disutility the agent bears as a result of reorganization of the production. The sequence of events is as follows. The organizational form is chosen and the contract is signed. Then the agent chooses an action e, that determines the distribution of π. Before the realization of π, each party observes a noisy signal of profits, s. Then the party in control decides whether or not to intervene. At the end of the period, profits are realized and shared according to the initial contract.

2.1 Optimal Contract With Observable Effort and Perfect Commitment

Before examining the optimal incentive scheme under different organizational forms, we first examine the Pareto optimal contract under full information and perfect commitment. In this case, the principal observes the action the agent is taking and ex-ante commits to an intervention rule. Thus, the principal maximizes her net expected profits subject to the agent's participation constraint.

$$\max_{\substack{e \in \{e_L; e_H\}; \\ I; w(\pi)}} \int_I \int_\pi [\pi - w(\pi)] f_I(\pi \mid s; e)\, g(s \mid e)\, d\pi ds + \int_{I^C} \int_\pi [\pi - w(\pi)] f_{NI}(\pi \mid s; e)\, g(s \mid e)\, d\pi ds$$

$$\text{subject to} \quad \int_I \int_\pi w(\pi) f_I(\pi \mid s; e)\, g(s \mid e)\, d\pi ds + \int_{I^C} \int_\pi w(\pi) f_{NI}(\pi \mid s; e)\, g(s \mid e)\, d\pi ds - v(e) - \delta \int_I g(s \mid e)\, ds \geq U_0:$$

The optimal contract is a fixed wage contract since the action is observable and verifiable. From the individual rationality constraint, $w = U_0 + v(e_H) + \delta \int_I g(s \mid e_H)\, ds$ and the program can be written as

$$\max_I E_{NI}(\pi \mid e) + -(s; e) - \delta G(s \mid e) - U_0 - v(e)$$

where

$$\Gamma(s;e) = \int_I \left[\int_\pi \left(F_{NI}(\pi \mid s;e) - F_I(\pi \mid s;e) \right) d\pi \right] ds$$

The first term in the maximand is the expected profits if there is no intervention. The second term is the monetary gain from intervention. The third term is the expected cost of intervention. The principal chooses an intervention rule that maximizes the net gain from intervention. The following lemma describes the optimal intervention rule.

Lemma 1: If

1. $\frac{\partial}{\partial s}\left[\int [F_{NI}(\pi \mid s;e_H) - F_I(\pi \mid s;e_H)]\, d\pi\right] \leq 0$ for all s and π and
2. $\exists \hat{s}$ such that $E_I[\pi \mid \hat{s};e_H] = E_{NI}[\pi \mid \hat{s};e_H]$

then the optimal intervention rule is a cut-off rule.[8]

Proof. From condition (2) we have

$$\int [F_{NI}(\pi \mid \hat{s};e_H) - F_I(\pi \mid \hat{s};e_H)]\, d\pi = 0.$$

Together with the condition (1) it follows that

$$\int [F_{NI}(\pi \mid s;e_H) - F_I(\pi \mid s;e_H)]\, d\pi \begin{array}{ll} \geq 0 & \text{for } s < \hat{s} \\ < 0 & \text{for } s > \hat{s}. \end{array}$$

Due to the monotonicity assumption, there exists s^* that is smaller than $\hat{s}$ and satisfies

$$F_{NI}(\pi \mid s^*;e_H) - F_I(\pi \mid s^*;e_H) - \delta = 0$$

Thus, the set signals in which an intervention occurs is $I = \{s \mid s < s^*\}$ and the optimal intervention rule is a cut-off rule. As long as

$$E_{NI}(\pi \mid e_H) - v(e_H) > E_{NI}(\pi \mid e_L) - v(e_L)$$

then it is socially efficient to implement e_H.

[8] As a convention, we use indefinite integral when integral is taken over the entire domain of a variable.

Note that the optimal contract can also be written contingent on the intervention. In other words it is feasible to write a contract that promises to pay the agent different amounts depending on whether or not the intervention takes place. Given this contract, the optimal intervention rule is the same as before. The agent is paid $U_0 + v(e_H)$ if there is no intervention and $U_0 + v(e_H) + \delta$ if there is an intervention.

2.2 Employment Relationship

In the employment relationship, the party in control is the principal. She wants to maximize her expected profits subject to the agent's individual rationality and the incentive compatibility constraint. This case is more complicated than the simple principal-agent problem. Each contract that the principal proposes to the agent induces a subgame in which the agent chooses an action and the principal decides whether to intervene or not. The game is one of imperfect information. At the time the principal decides whether to intervene or not, she does not know which action the agent has taken. In the rest of the model we will restrict attention to a set of linear contracts such that $w(\pi) = \alpha\pi + \beta$ where $\alpha \in [0, 1]$ and $\beta \in \Re$. The principal solves the following program.

$$\max_{\alpha,\beta} \quad (1 - \alpha)\left[E_{NI}(\pi \mid s^e, e_H) + \Gamma(s^e, e_H)\right] - \beta$$

$$s.t \quad E(w(\pi) \mid s^e, e_H) - v(e_H) \geq U_0$$

$$E(w(\pi) \mid s^e, e_H) - v(e_H) \geq E(w(\pi) \mid s^e_L, e_L) - v(e_L)$$

where

$$E(w(\pi) \mid s, e_i) = \beta + \alpha\left[E_{NI}(\pi \mid e_i) + \Gamma(s, e_i)\right] - \delta G(s \mid e_i)$$

for $i = L, H$ is the expected compensation paid to the agent and

$$s^e = \inf_s \left\{ s \mid \int \pi f_I(\pi \mid s, e)\, d\pi \geq \int \pi f_{NI}(\pi \mid s, e)\, d\pi \right\}$$

is the optimal intervention rule.

The principal maximizes the expected net profits subject to agent's individual rationality constraint, the incentive compatibility constraint, and the principal's ex post intervention rule. By the time the principal decides whether to intervene or not, the contract has been signed and the agent has chose an effort level. Due to the linearity of the contract, the principal simply compares the expected profits with intervention with the one without intervention.

Lemma 2 : The optimal intervention rule is a cutoff rule where the princpal intervenes in the project if the signal observed is less than s^e and does not intervene otherwise.

It is trivial to show that due to the second assumption of the lemma (1) s^e is in fact equal to $\hat{s}$ and greater than s^*.

Proposition 3 If it is socially optimal to implement e_H then there exists a contract where $\alpha = 1$ and

$$\beta = U_0 + v(e_H) + \delta G(s^e \mid e_H) - E_{NI}(\pi \mid e_H) - (s^e; e_H)$$

that implement $(e_H; s^e)$.

Corollary 4 The payment to the agent (the expected net surplus) in ER is greater (smaller) than the payment to the agent (the expected net surplus) in the first best case.

$$w_{FB} = U_0 + v(e_H) + \delta G(s^* \mid e_H)$$

$$w_{ER} = U_0 + v(e_H) + \delta G(s^e \mid e_H)$$

2.3 Independent Contracting

In this case the control rights are given to the agent. After the signal is observed the agent intervenes in the project if

$$\alpha \int \pi f_I(\pi \mid s; e)\, d\pi - \delta \geq \alpha \int \pi f_{NI}(\pi \mid s; e)\, d\pi$$

Lemma 1 The optimal intervention rule is a cutoff rule where the princpal intervenes in the project if the signal observed is less than $s^I(\alpha)$ and does not intervene otherwise.

The treshehold level of the signal for the agent's intervention rule depends on α. If $\alpha = 1$ then the agent's interventionn rule is the same as the first best intervention rule s^*. Given the agent's optimal intervention rule the principal's problem is as follows

$$\max_{\alpha;\beta} \; (1-\alpha)\left[E_{NI}\left(\pi \mid s^I; e_H\right) + \Gamma\left(s^I; e_H\right)\right] - \beta$$

$$s.t. \quad E\left(w(\pi) \mid s^I; e_H\right) - v(e_H) \geq U_0$$

$$E\left(w(\pi) \mid s^I; e_H\right) - v(e_H) \geq E\left(w(\pi) \mid s^I; e_L\right) - v(e_L)$$

Proposition 5 *If it is socially optimal to implement e_H then there exists a contract where $\alpha = 1$and*

$$\beta = U_0 + v(e_H) + \delta G(s^* \mid e_H) - E_{NI}(\pi \mid e_H) - \Gamma(s^*; e_H)$$

that implement $(e_H; s^*)$.

The results of the basic model can be summarized as follows:

- Principal prefers independent contracting over employment relationship since payment to the agent is lower in the former case.
- Independent contracting is also the efficient organizational form since it implements the efficient effort and the efficient intervention rule.
- Choosing independent contracting can be viewed as a commitment device which ensures that the principal will not intervene in the future.

In the next section we present an example where the contracts are linear and in addition the signal received by the agent isa garbling of the principal's signal. We examine how the solution to the simple principal-agent model changes with the introduction of a non-contractible action, and how the allocation of control rights influences the optimal contracts.

3 Example

Let $v(e_L) = 0$ and $v(e_H) = K > 0$: Consider a linear compensation scheme for the agent in the form of $w(\pi) = \alpha\pi + \beta$ where $\alpha \in [0; 1]$ and $\beta \in \Re$: The distribution of π, conditional on e is assumed to be a normal with mean "e" and variance "e^2". Therefore "low effort" generates low, but safer profits, while "high effort" generates high, but riskier profits. The principal observes the signal $s_P = \pi + \varepsilon$ and the agent observes $s_A = \pi + \varepsilon + \eta$, where the noise term ε is assumed to be normally distributed with mean zero and variance σ_ε^2, and η is assumed to be normally distributed with mean zero and variance σ_η^2. We set up the model in such a way that the agent's information is a garbling of the principal's information. After the signal is observed, the party in control decides whether or not to intervene. For simplicity, intervention is assumed to scale down profits by a factor λ, where $\lambda \in [0; 1]$. Hence, both the expected profitability, and the riskiness of the project are reduced after intervention.

Given the marginal distributions of π and s conditional on e, the distribution of π conditional on s and e is derived using Bayes' rule, and it is

$$(\pi \mid s_i; e) \sim N\left(\frac{e\sigma_i^2 + e^2 s_i}{e^2 + \sigma_i^2}; e^2\sigma_i^2\right)$$

where $i = P; A$ and $\sigma_P^2 = \sigma_\varepsilon^2$ and $\sigma_A^2 = \sigma_\varepsilon^2 + \sigma_\eta^2$. Note that the conditional mean of profits, given the signal, is a convex combination of e and s. As the noise term increases, the signal becomes uninformative about future profits, and the conditional mean of profits approaches the unconditional mean, e. As the noise becomes smaller, the signal becomes informative, and the conditional mean approaches the realized profits. The following lemma states that the values of s, for which the intervention takes place, is strictly lower-tailed.

Lemma 6 The optimal intervention rule is a cut-off rule.

Proof. It is sufficient to examine whether the conditions of Lemma 1 are satisfied. The derivative of $\int [F_{NI}(\pi \mid s_i; e_H) - F_I(\pi \mid s_i; e_H)]\, d\pi$ with respect to s is $(\lambda - 1)\left(\frac{e\sigma_i^2 + e^2 s_i}{e^2 + \sigma_i^2}\right)$ which is negative since $\lambda \in [0; 1]$. There exists $\hat{s}_i$ which is equal to $-\frac{\sigma_i^2}{e}$. Therefore the intervention rule is a cut-off rule. ■

3.1 Pareto Optimal Contract

The first-best is achieved if the principal has perfect information and there is no a commitment problem. In this environment, the pareto optimal contract is obtained by maximizing the principal's expected net profits subject to the agent's participation constraint. Since the principal's signal is a sufficient statistic for the agent's signal, the beliefs about the distribution of profits is updated by the principal's signal, s_P. Let

$$E(\pi \mid s_P; e_H) = e_H - (1-\lambda)\int_{-\infty}^{s_P}\left(\frac{e\sigma_P^2 + e^2 s_P}{e^2+\sigma_P^2}\right) g(s_P \mid e_H)\, d\pi\, ds$$

denote the expected profits when the effort level e_H is chosen by the agent and the cut-off rule for intervention is s_P. The first term is the unconditional expected profit and the second term, which in the future we will denote as $I(s_{PH}; e_H)$, is the difference in the expected profits due to the intervention. The value of $I(s_{PH}; e_H)$ is negative for $s_P < -\frac{\sigma_\epsilon^2}{e}$, therefore, it can be interpreted as the expected losses recovered by intervention. The Pareto optimal contract is generated by the program:

$$\begin{aligned} &\max_{\alpha;\beta;s_P} (1-\alpha) E(\pi \mid s_P; e_H) - \beta \\ \text{s.to}\quad &\alpha E(\pi \mid s_P; e_H) + \beta - K - \delta G(s_P \mid e_H) \geq w_0 \end{aligned}$$

where w_0 is the agent's expected outside wage. The following lemma provides a condition under which there exists an optimal contract that implements e_H and the first-best intervention rule.

Lemma 7 The Pareto optimal intervention rule is

$$D(s_P^*; e) = \begin{cases} \text{intervene if} & s_P \leq s_P^* \\ \text{do not intervene if} & s_P > s_P^* \end{cases} :$$

where $s_P^* = -\frac{\delta\left(e_H^2+\sigma_\epsilon^2\right)}{(1-\lambda)e_H^2} - \frac{\sigma_\epsilon^2}{e_H}$

The agent's individual rationality constraint is binding, which gives us the total compensation the agent is paid, $w(\pi)$. Substituting $w(\pi)$ into the maximand and solving for s_P, yields s_P^*, the cut-off point for the optimal intervention rule. The following proposition describes the optimal contracts.

Proposition 8 *Suppose that*

$$e_H - (1-\lambda) l(s^*_H; e_H) - K - \delta G(s^*_{PH}; e_H) \geq e_L - (1-\lambda) l(s^*_{PL}; e_L) - \delta G(s^*_{PL}; e_L) \quad (1)$$

holds. There exists a continuum of first-best incentive schemes $(\alpha; \beta)$ *that implement* e_H*, such that, the agent is paid* $w^*(\pi) \equiv w_0 + K + \delta \int_{-\infty}^{s^*_{PH}} g(s \mid a_H)\, ds = \alpha E(\pi \mid s^*_{PH}; e_H) + \beta$.

Condition (1) implies that it is socially desirable to choose "high effort".[9] The optimal contract pays the agent $w^*(\pi)$ which is the sum of his reservation wage, the disutility from exerting high levels of effort, and the expected cost of intervention. The fixed payment contract where

$$\alpha = 0 \text{ and } \beta = w_0 + K + \delta \int_{-\infty}^{s^*_{PH}} g(s \mid a_H)\, ds$$

is one of the solutions to the problem. With full information there is no moral hazard problem. A contract that pays $w^*(\pi)$ to the agent, if he exerts high effort, can be implemented. Since there is also no commitment problem, the allocation of residual control rights is irrelevant. The optimal intervention rule that the intervention will take place when a signal $s_{PH} \leq s^*_{PH}$ is observed, can be specified in the initial contract.

3.2 Employment Relationship

In an employment relationship, the principal has the residual control rights over production and decides whether or not to intervene depending on the signal, s_P, she receives. There are two problems that cause the employment relationship model to deviate from the pareto optimal case. First, there is a moral hazard problem, due to the unobservability of the agent's actions by the principal. Therefore, the principal has to offer an incentive payment scheme to the agent. Second, there is a commitment problem, due to non-contractibility of intervention. In order to correctly identify the sources of deviations from the first-best solution correctly we solve the problem in two stages, adding one friction at a time.

[9] In a simple principal-agent model, condition (1) corresponds to the condition that $e_H - e_L \geq K$.

3.2.1 Principal can commit to an intervention rule

We first assume that the principal can commit to an intervention rule. In other words, we assume that s is ex-ante contractible. Then the optimal contract solves the following program:

$$
\begin{array}{ll}
\max\limits_{\alpha;\beta;s} & (1-\alpha)E(\pi \mid s_P; e_H) - \beta \\
\text{subject} & \text{to} \\
 & \alpha E(\pi \mid s_P; e_H) + \beta - K - \delta G(s \mid a_H) \geq w_0 \\
\text{and} & \\
 & \alpha E(\pi \mid s_P; e_H) + \beta - K - \delta G(s \mid a_H) \geq \\
 & \alpha E(\pi \mid s_P; e_H) + \beta - \delta G(s \mid a_L)
\end{array}
$$

Proposition 9 If it is socially optimal to implement e_H (i.e. condition (1) holds), then there exists a continuum of first best incentive schemes $(\alpha;\beta)$ that implement $(e_H; s^*_{PH})$, such that, the agent is paid a total compensation of $w^*(\pi)$ and $\alpha \in \left[\frac{K+\delta[G(s^*_{PH};e_H)-G(s^*_{PH};e_L)]}{e_H-e_L-(1-\lambda)[I(s^*_{PH};e_H)-I(s^*_{PH};e_L)]}; 1\right]$.

Since the principal cannot observe the effort level of the agent, she has to offer him an incentive contract. It is a well known result in principal-agent theory, that when the agent is risk neutral, making the agent residual claimant is an optimal solution. Since s is assumed to be contractible, there is no commitment problem. Giving the agent residual claimancy with a fee of $F = E\Pi(s^*_{PH}; e_H) - w^*(\pi)$ (i.e.: $\alpha = 1$ and $\beta = w^*(\pi) - E\Pi(s^*_{PH}; e_H) < 0$ which is in fact the payment to the principal) is one of the optimal solutions to the program. Again the individual rationality constraint is binding. The incentive compatibility constraint is not binding since the principal can adjust β accordingly as long as α is greater than the lower bound. There is a constraint on the values that α is allowed to take in order for $\alpha \in (0; 1)$ to exist. This constraint which is derived from the incentive compatibility constraint is

$$e_H - (1-\lambda)I(s^*_{PH}; e_H) - K - \delta G(s^*_{PH}; e_H) \geq e_L - (1-\lambda)I(s^*_{PH}; e_L) - \delta G(s^*_{PH}; e_L): \quad (2)$$

Condition (1) is sufficient for condition (2) to hold (see Appendix). Therefore, as long as e_H is efficient level of effort, there exists a linear contract that would induce the agent to choose e_H.

3.2.2 Principal cannot commit to an intervention rule

Now we consider the case where the principal cannot commit ex-ante to an intervention rule contingent on s_P. After the principal observes the signal s_P, she updates her belief about the distribution of profits π, and decides whether or not to intervene in the project. The expected value of profits, given the signal is, $E[\pi \mid s_P; e] = \frac{e\sigma_\pi^2 + e^2 s_P}{e^2+\sigma_\pi^2}$ which is a convex combination of e and s_P. Since the contract has already been signed, $w(\pi)$, the compensation to the agent, is a sunk cost from principal's point of view. Therefore, when she decides whether or not to intervene she is concerned only about the overall expected profits. Solving $E[\pi \mid s_P; e] = 0$, yields $s_P^E = -\frac{\sigma_\pi^2}{a}$ as the cut-off point for intervention. Then, the principal's decision rule is

$$D\left(s_P^E; e\right) = \begin{cases} \text{intervene if} & s_P \leq s_P^{ER} \\ \text{do not intervene if} & s_P > s_P^{ER} \end{cases}.$$

It is worthwhile to note that $s_P^E > s_P^*$. Thus, if the principal cannot commit ex ante to an intervention rule, she intervenes more often than the socially optimal rule.

At the beginning of the game, when the principal offers a contract to the agent both parties will take the principal's ex-post intervention rule into consideration. As we discussed earlier, every contract induces a subgame between the principal and the agent, in which the agent chooses an action, and the principal decides whether or not to intervene. The equilibria of these subgames are reflected in the principal's problem which is as follows:

$$\max_{\alpha;\beta} \quad (1-\alpha) E\left(\pi \mid s_{PH}^E; e_H\right) - \beta$$
$$\text{subject to} \quad \alpha E\left(\pi \mid s_{PH}^E; e_H\right) + \beta - K - \delta G\left(s_{PH}^E \mid e_H\right) \geq w_0$$
$$\text{and} \quad \alpha E\left(\pi \mid s_{PH}^E; e_H\right) + \beta - K - \delta G\left(s_{PH}^E \mid e_H\right) \geq \alpha E\left(\pi \mid s_{PH}^E; e_H\right) + \beta - \delta G\left(s_{PH}^E \mid e_L\right)$$

The solution to this problem is presented in the following proposition.

Proposition 10 If

$$e_H - (1-\lambda) I\left(s_{PH}^E; e_H\right) - K - \delta G\left(s_{PH}^E; e_H\right) \geq e_L - (1-\lambda) I\left(s_{PL}^E; e_{PL}\right) - G(s_{PL}^E; e_{PL}) \quad (3)$$

holds, then there exist a continuum of linear contracts $(\alpha; \beta)$ that implement $(s^{ER}_{PH}; e_H)$, such that the agent is paid the total compensation of $w^E(\pi) = w_0 + K + \delta G\left(s^E_{PH} \mid e_H\right)$ and $\alpha \in \left[\frac{K+\delta[G(s^E_{PH};e_H) - G(s^E_{PH};e_L)]}{e_H - e_L - (1-\lambda)[l(s^E_{PH};e_H) - l(s^E_{PH};e_L)]}; 1\right)$.

Condition (3) states that e_H is the principal's preferred action under her optimal intervention rule. Condition (3) is a sufficient but not a necessary condition for condition (1). In other words, e_H may not be an optimal action for the principal, even if it is socially optimal. The lower bound for α which is derived from the incentive compatibility constraint, requires that

$$e_H - (1-\lambda)\, l\left(s^E_{PH}; e_H\right) - K - \delta G\left(s^E_{PH}; e_H\right) \geq e_L - (1-\lambda)\, l\left(s^E_{PH}; e_L\right) - \delta G\left(s^E_{PH}; e_L\right) \tag{4}$$

holds. The condition (3) is sufficient for the condition (4). In other words, there exists a linear contract that would implements e_H, if it is the principal's preferred effort level.

Note that we deliberately excluded the case of $\alpha = 1$ from the solution set. If the agent becomes residual claimant, the principal's incentive to interfere in the project is distorted, since she gets a fixed rent from the agent in every state. Then the problem is reduced to a simple principal-agent problem without intervention. In this case, the expected value of the principal's payoff is $e_H - w_0 - K$ as opposed to $e_H - (1-\lambda)\, l\left(s^E_{PH}; e_H\right) - K - w_0 - \delta G\left(s^E_{PH}; e_H\right)$ which she would have received if $\alpha < 1$. We will assume that $-(1-\lambda)\, l\left(s^E_{PH}; e_H\right) \geq \delta G\left(s^E_{PH}; e_H\right)$, that is intervention provides positive gains. Therefore, the principal prefers to set $\alpha < 1$ and intervene in the project.

Corollary 11 If a linear contract exist that implements $\left(s^E_{PH}; e_H\right)$, then the expected payment to the agent is higher, and the principal's net surplus is lower, in the non-commitment case than in the commitment case.

In both cases the agent's compensation is the sum of his outside wage, w_0, the disutility from exerting high levels of effort, K, and the expected cost of intervention, $\delta G(s_{PH}; e_H)$. Since the cut-off point for intervention is greater in the case of non-commitment the expected costs are higher and the worker is paid a higher compensation. The principal pays a premium to the agent in the non-commitment case because she intervenes more often.

The principal's net surplus, $e_H - (1-\lambda)\, l(s_{PH}; e_H) - K - \delta G(s_{PH}; e_H) - w_0$, is increasing in the values of the signal s that are less than s^*_{PH}. Since $s^*_{PH} < s^E_{PH}$, her net surplus is greater under s^*_{PH} than s^E_{PH}.

3.3 Independent Contracting

In the case of independent contracting, the principal has no further role after the contract is signed. We first characterize the optimal intervention rule after the agent observes his signal. The agent observes a signal s_A, which is noisier than the principal's signal. After observing his signal, the agent decides whether or not to intervene taking into account his expected compensation rather than the project's expected profits. Having the residual control rights, the agent trades off the cost of intervention with its benefit. The agent will intervene in the project if the expected compensation after intervention is greater than the one without intervention,

$$\alpha\lambda E(\pi \mid s_A; e) + \beta - K - \delta \geq \alpha E(\pi \mid s_A; e) + \beta - K.$$

Solving the above for s_A yields $s_A^I = -\frac{\sigma_\pi^2+\sigma_\varepsilon^2}{e} - \frac{\delta\left(\sigma_\pi^2+\sigma_\varepsilon^2+e^2\right)}{e^2\alpha(1-\lambda)}$, as the cut-off for intervention. The agent's decision rule is

$$D(s_A^I; e) = \begin{cases} \text{intervene if} & s_A \leq s_A^I \\ \text{do not intervene if} & s_A > s_A^I \end{cases}. \tag{5}$$

When designing an incentive scheme, the principal takes into account the agent's optimal decision rule. The optimal contract not only induces the agent to choose e_H but also aligns his incentives to intervene with hers. The optimal contract is generated by the following program:

$$\begin{aligned} &\max_{\alpha,\beta} && (1-\alpha)E\left(\pi \mid s_{AH}^I; e_H\right) - \beta \\ &\text{subject to} && \alpha E\left(\pi \mid s_{AH}^I; e_H\right) + \beta - K - \delta G\left(s_{AH}^I \mid e_H\right) \geq w_0 \\ &\text{and} && \alpha E\left(\pi \mid s_{AH}^I; e_H\right) + \beta - K - \delta G\left(s_{AH}^I \mid e_H\right) \geq \\ & && \alpha E\left(\pi \mid s_{AH}^I; e_H\right) + \beta - \delta G\left(s_{AH}^I \mid e_L\right) \end{aligned}$$

The following lemma provides the solution to this program.

Lemma 12 *If it is socially optimal to implement e_H (i.e.: condition (1) holds), then there exists an optimal incentive scheme that makes the agent the residual claimant and implements $(e_H; s_{AH}^I)$. This contract is given by $\alpha = 1$ and $\beta = w^*(\pi) - E\left(\pi \mid s_{AH}^I; e_H\right)$.*

Proof. See Appendix. ■

Note that s^I_H depends on α. The choice of α will not only induce the agent to exert high levels of effort but it will also influence the agent's decision to intervene. If only linear contracts are available, then there does not exist a contract that perfectly aligns the agent's incentives with the principal's. In other words, there does not exist an $\alpha \in [0;1]$ that equalizes s^I_{AH} with s^E_{AH}.

4 Comparison of the Two Organizational Form

In any organizational form, the critical value of s, which determines the intervention rule, is decreasing in σ^2, the variance of the noise term in the signal. As the signal becomes noisier, the probability of intervention goes down. This reduces the expected cost of intervention and also increases the losses recovered by intervention. Thus, the net benefit from intervention goes up. In the model, we assume that the principal and the agent observe different signals. In particular, the agent's signal is a garbling of the principal's signal. As a benchmark, we now consider the case in which both the principal and the agent receive the same signal before the actual profits are realized. This is a special case of the model where σ_ϵ^2, the additional noise term in the agent's signal equals zero. Then, the optimal contract in independent contracting is Pareto efficient, since the cut-off point for the agent's optimal intervention rule becomes s^*_{PH} which is the first best intervention rule and the optimal contract implements $(e_H; s^*_{PH})$. Given Lemma (11), the principal prefers independent contracting over the employment relationship as the organizational form, since in the former her net surplus is greater. In independent contracting the principal saves on the up-front payment to the agent which she would have to pay in the employment relationship.

As the agent's signal becomes noisier, intervention in independent contracting is inefficient. The agent intervenes less than the optimal level which results with "underinvestment". Even though he is the residual claimant under the optimal contract, his incentives are distorted because his information is noisier than the principal's information. As the variance of the signal increases, the losses from underinvestment outweighs the gains from the compensation paid to the worker, and the principal finds the employment relationship more desirable. The following proposition summarizes this result.

Proposition 13 When $\sigma_\epsilon^2 = 0$, the principal prefers independent contracting over the employment relationship. In this case, independent contracting is also Pareto efficient. For small values of σ_ε^2, independent contracting continues to dominate the employment relationship. As the agent's signal becomes noisier, the employment relationship is the preferred organizational form.

Proof. Let $B\left(s_P^E; e_H\right)$ be equal to

$$-(1-\lambda) I\left(s_P^E; e_H\right) - \delta G\left(s_P^E; e_H\right);$$

the net benefit from intervention under the employment relationship and let $A\left(s_A^I; e_H\right)$ be the corresponding function under independent contracting. When $\sigma_\varepsilon^2 = 0$, both the principal and the agent observes the same signal. From the result of the lemma 12 the independent contracting implements the first best. From the result of the lemma 11, the net surplus of the principal is higher under independent contracting than under the employment relationship, thus $A\left(s_A^I; e_H\right) > B\left(s_P^E; e_H\right)$.

We show in the appendix D that as σ_ε^2 increases $A\left(s_A^I; e_H\right)$ decreases while $B\left(s_P^E; e_H\right)$ stays constant. As σ_ε^2 approaches 1, $A\left(s_A^I; e_H\right)$ approaches to 0 from right. Thus, the principal's expected profits under independent contracting, $e_H - K + A\left(s_A^I; e_H\right)$ is bounded away from $e_H - K$. As σ_η^2 approaches 1, $B\left(s_P^E; e_H\right)$ also approaches 0. We can find σ_η^2 which is sufficiently small so that $B\left(s_P^E; e_H\right)$ is greater than 0. Therefore for each values of σ_η^2 there exists $\bar{\sigma}_\varepsilon^2$ such that $A\left(s_A^I; e_H\right) = B\left(s_P^E; e_H\right)$ and for $\sigma_\varepsilon^2 > \bar{\sigma}_\varepsilon^2$ $A\left(s_A^I; e_H\right) < B\left(s_P^E; e_H\right)$. In other words, if the agent's signal is very noisy, then the principal's profits under employment relationship is greater than her profits under independent contracting. ■

If the principal's signal is perfectly informative, i.e.: $\sigma_\eta^2 = 0$, then for small σ_ε^2, the independent contracting continues to be the principal's preferred organizational form. When $\sigma_\eta^2 = 0$, the principal intervenes whenever the signal received is less than 0. However the optimal intervention rule trades off the benefit from intervention with its cost in the margin. The efficient intervention rule proposes that intervention takes place when $s \leq -\frac{\delta}{1-\lambda}$. When the agent's information is not very noisy, the intervention rule under independent contracting is closer to the efficient intervention rule than the intervention rule under the employment relationship. As σ_ε^2 becomes larger, however, the agent intervenes very infrequently so that the principal prefers the employment relationship.

5 Concluding Remarks

We study a firm's decision to choose between employing a worker and using an independent contractor to carry out a task. We analyze this problem using a two-stage principal-agent model. We derive conditions under which an optimal contract, which implements high effort level, e_H, of the worker, exists. When we restrict the set of feasible contracts to those that are linear in profits, e_H can be implemented under independent contracting, as long as it is socially efficient. In the employment relationship, however, the linear contracts that implements e_H exist only for certain parameter values of the model. The intervention decision remains inefficient under both organizational structures. The inefficiency in the employment relationship arises because the principal cannot commit ex ante to an intervention rule. When she makes the second stage decision, she does not take into account the costs incurred by the agent as a result of her intervention. Thus, in the employment relationship, there is "too much" intervention. Even though the commitment problem is avoided in independent contracting by delegating the intervention decision to the agent, there is "too little" intervention. The distortion in the agent's intervention decision is created by the agents's inferior information.

When both parties receive the same signal, thus, there is no informational asymmetry, independent contracting is Pareto efficient organizational form. The optimal contract implements both the first-best effort level and the intervention rule. The principal prefers independent contracting because she receives higher net profits. As the signal of the agent becomes noisier, the agent's intervention rule becomes more distorted and the cost-saving advantages of the independent contracting dissipate. Even if the principal's signal is perfectly informative about the profitability of the project, for small noise in the agent's signal, the principal finds independent contracting more desirable than the employment relationship. In the model, we assume that the agent's information is worse than the principal's information. If the agent possesses better information, then independent contracting always Pareto dominates the employment relationship. These results support the empirical evidence presented by Masten [12] who examines the firm's integration decision with the upstream firm in the aerospace industry. He finds that the specificity of the component is a detrimental factor in this decision. As the component becomes more specific, the firm prefers in-house production to independent contracting. The specificity of the component can be interpreted in our model as the principal having superior information about the project.

In this model we assume that the players observe their signal privately and there is no communication between them. In the employment relationship the principal makes the second stage decision. Since the principal's signal is a sufficient statistic for the agent's signal, communication does not improve efficiency. In independent contracting, however, the agent makes the second stage decision based on his signal which is noisier than the principal's signal. In fact the main source of inefficiency in independent contracting is that the agent has inferior information.

A possible extension to the model above would be to allow communication in independent contracting. With communication, the principal announces the signal she observes and based on that announcement the agent decides whether or not to intervene. If the principal's announcement is verifiable, then the outcome of the employment relationship can be replicated in independent contracting. The fact that the principal can write a contract that is contingent on her announcement avoids the non-contractibility problem. This, in turn, eliminates the need for the allocation of residual control rights. If the principal's announcement, however, is not contractible, a contract that is contingent on the announcement cannot be implemented. When the principal announces the signal she observes, she also takes into account how the agent's incentives are affected by this announcement. In particular, the cost of compensating the agent, when information is revealed, may exceed the benefits. Then, the principal may find it more desirable not to announce her information. The complications that may arise in the model is similar to the problem of incentive contracting with informed principal which was originally introduced by Myerson [13].

6 Appendices

6.1 Appendix A

Claim: C1 implies C2.
Proof. Rewriting C1 gives

$$e_H - e_L \geq K + (1-\lambda)l(s^*_H; e_H) + \delta G(s^*_H; e_H) - (1-\lambda)l(s^*_L; e_L) - \delta G(s^*_L;{}_L)$$

and rewriting C2 gives

$$e_H - e_L \geq K + (1-\lambda)l(s^*_H; e_H) + \delta G(s^*_H; e_H) - (1-\lambda)l(s^*_H; e_L) - \delta G(s^*_H;{}_L)$$

If $(1-\lambda)I(s^*_H;e_L)+\delta G(s^*_H;e_L) > (1-\lambda)I(s^*_L;e_L)+\delta G(s^*_L;e_L)$, then C1 implies C2. Since $s^*_H > s^*_L$, it is sufficient to prove that $(1-\lambda)I(s;e)+\delta G(s;e)$ is increasing in s since $s^*_H > s^*_L$. Taking derivatives with respect to s yields $(1-\lambda)\left(\frac{e\sigma_\varepsilon^2+e^2 s}{e^2+\sigma_\varepsilon^2}\right)$ which is positive for $s > s^*$. ■

6.2 Appendix B

Given $\pi \mid e \sim N(e, e^2)$; $\varepsilon \mid e \sim N(0, \sigma_\varepsilon^2)$ and $s_P = \pi + \varepsilon$; first we will derive the pdf of $\pi \mid s_P, e$:

Using Bayes rule $h(\pi \mid s, e) = \frac{f(\pi, s \mid e)}{g(s \mid e)}$ and assuming that $\mathrm{cov}(\pi, \varepsilon \mid e) = 0$,

$$f(\pi, s \mid e) = \frac{1}{\sqrt{2\pi}e}\exp\left\{-\frac{1}{2}\left(\frac{\pi-e}{e}\right)^2\right\} \cdot \frac{1}{\sqrt{2\pi}\sigma_\varepsilon}\exp\left\{-\frac{1}{2}\frac{(s-\pi)^2}{\sigma_\varepsilon^2}\right\} \tag{6}$$

and

$$\begin{aligned} g(s \mid e) &= \int_{-\infty}^{\infty} \frac{1}{\sqrt{2\pi}e}\exp\left\{-\frac{1}{2}\left(\frac{\pi-e}{e}\right)^2\right\} \cdot \frac{1}{\sqrt{2\pi}\sigma_\varepsilon}\exp\left\{-\frac{1}{2}\left(\frac{s-\pi}{\sigma_\varepsilon}\right)^2\right\} d\pi \\ &= \frac{1}{\sqrt{2\pi}\left(\sigma_\varepsilon^2+e^2\right)^{\frac{1}{2}}}\exp\left\{-\frac{1}{2}\frac{(s-e)^2}{\sigma_\varepsilon^2+e^2}\right\} \end{aligned} \tag{7}$$

then

$$\begin{aligned} h(\pi \mid s, e) &= \frac{\frac{1}{\sqrt{2\pi}e}\exp\left\{-\frac{1}{2}\left(\frac{\pi-e}{e}\right)^2\right\} \cdot \frac{1}{\sqrt{2\pi}\sigma_\varepsilon}\exp\left\{-\frac{1}{2}\left(\frac{s-\pi}{\sigma_\varepsilon}\right)^2\right\}}{\frac{1}{\sqrt{2\pi}\left(\sigma_\varepsilon^2+e^2\right)^{\frac{1}{2}}}\exp\left\{-\frac{1}{2}\frac{(s-e)^2}{\sigma_\varepsilon^2+e^2}\right\}} \\ &= \frac{\left(\sigma_\varepsilon^2+e^2\right)^{\frac{1}{2}}}{\sqrt{2\pi}e\sigma_\varepsilon}\exp\left\{-\frac{1}{2}(\pi-b)^2\frac{\sigma_\varepsilon^2+e^2}{(e\sigma_\varepsilon)^2}\right\} \end{aligned} \tag{8}$$

where $b = \left(\frac{e\sigma_\varepsilon^2+se^2}{\sigma_\varepsilon^2+e^2}\right)$ is the conditional mean of profits given the signal. Rewriting $b = \left(\frac{\sigma_\varepsilon^2}{\sigma_\varepsilon^2+e^2}\right)e + \left(\frac{e^2}{\sigma_\varepsilon^2+e^2}\right)s$; we see that it is a convex combination of $e = E[\pi]$ and s. As $\sigma_\varepsilon^2 \to \infty$; the signal becomes uninformative and $b \to e$ while as $\sigma_\varepsilon^2 \to 0$; the signal becomes informative and $b \to \pi$:

6.3 Appendix C

Let μ and γ be the multipliers of the individual rationality and incentive compatibility conditions respectively. The first order conditions are

$$
\begin{aligned}
\frac{\partial L}{\partial \alpha} = {} & E\left(\pi \mid s^I_{AH}; e_H\right)\left(\frac{\partial E\left(\pi|s^I_{AH};e_H\right)}{\partial \alpha}(\mu + \gamma - 1) - \delta\frac{\partial G\left(s^I_{AH};e_H\right)}{\partial \alpha}(\mu + \gamma)\right) + \\
& \gamma E\left(\pi \mid s^I_{AL}; e_L\right)\left(\frac{\partial E\left(\pi|s^I_{AL};e_L\right)}{\partial \alpha} - \delta\frac{\partial G\left(s^I_{AL};e_L\right)}{\partial \alpha}\right) \quad
\begin{array}{ll}
\geq 0 & \text{if } \alpha = 0 \\
= 0 & \text{if } \alpha \in (0;1) \\
\leq 0 & \text{if } \alpha = 1
\end{array}
\end{aligned}
$$

and

$$
\frac{\partial L}{\partial \beta} = -1 - \mu = 0
$$

Substituting $\mu = 1$ into $\frac{\partial L}{\partial \alpha}$ and setting $\eta = 0$ (assuming that incentive compatibility constraint is not binding) yields

$$
\frac{\partial L}{\partial \alpha} = -\delta\left(\frac{\delta\left(e_H^2 + \sigma_\eta^2 + \sigma_\varepsilon^2\right)}{(1-\lambda)e_H^2}\right) g(s^I_H; e_H)
$$

which is negative, hence $\alpha = 1$: When $\alpha = 1$, $s^I_{PH} = -\frac{\sigma_\varepsilon^2 + \sigma_\eta^2}{e} - \frac{\delta\left(\sigma_\varepsilon^2 + \sigma_\eta^2 + e^2\right)}{e^2(1-\lambda)}$ which is less than s^*_{PH}. Therefore the optimal contract in independent contracting is not Pareto efficient.

6.4 Appendix D

Let

$$
B\left(s^E_P; e_H\right) = -(1-\lambda) I\left(s^E_P; e_H\right) - \delta G\left(s^E_P; e_H\right);
$$

the net benefit from intervention under the employment relationship and

$$
A\left(s^I_A; e_H\right) = -(1-\lambda) I\left(s^I_A; e_H\right) - \delta G\left(s^I_A; e_H\right)
$$

be the net benefit from intervention under independent contracting. We first substitute the values of s^E_P and s^I_A, and then rewrite the integrals by replacing s with

$$
z = \frac{s - e}{e^2 + \sigma^2}:
$$

Then we obtain

$$B\left(e_H; \sigma_\varepsilon^2\right) = -\int^{z^E} \left((1-\lambda)\left(e + \frac{e^2 z}{(e^2+\sigma_\varepsilon^2)^{\frac{1}{2}}}\right) + \delta\right) f(z)\,dz$$

and

$$A\left(e_H; \sigma_\varepsilon^2; \sigma_\eta^2\right) = -\int^{z^I} \left((1-\lambda)\left(e + \frac{e^2 z}{\left(e^2+\sigma_\varepsilon^2+\sigma_\eta^2\right)^{\frac{1}{2}}}\right) + \delta\right) f(z)\,dz$$

Taking the derivative of $A\left(e_H; \sigma_\varepsilon^2; \sigma_\eta^2\right)$ with respect to σ_η^2 we obtain

$$\frac{\partial A\left(e_H; \sigma_\varepsilon^2; \sigma_\eta^2\right)}{\partial \sigma_\eta^2} = -\int^{z^{IC}} \left(\frac{e^2 z}{2\left(e^2+\sigma_\varepsilon^2+\sigma_\eta^2\right)^{\frac{3}{2}}}\right) f(z)\,dz$$

which is negative. Therefore as σ_η^2 increases the net benefit from intervention in independent contracting decreases.

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