Optimal Compensation Schemes in a Repeated Monitoring Relationship

Job Market Paper

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Consider a standard moral hazard problem

The owner is the principal. The productive worker is the agent.

The principal observes only a noisy signal about the agent’s effort such as output, the stock prices, profits etc.

A standard remedy to this problem in the literature is that the owner designs a wage scheme conditional on the output signal.
In reality, the principal uses more direct mechanisms to get around the informational disadvantage.

One such mechanism is supervision:
- Foreman supervising a worker
- The Board of Directors supervises the CEO
- The Public Agency supervises defense contractor

Introduce a supervisor as a third player.
The supervisor (She) is another employee. She interacts repeatedly with the agent. She decides whether to exert costly monitoring effort or not. The monitoring outcome is imperfect:
- sometimes produces verifiable evidence
- sometimes does not produce any evidence at all
Moreover, the supervisor interacts repeatedly. Due to their close interaction, agent and supervisor can observe each other’s actions. Such subjective information cannot be used in the design of wage contracts.

However, this information can still be valuable in a repeated setting. The principal can use two (objective) signals to design the contracts:

- the output signal
- the supervisory report

**Research Question:** How should the principal structure incentives in this more complex environment?
The Contribution

- Here the setting is very different than standard models. A key difference is that the principal can use two signals.
- But the supervisory signal is not merely a source of additional information. The supervisor interacts repeatedly and strategically with the agent.
- In this setting, the principal designs the wages in order to create a game between employees in which it is easier for the supervisor to “discipline” the agent.
- As a result, optimal wages here is different both qualitatively and quantitatively then their counterparts in other settings.
- A particularly interesting result is that the principal prefers to put the emphasis on the supervisory signal.
Model

- Binary effort
- $e_i \in \{\text{Effort}, \text{No Effort}\}$
- Costly effort: $c_i(e_i) \geq 0$
$x_1$ : the output signal

$x_1 = \text{High Output (H)}$ or $x_1 = \text{Low output (L)}$
Model

- $x_2$: the supervisory report
- $x_2 = \text{Hard evidence (}h\text{)}$ or $x_1 = \text{No evidence (}\emptyset\text{)}$
Model

Compensation Scheme:
\[ w_i(x_1, x_2) \geq 0 \]

- Limited Liability
- Risk-neutrality

[Click here](#) for signal distribution
(w_1(x), w_2(x)) \rightarrow (e_1, e_2) \\
Both accept \rightarrow (e_1, e_2) \\
If one rejects \\
Game ends
Under the contract announced at the beginning, the agent and the supervisor play a repeated effort choice game.

The payoffs in this game are determined endogenously by the wage contract.

I assume that due to their close interaction, both employees can observe each other's actions, and hence condition their strategies on the past history of the play.

The principal’s problem is to choose the least costly wage scheme that implements \((\text{Effort}, \text{Effort})\) forever as a subgame-perfect equilibrium (SPE).
(Effort, Effort) is a SPE under $w$ iff

Payoff on eq’m path under $w \geq (1 - \delta)(\text{current deviation payoff under } w) + \delta(\text{worst eq’m payoff under } w)"

Optimal wages must fulfill two incentives:
- deter shirking in the current period
- induce the harshest off-equilibrium punishments

As $\delta$ increases, the wages are shaped by what happens off equilibrium
Off equilibrium punishments

- In a repeated game, the harshest possible punishment is the minmax payoff.
- However, in general minmax payoff is not credible.
- I show that in this setting the minmax payoff can be credible even for low discount factors.
- Hence, either employee can be punished severely for deviating.
- Therefore, the principle can afford to pay lower wages in the long run.
- In fact, I show that the principal extracts all the rent from the agent as $\delta \to 1$. 

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Repeated Monitoring
When employees are patient, I find that the agent should be rewarded for ‘favorable supervisory report’

The intuition:
- Suppose the agent deviates, and the play switches to the punishment phase
- In that phase the supervisor can single-handedly hold back favorable reports by refraining to monitor
- This makes sure that no wages are paid to the agent at the punishment phase
- Hence the agent can be punished severely under such scheme
A Counterintuitive Result: Pay for failure

- When $\delta$ is high enough, I show that the agent should be rewarded for low output and favorable report.
- This wouldn’t make sense in other settings.
- The intuition: the principal can use two types of signals:
  - the supervisory report is valuable because it can create severe off-equilibrium punishments.
  - the other signal can be used for other purposes.
Suppose there is a very small probability that both signals are high \((Hh)\) regardless of effort levels, e.g., a stock market bubble.

Consider a wage scheme that pays only at \(x = Hh\).

Now let’s look at the incentive constraint in the repeated game:

\[
\text{Payoff on eq’m path under } w \geq (1 - \delta) (\text{current deviation payoff under } w)_{\downarrow} + \delta (\text{worst eq’m payoff under } w)_{\uparrow}
\]

- The agent can always guarantee a strictly positive payoff off equilibrium due to shock.
- So the agent extracts rent under this wage scheme as \(\delta\) increases.
Now consider a wage scheme that pays the agent only at signal $Lh$

Payoff on eq’m path under $w$  \[
\geq (1 - \delta)(\text{current deviation payoff under } w) + \delta(\text{worst eq’m payoff under } w)
\]

- I show that under this wage scheme there exists an equilibrium of the game in which the agent gets zero payoff
- So off equilibrium punishment can be as low as zero
- Therefore, as $\delta \to 1$ the principal can extract all the rent from the agent
- So this wage scheme becomes cheaper for the principal as $\delta$ increases
In the repeated game, there is multiplicity of equilibria. Players can coordinate to play any equilibria, in particular the equilibria that is most favorable for them. To ensure a unique prediction, I focus on the equilibrium that is most favorable to the agents in the sense that the prescribed equilibrium yields the highest total payoff for the agents among all equilibria. If a wage scheme satisfies this, I call it a collusion-proof scheme.
If supervisor’s signal is more accurate than the output signal, then the equilibrium under the principal’s optimal wages is collusion-proof.

If the opposite condition holds, the equilibrium is not collusion-proof.
Application to CEO compensation

- Principal is the shareholders, the agent is a CEO and the supervisor is the Board of Directors
- $x_1$ is the stock price and $x_2$ is the Board’s report
- A popular compensation scheme is to reward the CEO based on the stock price
- Such schemes are criticized on the grounds that they reward the CEO for luck during stock market bubbles (Bertrand and Mullainathan (2001), Bebchuk and Fried (2003))
- The findings in this paper suggest that tying CEO compensation primarily to the Board’s report may also provide strong incentives, especially when the CEO and Board are in long-term interaction
Concluding Remarks

- I showed that the principal benefits from employing a supervisor for long-term.
- The principal can now use two types of signals, and prefers to put the emphasis on the supervisory signal in the long run.
- The supervisory signal becomes more important in repeated interaction because it can be used as a credible threat by the supervisor if the agent deviates.
- From an organizational behavior perspective, this off equilibrium threats can be interpreted as “informal incentives” or “work norms”.
- My model could also be seen as a theoretical treatment for the interaction of formal incentives (wage contracts) with the informal incentives (off-equilibrium punishments).
- My findings suggest that informal incentives can be very powerful in an agent-supervisor framework.
THANK YOU!
Signal Distribution

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