Optimal Contracts with Cost Padding and Auditing

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1. Introduction

During the past three decades, the theory of contracts has investigated various problems related to adverse selection and moral hazard and provided many insights into incentive theory (Laffont and Tirole (1993), Laffont and Marti-mort (2002), and Salanié (1997)). The manipulation of accounting information in principal and agent relationships in government procurement or regulation has received serious attention. An important implication of the theory of contracts is that more the information the principal has about the agent's characteristics, the better result the principal can attain. For example, it might be beneficial for the government to audit a regulated firm's costs to acquire more precise information. The literature on auditing has focused on the audit of information regarding an agent's productivity or costs (Baron and Besanko (1984) and Kofman and Lawarrée (1993)). However, there has been little work investigating the effects of cost padding on incentive schemes. Laffont and Tirole (1992) examined the inter-action between the power of incentive schemes and auditing. They showed that without an audit of the firm's cost padding activities, a fixed price contract is optimal and that under imperfect auditing, incentive schemes are more powerful than perfect auditing.

Several papers have examined the issue of input versus output monitoring. Among them, Maskin and Riley (1985) showed that output monitoring is superior to input monitoring and Khalil and Lawarrée (1995) demonstrated that input monitoring gives the highest payoff to the principal when he is the residual claimant. Very little, however, is known about manipulations of cost data under asymmetric information when the principal can choose a set of monitoring or auditing instruments.

This study examines optimal contracts in a setting that considers both the possibility of cost padding by the agent and the principal's choice of residual claimancy. In particular, this paper examines the relationship between the choices of monitoring and residual claimancy in a model in which a firm (the agent) constructing and operating facilities (for example, toll expressways) for a government (the principal) can pad its costs. We assume that the firm's reported cost is comprised of an efficiency parameter, cost reduction efforts, and cost padding. We also suppose that the government can choose one among the following pairs of monitoring instruments: (i) monitoring efforts at cost reduction and the extent of cost padding, (ii) monitoring the extent of cost padding and total cost, and (iii) monitoring efforts at cost reduction and total cost.

The contracting game we consider proceeds as follows. Nature chooses the value of an efficiency parameter.

Only the firm knows it. The residual claimancy for profits is determined exogenously or by the government which chooses one among the sets of monitoring instruments and offers a contract to the firm. The firm accepts or rejects the contract. The firm makes cost reduction efforts and pads its reported costs. Finally the contracts are executed. We show that when the government is the residual claimant, monitoring the firm's efforts at cost reduction and attempts at cost padding provides the highest payoff to the government, whereas monitoring cost reduction efforts and total cost gives the lowest payoff to the government. In contrast, when the firm is the residual claimant, monitoring cost reduction efforts and total cost provides the highest payoff to the government.

　　　The paper is organized as follows. In Section 2, we present the model. In Section 3, we characterize optimal contracts for scenarios in which the government is the residual claimant and in which the firm is the residual claimant. In Section 4, we compare the government's payoff under the two scenarios involving residual claimancy. Section 5 concludes.

2. The Model

This section constructs the basic principal and agent model of cost padding and monitoring. The principal is a government and the agent is a firm. The government delegates the firm to construct and operate facilities such as toll expressways. Let S denote the social benefit of the facilities. Let R be revenue from the facilities. Because we focus on hidden information and hidden actions with respect to costs, we fix S and R. Let a be the level of cost padding by the firm with $a \geq 0$. The level of cost padding a gives monetary benefit a to the firm. For simplicity, we assume that the firm can engage in cost padding without incurring disutility. We assume that the firm's cost function is given by

$$C(\theta, e, a) = \theta - e + a, \tag{1}$$

where an efficiency parameter θ is either θ_1 (efficient) or θ_2 (inefficient) and $0 < \theta_1 < \theta_2$ with respective probabilities p and $1 - p$. The firm's cost reduction effort is e with $e \geq 0$. The disutility of the firm's cost reduction efforts for the firm is assumed to be $\varphi(e) = \dfrac{e^2}{2}$. Only the firm knows θ, e, a, and C. We assume that the government can monitor and choose one of the following sets of monitoring instruments: (i) monitoring effort e and cost padding a, (ii) monitoring total cost C and cost padding a, and (iii) monitoring total cost C and effort e.

　　　We consider two scenarios regarding residual claimancy. When the government is the residual claimant, its payoff is given by

$$\Pi = S + R - C - t,$$

where t is a monetary transfer from the government to the firm. The firm's payoff is given by

$$U = t + a - \frac{e^2}{2}.$$

With the firm as residual claimant, the government's payoff is given by

$$\Pi = S + \tau,$$

where τ is a monetary transfer from the firm to the government. The firm's payoff is given by

$$U = R - C - \tau + a - \frac{e^2}{2}.$$

To conclude this section, we summarize the sequence of events as follows.

1. Nature chooses the value of the efficiency parameter θ.

2. The government chooses one of the sets of monitoring instruments.

3. The government offers a contract to the firm.

4. The firm exerts cost reduction efforts e and chooses cost padding level a.

5. Monitoring takes place.

6. The contracts are executed.

3. Optimal Contracts

In this section, we characterize optimal contracts under the two scenarios with respect to residual claimancy. We first analyze the optimal contracts when the government is the residual claimant. Subsequently, we examine the optimal contracts when the firm is the residual claimant. For each scenario of residual claimancy, we analyze optimal contracts for three cases depending on the sets of monitoring instruments.

When the government is the residual claimant, its objective is to maximize its expected payoff

$$S + R - p[(\theta_1 - e_1 + a_1) + t_1] - (1 - p)[(\theta_2 - e_2 + a_2) + t_2]. \tag{2}$$

3.1 Case 1 (Monitoring e and a)

Suppose that the government can monitor the firm's cost reduction efforts e and audit its cost padding level a. Because the government can audit the firm's cost padding level a, the optimal contract requires $a = 0$ for both the efficient and the inefficient types. For simplicity, we assume that the firm's reservation payoff is set at zero. In this case, the individual rationality constraints for the efficient type are given by

$$t_1 - \frac{e_1^2}{2} \geq 0 \tag{3}$$

and for the inefficient type by

$$t_2 - \frac{e_2^2}{2} \geq 0. \tag{4}$$

The incentive compatibility constraints are given by

$$t_1 - \frac{e_1^2}{2} \geq t_2 - \frac{e_2^2}{2} \tag{5}$$

for the efficient type and

$$t_2 - \frac{e_2^2}{2} \geq t_1 - \frac{e_1^2}{2} \tag{6}$$

for the inefficient type. Then the government's contract problem is given by

$$\max_{e,\,a,\,t} \; S + R - p[(\theta_1 - e_1 + a_1) + t_1] - (1-p)[(\theta_2 - e_2 + a_2) + t_2],$$

$$s.t. (3), (4), (5), \; and \; (6).$$

As usual, constraints (4) and (5) are binding. Then, by these binding conditions, we have

$$t_1 = \frac{e_1^2}{2},$$

$$t_2 = \frac{e_2^2}{2}.$$

Thus, the government's contract problem can be rewritten as

$$\max_{e,\,a,\,t} \; S + R - p\left(\theta_1 - e_1 + \frac{e_1^2}{2}\right) - (1-p)\left(\theta_2 - e_2 + \frac{e_2^2}{2}\right).$$

The first-order conditions with respect to e yield

$$e_1 = e_2 = e^{FB} = 1,$$

where e^{FB} is the first best effort level. Each type of the firm is required to exert the first-best effort level. Thus, we obtain

$$t_1 = t_2 = \frac{1}{2}.$$

Hence the government's payoff Π^{GEA} in Case 1 is

$$\Pi^{GEA} = S + R - p\theta_1 - (1-p)\theta_2 - \frac{1}{2}.$$

The firm's payoff U^{GEA} is

$$U_1^{GEA} = U_2^{GEA} = 0.$$

The optimal contract $\{a_i, e_i, t_i\}$ in Case 1 is $\{0, 1, \frac{1}{2}\}$ for both types. Each type of the firm obtains no information rent. Note that the optimal contract in Case 1 corresponds to that with input monitoring in Khalil and Lawarree (1995).

3.2 Case 2 (Monitoring a and C)

Suppose that the government can monitor the firm's cost padding level a and audit total cost C. Then the optimal contract requires $a = 0$ for both types. In this case, the individual rationality constraints are given by

$$t_1 - \frac{e_1^2}{2} \ge 0, \tag{7}$$

$$t_2 - \frac{e_2^2}{2} \ge 0. \tag{8}$$

The incentive compatibility constraints are given by

$$t_1 - \frac{e_1^2}{2} \geq t_2 - \frac{\hat{e}_2^2}{2}, \tag{9}$$

$$t_2 - \frac{e_2^2}{2} \geq t_1 - \frac{\hat{e}_1^2}{2}, \tag{10}$$

where $\hat{e}_1$ and $\hat{e}_2$ are defined by

$$\hat{e}_2 = e_2 + \theta_1 - \theta_2,$$

$$\hat{e}_1 = e_1 + \theta_2 - \theta_2.$$

Since constraints (8) and (9) are binding, we have

$$t_1 = \frac{e_1^2 + (\theta_2 - \theta_1)(2e_2 + \theta_1 - \theta_2)}{2},$$

$$t_2 = \frac{e_2^2}{2}.$$

Thus, the government's problem can be rewritten as

$$\max_{e,\,a,\,t} \ S - p\left[\theta_1 - e_1 + \frac{e_1^2 + 2(\theta_2 - \theta_1)e_2 + (\theta_2 - \theta_1)^2}{2}\right] - (1-p)[\theta_2 - e_2 + \frac{e_2^2}{2}].$$

The first-order conditions with respect to e yield

$$e_1 = 1,$$

$$e_2 = 1 - \frac{p}{1-p}(\theta_2 - \theta_1).$$

The inefficient type's second-best effort is below the first-best effort level. The transfers are given by

$$t_1 = \frac{1}{2} + (\theta_2 - \theta_1) - \frac{1+p}{2(1-p)}(\theta_2 - \theta_1)^2,$$

$$t_2 = \frac{1}{2} - \frac{p}{1-p}(\theta_2 - \theta_1) + \frac{p^2}{2(1-p)^2}(\theta_2 - \theta_1)^2.$$

Then, the government's payoff Π^{GAC} in Case 2 is

$$\Pi^{GAC} = S + R - \theta_2 + \frac{1}{2} + \frac{p}{2(1-p)}(\theta_2 - \theta_1)^2.$$

The firm's payoff U^{GAC} is

$$U_1^{GAC} = (\theta_2 - \theta_1) - \frac{1+p}{2(1-p)}(\theta_2 - \theta_1)^2,$$

$$U_2^{GAC} = 0.$$

The optimal contract $\{a_i, e_i, t_i\}$ is $\left\{0, 1, \frac{1}{2} + (\theta_2 - \theta_1) - \frac{1+p}{2(1-p)}(\theta_2 - \theta_1)^2\right\}$ for type θ_1 and $\left\{0, 1 - \frac{p}{1-p}(\theta_2 - \theta_1), \frac{1}{2} - \frac{p}{1-p}(\theta_2 - \theta_1) + \frac{p^2}{2(1-p)^2}(\theta_2 - \theta_1)^2\right\}$ for type θ_2. The efficient type earns an information rent, whereas the inefficient type does not. Note that the optimal contract in this case corresponds to that in Laffont and Tirole (1986). The optimal contract in this case also corresponds to the one without cost padding in which the principal chooses output monitoring and is the residual claimant in Khalil and Lawarree (1995).

3.3 Case 3 (Monitoring e and C)

Suppose that the government can monitor cost reduction effort e and audit total cost C. In this case, the individual rationality constraints are given by

$$t_1 + a_1 - \frac{e_1^2}{2} \geq 0, \tag{11}$$

$$t_2 + a_2 - \frac{e_2^2}{2} \geq 0. \tag{12}$$

Let $\hat{a}_1$ and $\hat{a}_2$ be defined by

$$\theta_1 - e_1 + a_1 = \theta_2 - e_1 + \hat{a}_1,$$
$$\theta_2 - e_2 + a_2 = \theta_1 - e_2 + \hat{a}_2.$$

That is,

$$\hat{a}_2 = a_2 + \theta_2 - \theta_1,$$
$$\hat{a}_1 = a_1 - \theta_2 + \theta_1.$$

Then, the incentive compatibility constraints are given by

$$t_1 + a_1 - \frac{e_1^2}{2} \geq t_2 + \hat{a}_2 - \frac{e_2^2}{2}, \tag{13}$$

$$t_2 + a_2 - \frac{e_2^2}{2} \geq t_1 + \hat{a}_1 - \frac{e_1^2}{2}. \tag{14}$$

Since constraints (12) and (13) are binding, the transfers are

$$t_1 = \frac{e_1^2}{2} - a_1 + \hat{a}_2 - a_2$$
$$= \frac{e_1^2}{2} - a_1 + \theta_2 - \theta_1,$$
$$t_2 = \frac{e_2^2}{2} - a_2.$$

Thus, the government's contract problem can be rewritten as

$$\max\ S + R - p\left[\theta_1 - e_1 + a_1 + \left(\frac{e_1^2}{2} - a_1 + \theta_2 - \theta_1\right)\right] - (1-p)\left(\theta_2 - e_2 + a_2 + \frac{e_2^2}{2} - a_2\right)$$
$$= S + R - p\left(\theta_2 - e_1 + \frac{e_1^2}{2}\right) - (1-p)\left(\theta_2 - e_2 + \frac{e_2^2}{2}\right).$$

The first order conditions with respect to e yield

$$e_1 = e_2 = e^{FB} = 1.$$

Thus, we obtain

$$t_1 + a_1 = \frac{1}{2} + \theta_2 - \theta_1,$$

$$t_2 + a_2 = \frac{1}{2}.$$

The government offers the following contract to each firm.

$$t(C) = \frac{(e^{FB})^2}{2} - \{C - \theta_2 + e^{FB}\}.$$

Then, the government's payoff Π^{GEC} is

$$\Pi^{GEC} = S + R - p\left(\theta_2 - \frac{1}{2}\right) - (1-p)\left(\theta_2 - \frac{1}{2}\right)$$

$$= S + R - \theta_2 + \frac{1}{2}.$$

The firm's payoff U^{GEC} is

$$U_1^{GEC} = \theta_2 - \theta_1,$$

$$U_2^{GEC} = 0.$$

The optimal contract $\{e_i, t_i\}$ is $\left\{1, t = \frac{(e^{FB})^2}{2} - \{C - \theta_2 + e^{FB}\}\right\}$ for type θ_1 and $\left\{1, t = \frac{(e^{FB})^2}{2} - \{C - \theta_2 + e^{FB}\}\right\}$ for type θ_2. The efficient type earns an information rent, whereas the inefficient type earns no information rent.

Thus far, we have examined optimal contracts for cases in which the government is the residual claimant. Next, we analyze cases in which the firm is the residual claimant. The government's expected payoff under this scenario is

$$S + p\tau_1 + (1-p)\tau_2.$$

The firm's expected payoff is given by

$$R - p\left[(\theta_1 - e_1 + a_1) + \tau_1 - a_1 + \frac{e_1^2}{2}\right] - (1-p)\left[(\theta_2 - e_2 + a_2) + \tau_2 - a_2 + \frac{e_2^2}{2}\right]$$

$$= R - p\left(\theta_1 - e_1 + \tau_1 + \frac{e_1^2}{2}\right) - (1-p)\left(\theta_2 - e_2 + \tau_2 + \frac{e_2^2}{2}\right).$$

3.4 Case 4 (Monitoring e and a)

Suppose that the government can monitor cost reduction effort e and cost padding level a. In this case, the individual rationality constraints are given by

$$R - \theta_1 + e_1 - \tau_1 - \frac{e_1^2}{2} \geq 0, \tag{15}$$

$$R - \theta_2 + e_2 - \tau_2 - \frac{e_2^2}{2} \geq 0. \tag{16}$$

The incentive compatibility constraints are given by

$$R - \theta_1 + e_1 - \tau_1 - \frac{e_1^2}{2} \geq R - \theta_1 + e_2 - \tau_2 - \frac{e_2^2}{2}, \tag{17}$$

$$R - \theta_2 + e_2 - \tau_2 - \frac{e_2^2}{2} \geq R - \theta_2 + e_1 - \tau_1 - \frac{e_1^2}{2}. \tag{18}$$

Since constraints (16) and (17) are binding, the transfers are

$$\tau_1 = R - \theta_2 + e_1 - \frac{e_1^2}{2},$$

$$\tau_2 = R - \theta_2 + e_2 - \frac{e_2^2}{2}.$$

The government's contract problem can be rewritten as

$$\max_{e,\,a,\,\tau} S + p\left(R - \theta_2 + e_1 - \frac{e_1^2}{2}\right) + (1-p)\left(R - \theta_2 + e_2 - \frac{e_2^2}{2}\right).$$

The first-order conditions with respect to e yield

$$e_1 = e_2 = e^{FB} = 1.$$

Thus, the transfers are

$$\tau_1 = \tau_2 = R - \theta_2 + \frac{1}{2}.$$

The government's payoff Π^{FEA} is

$$\Pi^{FEA} = S + R - \theta_2 + \frac{1}{2}.$$

The firm's payoff U^{FEA} is

$$U_1^{FEA} = \theta_2 - \theta_1,$$

$$U_2^{FEA} = 0.$$

Thus, the optimal contract $\{e_i, a_i, \tau_i\}$ is $\left\{1, 0, R - \theta_2 + \frac{1}{2}\right\}$ for type θ_1 and $\left\{1, 0, R - \theta_2 + \frac{1}{2}\right\}$ for type θ_2.

The efficient type earns an information rent, whereas the inefficient type earns no information rent. Note that the optimal contract in this case corresponds to that in which the principal chooses input monitoring and the agent is the residual claimant in Khalil and Lawarree (1995).

3.5 Case 5 (Monitoring a and C)

Suppose that the government can monitor cost padding a and audit total cost C. In this case, the individual rationality constraints are given by

$$R - \theta_1 + e_1 - \tau_1 - \frac{e_1^2}{2} \geq 0, \tag{19}$$

$$R - \theta_2 + e_2 - \tau_2 - \frac{e_2^2}{2} \geq 0. \tag{20}$$

The incentive compatibility constraints are given by

$$R - \theta_1 + e_1 - \tau_1 - \frac{e_1^2}{2} \geq R - \theta_1 + \hat{e}_2 - \tau_2 - \frac{\hat{e}_2^2}{2}, \tag{21}$$

$$R - \theta_2 + e_2 - \tau_2 - \frac{e_2^2}{2} \geq R - \theta_2 + \hat{e}_1 - \tau_1 - \frac{\hat{e}_1^2}{2}, \tag{22}$$

where $\hat{e}_1$ and $\hat{e}_2$ are defined by

$$\hat{e}_2 = e_2 + \theta_1 - \theta_2,$$
$$\hat{e}_1 = \hat{e}_1 + \theta_2 - \theta_1.$$

Since constraints (20) and (21) are binding, the transfers are

$$\tau_1 = R - \theta_2 + e_1 - \frac{e_1^2 + (\theta_2 - \theta_1)(2e_2 + \theta_1 - \theta_2)}{2},$$
$$\tau_2 = R - \theta_2 + e_2 - \frac{e_2^2}{2}.$$

Thus, the government's contract problem can be rewritten as

$$\max_{e,\, a,\, \tau} S + p\left(R - \theta_1 + e_1 - \frac{e_1^2 + (\theta_2 - \theta_1)(2e_2 + \theta_1 - \theta_2)}{2}\right) + (1 - p)\left(R - \theta_2 + e_2 - \frac{e_2^2}{2}\right).$$

The first-order conditions with respect to e yield

$$e_1 = 1,$$
$$e_2 = 1 - \frac{p}{1 - p}(\theta_2 - \theta_1).$$

Thus, the transfers are

$$\tau_1 = R - \theta_2 + \frac{1}{2} + \frac{1 + p}{2(1 - p)}(\theta_2 - \theta_1)^2,$$
$$\tau_2 = R - \theta_2 + \frac{1}{2} - \frac{p^2}{2(1 - p)^2}(\theta_2 - \theta_1)^2.$$

The government's payoff Π^{FAC} is

$$\Pi^{FAC} = S + R - \theta_2 + \frac{1}{2} + \frac{p}{2(1 - p)}(\theta_2 - \theta_1)^2.$$

The firm's payoff U^{FAC} is

$$U_1^{FAC} = R - \theta_1 + 1 - \left(R - \theta_2 + \frac{1}{2} + \frac{1 + p}{2(1 - p)}(\theta_2 - \theta_1)^2\right) - \frac{1}{2} = (\theta_2 - \theta_1) - \frac{1 + p}{2(1 - p)}(\theta_2 - \theta_1)^2.$$
$$U_2^{FAC} = 0.$$

Thus, the optimal contract $\{a_i, C_i, \tau_i\}$ is $\left\{0, \theta_1, R - \theta_2 + \frac{1}{2} + \frac{1+p}{2(1-p)}(\theta_2 - \theta_1)^2\right\}$ for type θ_1 and $\left\{0, \theta_2, R - \theta_2 + \frac{1}{2} - \frac{p^2}{2(1-p)^2}(\theta_2 - \theta_1)^2\right\}$ for type θ_2. The efficient type earns an information rent, whereas

the inefficient type earns no information rent. Note that the optimal contract in this case corresponds to that without cost padding in which the principal chooses output monitoring and the agent is the residual claimant in Khalil and Lawarree (1995).

3.6 Case 6 (Monitoring e and C)

Suppose that the government can monitor cost reduction effort e and audit total cost C. In this case, the individual rationality constraints are given by

$$R - \theta_1 + e_1 - \tau_1 - \frac{e_1^2}{2} \geq 0, \tag{23}$$

$$R - \theta_2 + e_2 - \tau_2 - \frac{e_2^2}{2} \geq 0. \tag{24}$$

The incentive compatibility constraints are given by

$$R - \theta_1 + e_1 - \tau_1 - \frac{e_1^2}{2} \geq R - \theta_1 + e_2 - a_2 - \tau_2 + a_2 - \frac{e_2^2}{2}, \tag{25}$$

$$R - \theta_2 + e_2 - \tau_2 - \frac{e_2^2}{2} \geq R - \theta_2 + e_1 - a_1 - \tau_1 + a_1 - \frac{e_1^2}{2}. \tag{26}$$

Since constraints (24) and (25) are binding, the transfers are

$$\tau_1 = R - \theta_1 + e_1 - \frac{e_1^2}{2},$$
$$\tau_2 = R - \theta_2 + e_2 - \frac{e_2^2}{2}.$$

The government's problem can be rewritten as

$$\max_{e,\,a,\,\tau} S + p\left(R - \theta_1 + e_1 - \frac{e_1^2}{2}\right) + (1-p)\left(R - \theta_2 + e_2 - \frac{e_2^2}{2}\right).$$

The first-order conditions with respect to e yield

$$e_1 = e_2 = e^{FB} = 1.$$

Then, the transfers are

$$\tau_1 = R - \theta_1 + \frac{1}{2},$$
$$\tau_2 = R - \theta_2 + \frac{1}{2}.$$

Thus, the government's payoff Π^{FEC} is

$$\Pi^{FEC} = S + R - p\theta_1 - (1-p)\theta_2 + \frac{1}{2}.$$

The firm's payoff is

$$U_1^{FEC} = U_2^{FEC} = 0.$$

The optimal contract $\{e_i, C_i, \tau_i\}$ is $\left\{1, \theta_1 - 1, R - \theta_1 + \frac{1}{2}\right\}$ for type θ_1 and $\left\{1, \theta_2 - 1, R - \theta_2 + \frac{1}{2}\right\}$ for type θ_2. Both type θ_1 and type θ_2 earn no information rent.

4. Comparison

In the previous section, we derived the optimal contracts for the six cases depending on choices among the set of monitoring instruments and residual claimancy. In this section, we are now ready to compare the government's payoffs under those six cases. The government's payoffs for each of the six cases are summarized in Table 1.

Table 1. Government's payoff with cost padding

Case	Residual claimant	Monitoring	Government's payoff
1	Government	e and a	$\Pi^{GEA} = S + R - p\theta_1 - (1-p)\theta_2 + \frac{1}{2}$
2		a and C	$\Pi^{GAC} = S + R - \theta_2 + \frac{1}{2} + \frac{p}{2(1-p)}(\theta_2 - \theta_1)^2$
3		e and C	$\Pi^{GEC} = S + R - \theta_2 + \frac{1}{2}$
4	Firm	e and a	$\Pi^{FEA} = S + R - \theta_2 + \frac{1}{2}$
5		a and C	$\Pi^{FAC} = S + R - \theta_2 + \frac{1}{2} + \frac{p}{2(1-p)}(\theta_2 - \theta_1)^2$
6		e and C	$\Pi^{FEC} = S + R - p\theta_1 - (1-p)\theta_2 + \frac{1}{2}$

First, note that the following relationships hold:

$$\Pi^{GEA} = \Pi^{FEC},$$
$$\Pi^{GAC} = \Pi^{FAC}, \tag{27}$$
$$\Pi^{GEC} = \Pi^{FEA}.$$

Next, we compare Π^{GEA} with Π^{GAC}. Since $\hat{e}_2 \geqq 0$ and $e_2^{SB} \geqq 0$, we must have $\theta_2 - \theta_1 \leq 1 - p$. Thus, we have

$$\Pi^{GEA} - \Pi^{GAC} = \left[S + R - p\theta_1 - (1-p)\theta_2 + \frac{1}{2}\right] - \left[S + R - \theta_2 + \frac{1}{2} + \frac{p}{2(1-p)}(\theta_2 - \theta_1)^2\right]$$

$$= S + R - p\theta_1 - (1-p)\theta_2 + \frac{1}{2} - S - R + \theta_2 - \frac{1}{2} - \frac{p}{2(1-p)}(\theta_2 - \theta_1)^2$$

$$= (\theta_2 - \theta_1)\left[p - \frac{p}{2(1-p)}(\theta_2 - \theta_1)\right] \geq (\theta_2 - \theta_1)\left[p - \frac{p}{2(1-p)}(1-p)\right]$$

$$= \frac{p(\theta_2 - \theta_1)}{2} > 0.$$

Hence, we obtain the result that $\Pi^{GEA} > \Pi^{GAC}$.

We also have

$$\Pi^{GAC} - \Pi^{GEC} = \left[S + R - \theta_2 + \frac{1}{2} + \frac{p}{2(1-p)}(\theta_2 - \theta_1)^2\right] - \left[S + R - \theta_2 + \frac{1}{2}\right]$$

$$= \frac{p}{2(1-p)}(\theta_2 - \theta_1)^2 > 0.$$

Thus, we can conclude that $\Pi^{GAC} > \Pi^{GEC}$. Therefore, we have the following proposition.

Proposition 1. *When the government is the residual claimant, monitoring cost reduction efforts and cost padding provides the highest payoff to the government, whereas monitoring cost reduction efforts and total cost provides the government with the lowest payoff.*

By (27), we also obtain the following result.

Proposition 2. *When the firm is the residual claimant, monitoring cost reduction efforts and total cost provides the highest payoff to the government, whereas monitoring cost reduction efforts and cost padding provides the government with the lowest payoff.*

We note that the government's payoffs under the six cases can be ordered as

$$\Pi^{GEA} = \Pi^{FEC} > \Pi^{GAC} = \Pi^{FAC} > \Pi^{GEC} = \Pi^{FEA}.$$

We have shown that when the government is the residual claimant, its optimal payoff results from monitoring cost reduction efforts and cost padding. In contrast, when the firm is the residual claimant, the government's optimal choice is monitoring cost reduction efforts and total cost.

Next, suppose that the government can choose residual claimancy. Then, we have the following proposition.

Proposition 3. *When the government can choose both residual claimancy and the set of monitoring instruments, it chooses to be the residual claimant and to monitor cost reduction efforts and cost padding.*

Finally, for comparison, let us consider the government's payoffs in a model without cost padding by the firm. When the government is the residual claimant and monitors cost reduction effort e, its payoff is $\pi^{GE} = S + R - p\theta_1 - (1-p)\theta_2 + \frac{1}{2}$. When the government is the residual claimant and monitors cost C, its payoff is $\pi^{GC} = S + R - \theta_2 + \frac{1}{2} + \frac{p}{2(1-p)}(\theta_2 - \theta_1)^2$. In contrast, when the firm is the residual claimant and the government monitors cost reduction efforts e, the government's payoff is $\pi^{FE} = S + R - \theta_2 + \frac{1}{2}$. When the firm is the residual claimant and the government monitors cost C, the government's payoff is $\pi^{FC} = S + R - \theta_2 + \frac{1}{2} + \frac{p}{2(1-p)}(\theta_2 - \theta_1)^2$.

With regard to the government's payoffs, we obtain the following relationship between the model with cost padding and that without cost padding (Table 2).

Table 2　Government's payoff with and without cost padding

Case 1 and Case 6	$\Pi^{GEA} = \Pi^{FEC} =$	$S + R - p\theta_1 - (1-p)\theta_2 + \frac{1}{2}$	$= \pi^{GE}$
Case 2 and Case 5	$\Pi^{GAC} = \Pi^{FAC} =$	$S + R - \theta_2 + \frac{1}{2} + \frac{p}{2(1-p)}(\theta_2 - \theta_1)^2$	$= \pi^{GC} = \pi^{FC}$
Case 3 and Case 4	$\Pi^{GEC} = \Pi^{FEA} =$	$S + R - \theta_2 + \frac{1}{2}$	$= \pi^{FE}$

5. Conclusion

This paper has described and discussed what constitutes the optimal contracts between the government and the firm in a model in which the firm can engage in cost padding. We have considered the setting in which the government

chooses among three sets of monitoring instruments: (i) monitoring cost reduction efforts and cost padding, (ii) monitoring cost padding and total cost, and (iii) monitoring cost reduction efforts and total cost. We have shown that when the government is the residual claimant, monitoring cost reduction effort and cost padding provides the highest payoff to the government, whereas monitoring cost reduction efforts and total cost provides the government with the lowest payoff. In contrast, when the firm is the residual claimant, monitoring cost reduction efforts and total cost provides the highest payoff to the government.

We have assumed in this paper that the firm does not incur costs when it engages in cost padding. In a related study, Kobayashi and Ohba (2010), we show that if the firm incurs costs when engaging in cost padding, the inefficient firm employs cost padding at equilibrium. In this equilibrium, the inefficient firm exerts the first-best effort for cost reduction.

We have also assumed in this paper that monitoring or auditing is perfect. In reality, monitoring effort and/or auditing costs or revenues is often imperfect. How imperfect auditing, given the principal's choices of monitoring instruments, affects optimal incentive schemes and cost padding in the presence of both adverse selection and moral hazard is an important issue to be addressed by further research.

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