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Joint Product Improvement by Client and Customer Support Center: The Role of Gain-Share Contracts in Coordination

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We study the role of different contract types in coordinating the joint product improvement effort of a client and a customer support center. The customer support center’s costly efforts include transcribing and analyzing customer feedback, analyzing market trends, and investing in product design. Yet this cooperative role must be adequately incentivized by the client, since it could lead to fewer service requests and hence lower revenues for the customer support center. We model this problem as a sequential game with double-sided moral hazard in a principal-agent framework (in which the client is the principal). We follow the contracting literature in modeling the effort of the customer support center, which is the first mover, as either unobservable or observable; in either case, the efforts are unverifiable and so cannot be contracted on directly. We show that it is optimal for the client to offer the customer support center a gain-share contract when efforts are unobservable, even though it can yield only the second-best solution for the client. We also show that the cost-plus contracts widely used in practice do not obtain the optimal solution. However, we demonstrate that if efforts are observable then a gain-share and cost-plus options based contract is optimal and will also yield the first-best solution. Our research provides a systematic theoretical framework that accounts for the prevalence of gain-share contracts in the IT industry’s joint improvement efforts, and it provides guiding principles for understanding the increased role for customer support centers in product improvement.

Key words: IT outsourcing, gain-share contract, cost-plus contract, joint product improvement, double-sided moral hazard.

History:
1. Introduction

The importance of incorporating customer feedback into the product improvement process has long been recognized. A number of studies have demonstrated the value of incorporating customer feedback into the product improvement process (von Hippel and Katz 2002) and in new services development (Carbonell et al. 2009). However, the avenues of obtaining customer feedback in product design have been increasingly focused on the third parties responsible for customer support on previous versions of products and services. Customer support centers operated by third parties are a primary customer-facing channel for firms in many industries (Aksin et al. 2007). Nambisan and Baron (2009) also report that firms increasingly seek to establish “virtual” customer environments in association with customer support centers. In the traditional model of customer interaction, firms could directly obtain customer feedback on product design and then focus on improvements using the feedback they had gathered. But when support centers are operated by third parties, customer feedback on product design must be incorporated into products jointly with the customer support center partners.

There are important advantages to partnering with customer support centers in the product improvement process. Mehrotra and Grossman (2009) describe how, by using information captured during customer interactions, analysts from the customer support center and the client quantified the impact of specific issues on customer satisfaction and call volumes and then worked with the product engineering, marketing, and documentation groups to eliminate specific problems from future software releases. These improvements resulted in increased customer satisfaction as well as fewer service calls by customers. Thus, although the joint product improvement effort significantly increases the client’s revenues, it also results in fewer service requests to the customer support center and hence lower revenues for the support center.

An illustration of the agency issues arising in a typical joint product improvement effort is given by the partnership between WNX, a service outsourcing firm that provides customer support services, and Travelcountry, an online travel agency\(^1\). In accordance with standard industry practice

\(^1\) The names of the firms have been changed to protect confidentiality.
(see Hasija et al. 2008), WNX had been compensated historically by Travelcountry on a payment-per service request basis. Revenues for WNX were therefore based on the number of problems that customers encountered when using Travelcountry’s products and services. WNX frequently received requests from customers to help them access their itinerary as they could not access them smoothly because of the design of the website interface. Yet if WNX were to help Travelcountry with the design of their website to improve the accessibility of customer itineraries, then WNX stood to lose a significant stream of revenues because the number of service requests associated with this problem would decrease markedly. At the same time, solving the problem would improve Travelcountry’s product and thus allow it to earn higher revenues. Travelcountry worked closely with WNX to redesign their website (including the itinerary accessing problem) and then compensated WNX by means of a gain-share contract — wherein the gains made due to lower service request volumes are shared with WNX. This case study highlights the agency issues embedded in the cooperation between the customer support center and the client in product improvement. If the customer support center partners with the client on product improvement, the client then profits more from a product that has fewer bugs and thus serves better customer needs, however, unless appropriately compensated by the client, the revenues of the customer support center then stand to decrease because they are contingent on the volume of service requests.

Another example of successfully applying gain-share contracts is provided by Martinez-Jerez and Narayanan (2007), who describe the outsourcing of IT services by Bharti Airtel to IBM in 2004. In this case, IBM provided Bharti Airtel with comprehensive end-to-end services for the management of all hardware and software requirements for the IT architecture needed by Bharti and all of the applications needed to operate it. Bharti Airtel was responsible for designing and managing all telecom-specific structures and networks. The contract used to govern this joint product improvement effort was a gain-share contract based on revenues. This joint improvement effort was very successful, and both firms renewed their contract in 2009; the contract grew in value from $750 million in 2004 to $2.5 billion in 2009 (Vadlamani 2009).
Gain-sharing contracts are increasingly used in the governance of IT outsourcing relationships between clients and customer support centers (Kapadia 2010), and they feature several managerial advantages: fewer resources required by the client, higher levels of motivation in the customer support center, and the use of targets as milestones (Koelsch 2004). Gain-share contracts are structured in terms of the verifiable performance output of the product or service in the market after the improved product is launched, and they are based on the difference between the actual performance output and a prespecified verifiable target performance output. In this paper, the improved product yields two sets of outputs: more revenues for the client and fewer service requests attended to by the customer support center. The revenues from the improved product may or may not be verifiable by both parties, but the realized volume of service requests handled for the improved product is definitely verifiable by both the client and the customer support center. Our industry observations indicate that the client and the customer support center share data on call volumes or e-mails answered in real-time and also on the cumulative number of calls and e-mails, so we model gain-share contracts based on service request volumes handled for the improved product with reference to a prespecified target level. Apart from gain-share contracts, cost-plus contracts are also used in IT outsourcing (Gopal and Sivaramakrishnan 2008). We investigate the efficacy of these two prevalent contract types (gain-share, cost-plus) in the IT industry and compare contractual efficiencies from the perspective of the principal (i.e., the client).

We develop a model of the joint product improvement effort of a client and its customer support center, where the support center’s costly efforts include transcribing and analyzing customer feedback, analyzing market trends, and investing in product design. The problem is modeled as a sequential-move game in which the customer service center is the first mover in a principal–agent framework. The client is modeled as the principal because in most IT outsourcing partnerships, the client has more resources and is closer to the customer (Dey et al. 2010). The successful conclusion of such outsourcing partnerships entails optimal efforts of both parties in the joint improvement effort, but this sequential-move game is complicated by agency issues due to the decentralized decision making of self-interested firms. Although such bilateral efforts may be observable to both
parties, they are not verifiable in a court of law and so are not directly contractible, which creates a double-sided moral hazard problem. When efforts are unobservable, the sequential-move game mirrors a simultaneous-move game; hence the double-sided moral hazard problem may lead to inefficiency stemming from the free-rider problem (Holmstrom 1982, Bhattacharyya and Lafontaine 1995, Roels et al. 2010). When efforts are observable but not verifiable, the double-sided moral hazard may lead to suboptimal effort by the support center due to the classic holdup problem (Demski and Sappington 1991, Noldeke and Schmidt 1998, Edlin and Hermelin 2000). Therefore, the design of optimal contracts in the presence of such agency issues is critical for the effective governance of these joint product improvement partnerships.

Our objective is to find if the first-best solution can be achieved where the first-best solution is characterized by (i) both parties make system-optimal efforts, and (ii) the principal attains the maximum profits possible. Specifically, we ask the following questions: (i) What is the optimal contractual structure to be offered by the client if efforts are unobservable? (ii) Can the optimal contract implement the first-best solution for the client for unobservable efforts? (iii) How do different contracts observed in practice (gain-share, cost-plus) perform in the case of unobservable efforts? (iv) What is the optimal contractual structure to be offered by the client if efforts are observable but not verifiable, and does it attain the first-best solution?

Our findings are as follows. We show that if efforts are unobservable then the client should offer the customer support center a gain-share contract, as it can achieve the optimal solution. However, the optimal solution achieved by the gain-share contract only yields the second-best solution. We also show that cost-plus contracts do not obtain the optimal solution and perform worse than gain-share contracts. Finally, if efforts are observable we show that the optimal contract to be offered by the client is an options-based contract, where the client offers to compensate the customer support center by either a gain-share contract or a cost-plus contract at a later date. Finally, we show that such a gain-share/cost-plus options contract can attain the first-best solution for the client.
1.1. Literature Review

For products or services that are outsourced, the contract design problem has been studied in the context of several different applications. In the extant literature on contract design in information systems, a number of studies investigate contract structures from the client’s perspective in the outsourcing of software development and IT services, the monitoring and control of outsourced activities, and the role of extended contract provisions. Some studies have also investigated the implications of contract design from the vendor’s perspective by examining the impact of contractual structures on vendor profitability and vendor survival.

In the study of governance contracts for managing outsourced software development, studies have investigated contractual design (Dey et al. 2010) as well as the effect of outcome verifiability on contract design (Fitoussi and Gurbaxani 2011). Dey et al. (2010) consider the contracting of software projects to an outside developer; they find that fixed-price contracts are appropriate for simple projects with a short development time whereas cost-plus contracts are appropriate for complex projects with a low cost of monitoring. They also study contingent performance-based contracts (with quality as the criterion) and find that such contracts attain the first-best solution. Profit-sharing contracts perform well when the client does not have the power to offer a take-it-or-leave-it contract. Fitoussi and Gurbaxani (2011) find that contract efficiency is strongly influenced by the specific types of performance metrics used, and they offer insights into the design of contracts based on the verifiability of those metrics.

In the study of contractual structures for governing IT service outsourcing, Bapna et al. (2010) give prescriptive guidelines for contract design when sourcing from multiple vendors who are competitors but cooperate in a particular project for a common client. Tanriverdi et al. (2007) address the question of when to offshore and when to outsource IT business processes. In the literature on formal vendor monitoring and control, prior research has investigated outcome-based control versus behavioral and clan-based control (Choudhury and Sabherwal 2003), flexible control (Harris et al. 2009), and the degree of formal control (Rustagi et al. 2008). Gefen et al. (2008) find that business familiarity is an important tool for risk mitigation because it lowers the rents extracted...
due to adverse selection. Banker et al. (2006) study the impact of lower monitoring and coordination costs (due to information technology) on the number of suppliers; they find that higher contract completeness may lead to a higher cost per supplier — despite lower coordination and monitoring costs and consequently to a lower number of suppliers. Aron et al. (2008) investigate the role of real-time monitoring enabled by advances in IT and telecommunications. They show that the client can ensure a minimum level of performance by vendors, if it commits to a certain level of monitoring.

In the literature on contract provisions, a recent study of the holdup issue is that by Susarla et al. (2010), who find that contract provisions are difficult to design in the presence of task complexity. They also examine the role of contractual provisions and options (to increase the project’s duration) in reducing holdup and find that both provisioning and the extendibility of duration have a mitigating effect on the holdup problem. Chen and Bharadwaj (2009) also study the contract provisions issue; they find that asset specificity, prior interaction, and process interdependence all increase contractual provisions.

Another stream of literature focuses on the impact of different contractual structures on the profitability and survival of vendors. Gopal and Sivaramakrishnan (2008) find that the vendor’s ability to leverage adverse selection results in vendors preferring fixed-price contracts, although time-and-materials contracts are preferred when the risk of employee attrition is high. Susarla and Barua (2011) find that the probability of vendor survival is strongly influenced by contractual efficiency, and this influence is stronger when there are adjustment costs associated with shifting to aligned contracts. Gopal et al. (2003) analyze contractual structures for offshore software development contracts as well as the impact of these structures on vendor profits.

Finally, a number of studies address contract design when services are being offshored; these studies focus on the coordination of different units that are located separately. Cha et al. (2008) investigate the efficiency of offshoring operations by assessing the benefits of knowledge transfer and cost savings as well as the higher coordination costs. Dibbern et al. (2008) compare the efficiency of various contracts governing projects offshored to India.
Our paper contributes to the extant literature by considering the role of a service provider (who offers outsourced customer service) in the client’s product improvement process. We show that gain-share contracts and cost-plus contracts play an important role in achieving the optimal outcome for the client in this environment, and we characterize the structure of the contracts that achieve this optimal outcome. Finally, our paper relates to studies in contract theory that consider bilateral investments. Bhattacharyya and Lafontaine (1995) show that a revenue-sharing contract is the optimal solution to the bilateral investment problem with double-sided moral hazard if both parties move simultaneously. Roels et al. (2010) show that if the cost to monitor and verify the effort of the other party is incurred, the first-best solution can be achieved by cost-sharing and revenue-sharing contracts; yet the parties make less than their first-best profits due to the monitoring cost which thereby introduces contractual inefficiency. Demski and Sappington (1991), Noldeke and Schmidt (1998), and Edlin and Hermelin (2000) show that if bilateral investments are made sequentially, the first-best solution can be achieved by buyout option contracts under different sets of conditions. Our paper contributes to this stream of literature by studying gain-share contracts and cost-plus contracts that are based on the verifiable output of customer service requests, and not on revenue and cost sharing contracts or buyout options.

The rest of the paper is organized as follows. In Section 2, we describe the model and state our assumptions formally. Section 3 contains the formulation, analysis, and results of the model as well as the main contributions of the paper. Section 4 concludes with a discussion of our findings.

2. Model Description and Assumptions

In this section we describe the formal mathematical model in detail and state our assumptions. The problem is modeled as a sequential game, between the client and the customer support center, in four stages. The sequence of events in our model is described as follows (Figure 1). In the initial stage \( t = 0 \), the client proposes a contract \( f(\cdot) \) to the customer support center, where \( f \) is based on verifiable outcomes. Next, the customer support center exerts an effort in the first stage \( t = 1 \) of product improvement. Following this, the client makes its effort to improve the product \( t = 2 \).
Finally, the outcomes of the product improvement efforts are realized \((t = 3)\); in this case, the results are higher revenues for the client and reduced service requests for the customer support center.

**Figure 1  Timeline and sequence of events in the model**

After the contract is offered, the customer support center exerts an effort \(s\) in product improvement and incurs an investment of \(I(s)\). This is followed at \(t = 2\) by the client making an effort \(\theta\) toward product improvement that requires an investment of \(I_m(\theta)\). Finally, at \(t = 3\), the outcomes of the product improvement effort by the two parties are realized. Given the efforts \(\theta\) and \(s\), the client earns a revenue of \(E[m(\theta, s)]\) and the probability of service requests at the customer support center is \(p(\theta, s)\). The support center incurs a cost of \(c\) per customer service request.

We make the following assumptions about the model parameters.

\(A1\). The realized revenue \(m\) is a random variable with a pdf parameterized by \(\theta\) and \(s\). We assume \(E[m(0,s)] = m_0 \forall s \in [0, \infty] \); \(\frac{\partial E[m(\theta,s)]}{\partial \theta} \geq 0 \forall \theta \in [0, \infty] \forall s\); \(\frac{\partial^2 E[m(\theta,s)]}{\partial \theta^2} \leq 0 \forall \theta, s\); \(\frac{\partial E[m(\theta,s)]}{\partial s} \geq 0 \forall s \in [0, \infty], \forall \theta \in (0, \infty]\). These conditions imply that the client’s revenue is increasing and concave in both parties’ effort and that there is no improvement without the client’s minimal effort.

\(A2\). Service support requests follow the binomial distribution parameterized by the market size \(V\) and \(p(\theta, s)\). We also assume that \(p(0, s) = p_0 \leq 1 \forall s \in [0, \infty]\); \(\frac{\partial p(\theta,s)}{\partial \theta} = 0 \text{ as } \theta \to \infty, \forall s\); \(\frac{\partial^2 p(\theta,s)}{\partial \theta^2} < 0 \forall \theta \in [0, \infty] \forall s\); \(\frac{\partial p(\theta,s)}{\partial s} = 0 \text{ as } s \to \infty \forall \theta\); \(\frac{\partial^2 p(\theta,s)}{\partial s^2} < 0 \forall s \in [0, \infty] \forall \theta \in (0, \infty]\); \(\frac{\partial^2 p(\theta,s)}{\partial \theta \partial s} \geq 0 \forall \theta, s\). These conditions imply that the expected number of service requests is decreasing and convex in both parties’ effort and that there is no improvement without the client’s minimal effort.
A3. We assume that $I(s)$ is strictly convex and increasing; $I(0) = 0$; $I'(0) = 0$; $I'(\infty) = \infty$; $I_m(\theta)$ is strictly convex and increasing; $I_m(0) = 0$; $I'_m(0) = 0$; $I'_m(\infty) = \infty$. The boundary conditions on both investment functions ensure that the investment cost is incurred only if an effort is made and that $\infty$ is ruled out as an effort that is optimal.

The verifiable outcome of the joint efforts of the client and the customer support center at $t = 3$ will be the number of service requests $u(\theta, s)$. Observe that this outcome is inseparable in the two efforts, creating a double-sided moral hazard, and that $E[u(\theta, s)] = Vp(\theta, s)$.

3. Model Formulation and Analysis

In this section, we analyze the contractual structures that could potentially yield optimal outcomes for the client in two scenarios: (i) when efforts exerted by both parties are unobservable, and (ii) when efforts exerted by both parties are observable.

We begin with the sequential game in which the two parties coordinate their efforts to maximize joint profits. Since the efforts by the two parties are exerted sequentially, we determine the optimal efforts using backward induction as follows:

$$\theta^*(s) = \arg \max_{\theta \geq 0} E[m(\theta, s)] - cVp(\theta, s) - I_m(\theta), \quad (1)$$

$$s^* = \arg \max_{s \geq 0} E[m(\theta^*(s), s)] - cVp(\theta^*(s), s) - I_m(\theta^*(s)) - I(s). \quad (2)$$

Equations (1) and (2) determine the first-best efforts $(\theta^*(s), s^*)$ in the coordinated problem of the two parties to maximize their joint profits from the product improvement effort. We now present the results for our two scenarios (based on the observability of efforts), starting with the case where efforts are unobservable.

3.1. Unobservable Efforts

If the client offers the customer support center a contract $f$ based on the verifiable outcome $u(\theta, s)$, then the client’s problem can be stated as follows:

$$\max_{f(\cdot)} E[m(\tilde{\theta}, \tilde{s})] - I_m(\tilde{\theta}) - E[f(u(\tilde{\theta}, \tilde{s}))]. \quad (3)$$
\begin{align}
\text{s.t. } \tilde{\theta} &= \arg \max_{\theta} E[m(\theta, \tilde{s})] - I_m(\theta) - E[f(u(\theta, \tilde{s}))], \\
\tilde{s} &= \arg \max_s E[f(u(\tilde{\theta}, s))] - cVp(\tilde{\theta}, \tilde{s}) - I(s), \\
E[f(u(\tilde{\theta}, \tilde{s}))] - cVp(\tilde{\theta}, \tilde{s}) - I(\tilde{s}) &\geq v. 
\end{align}

Equation (6) represents the participation constraint for the customer support center (with a reservation value \( v \geq 0 \)), equation (5) represents the support center’s problem of determining its effort, equation (4) represents the equivalent problem for the client’s effort, and equation (3) represents the contract design problem for the client.

Although the decisions made by the two parties are sequential, if efforts are unobservable then (4) and (5) are solved simultaneously by the two parties, as each will base its best response on the reaction functions of the other. Given that efforts are unobservable, the client’s effort will be contingent upon its expectation of the effort to be made by the customer support center. Similarly, the customer support center (as a rational player) will assume that the client will make an effort that is based on the best response to its own effort.

**Proposition 1**: With unobservable efforts in product improvement, static gain-share contracts are optimal.

The client, as principal, prefers gain-share contracts because they incentivize the customer support center to invest optimally in the product improvement effort. In addition to being compensated for its loss of revenue due to fewer customer service requests, the customer support center has some upside potential from the gain-share contract. Gain-share contracts are widely used in the industry (Kapadia 2010) for the very reason that they induce optimal efforts from both parties even when efforts are unobservable, also they are easy to implement since the cost of monitoring the verifiable outcome is zero. That is, in almost all cases that we have observed in practice, data on customer service requests are already available to the client and is readily available for verification by legal authorities.

In the literature there have been other examples of performance-based contracts leading to the optimal outcome. For instance, Dey et al. (2010) show that in the context of outsourced software development projects, performance-based contracts that incorporate quality level agreements
achieve the optimal solution. We add to this stream of literature by showing that, when customer support centers perform the role of service providers and participate in product improvement, a gain-share contract (which is a type of a performance-based contract) achieves the optimal solution for the client. We next analyze whether the optimal solution is also the first-best solution from the client’s perspective.

Proposition 2: With unobservable efforts, the optimal gain-share contract attains the second-best solution.

Although the gain-share contract is optimal for the client, it cannot completely resolve the free-rider problem that stems from double-sided moral hazard. Gain-share contracts distribute the gains from fewer customer service requests resulting from joint product improvement between the client and the customer support center. For the gain-share contract to induce the client’s first-best effort after the customer support center has sunk its effort, all the surplus from the joint improvement effort should accrue to the client. However, owing to the lack of observability of the customer support center’s effort, the client cannot extract all the surplus from the joint effort, as it has to leave some of the surplus with the customer support center. Given that the client’s best-response function does not lead to its own first-best effort, the customer support center does not exert the first-best effort. Thus, both parties make their optimal (second-best) efforts but cannot achieve the first-best outcome.

Since gain-share contracts can attain the optimal solution with unobservable efforts, but they only attain the second-best solution, no contract can attain the first-best solution for the client. In the literature on outsourcing contracts with single moral hazard, performance-based contracts can resolve the single moral hazard issue (Dey et al. 2010). However, an important result of our paper is that in the presence of double-sided moral hazard and unobservable efforts, no contract can attain the first-best solution for the client. The reason is that the client can only offer outcome-based contracts to the customer support center, and there is no intermediate update of information on the effort exerted by the customer support center. This precludes attaining the first-best solution because the double-sided moral hazard cannot be resolved by performance-based contracts alone.
We now investigate whether an alternative, cost-plus contractual structure can replicate the optimal solution.

**Lemma 1**: With unobservable efforts in product improvement, a cost-plus contract is not optimal.

Cost-plus contracts are widely used for governing outsourced IT projects, and they have been shown to be efficient in governing outsourced software development contracts in some special cases, as when auditing effort is efficient and effective and so the cost of monitoring is low (Dey et al. 2010). Gopal and Sivaramakrishnan (2008) find that time-and-materials contracts (a type of cost-plus contracts) perform well when there is a high risk of project team member attrition. Cost-plus contracts do not perform optimally in the case of bilateral efforts with double-sided moral hazard and no observability for reasons that are similar to the case of single sided moral hazard (Dey et al. 2010). Cost-plus contracts must to be monitored in the case of single-moral hazard as vendors have the incentive to inflate costs. In the context of this paper, the support center’s effort cannot be monitored because efforts are not verifiable. In addition, the fixed-fee with the cost in cost-plus contracts does not adequately incentivize the service provider to invest in the joint product improvement effort, because it is not linked to the improvement achieved — unlike gain-share contracts, in which the service provider’s incentive for product improvement is linked to the effort invested. Hence cost-plus contracts are less efficient than gain-share contracts in coordinating the efforts the two parties.

We next analyze the joint product improvement problem when efforts made by both parties are observable.

### 3.2. Observable Efforts

When the efforts made by both parties are observable, the problem faced by the client is described formally as follows:

\[
\max_{\tilde{\theta}(s)} E[m(\tilde{\theta}(\tilde{s}), \tilde{s})] - I_m(\tilde{\theta}(\tilde{s})) - E[f(u(\tilde{\theta}(\tilde{s}), \tilde{s}))]
\]

s.t. \(\tilde{\theta}(s) = \arg\max_{\theta} E[m(\theta, s)] - I_m(\theta) - E[f(u(\theta, s))],\)

\(\tilde{s} = \arg\max_{s} E[f(u(\tilde{\theta}(\tilde{s}), s))] - cV p(\tilde{\theta}(\tilde{s}), s) - I(s),\)

\(7\)

\(8\)

\(9\)
As before, equation (10) represents the participation constraint for the customer support center; equation (9) represents the support center’s problem of determining its effort. Note that the support center will now exert its effort while taking the client’s best-response function into account. Equation (8) represents the equivalent problem for the client’s effort, which is a function of the customer support center’s observable effort $s$, and equation (7) represents the contract design problem for the client. We investigate the efficiency of different contractual structures, starting with static contracts (non contingent contracts that are not options based and cannot be renegotiated, in obtaining the first-best solution.

**Proposition 3:** With observable efforts, no static contract can yield the first-best outcome.

The result that static contracts do not attain the first-best solution, even if efforts are observable, is based on the conditions for obtaining the first-best outcome under double-sided moral hazard. In the centralized problem, the first-best effort by the client is obtained via equation (1), which gives the expected revenues from the joint improvement effort to the client minus the cost of servicing customer requests and the cost of effort exerted by the client. A contract will not elicit the client’s first-best efforts unless all the upside (from the joint improvement project) accrues to the client; yet by retaining all the upside, the client leaves no incentive for the customer support center to invest in the product improvement effort. No static contract will be able to incentivize both firms adequately to invest their first-best efforts, so static contracts do not obtain the first-best solution. This is an important insight for the analysis of optimal contracts for coordinating joint product improvement efforts. We now consider options-based contracts to see whether they can yield the client’s first-best solution to the joint product improvement problem.

**Proposition 4:** With observable efforts, a gain share/cost-plus option contract is optimal and attains the first-best solution. Here the client can use one of two options below to compensate the support center, and the exercise date of the option is set at $t \in (2, 3)$, i.e., when both parties have made their respective efforts in product improvement.
Option 1: Pay the support center using a gain-share contract.

Option 2: Pay the support center using a cost-plus contract.

The intuition behind Proposition 4 is as follows. The client offers the customer support center two different contractual structures and retains the option of compensating the support center using either structure after observing the efforts exerted by both parties. Option 1 is a gain-share contract, and Option 2 is a cost-plus contract. As we show in the proof, the support center will exert an effort \( s^* \) and the client will subsequently exert an effort \( \theta^* \) and choose to compensate the support center using the cost-plus contract. The intuition of the outcome of the option contract is straightforward. If the support center chooses to exert an effort \( s < s^* \) then the cost-plus contract will leave a surplus for the support center; hence the client will prefer to exert an effort \( \theta < \theta^* \) and choose the gain-share contract. In this case the outcome of the joint product improvement effort will be suboptimal and the contract will lead to lower payments to the support center than its required reservation value. To prevent this from occurring the support center will exert the system-optimal effort and thereby incentivize the client to exert its own system-optimal effort and to choose the cost-plus contract (under the cost-plus contract, the client has an incentive to invest the system-optimal effort). The client sets the contract parameters in such a way that, at \( s^* \), the support center earns a profit equal to its reservation value under the cost-plus contract and hence the client attains the first-best profit. Notice that the support center will not choose an effort greater than the system-optimal level, since doing so would lead to a lower profit for the support center than its reservation value (because then the client would choose the cost-plus contract).

The mechanics of this options contract are illustrated in Figure 2, where we have taken the functional forms of \( m(\theta, s) = 5\theta(1 + s^{0.5}) \), \( p(\theta, s) = e^{-0.01\theta(1+s)} \), \( I_m(\theta) = \frac{\theta^2}{2} \), \( I(s) = \frac{s^2}{2} \), and \( V = 100 \). The support center’s reservation value of profits is taken as \( v = 0 \).

Figure 2 shows that the support center prefers to be compensated by the cost-plus option for all levels of effort it exerts in product improvement. However the client prefers the gain-share option to compensate the support center, unless the support center exerts the system-optimal effort. Hence, the support center finds it optimal to exert the system-optimal effort \( (s^* = 16) \) because doing
so maximizes its total profit. This gives the support center a total expected profit equal to its reservation value, so the client finds it optimal to exert the system-optimal effort level $\theta^*$, thus this contract mechanism yields the first-best outcome for the client.

Studies in economics have shown that buyout options implement the first-best solution in bilateral investment games with double-sided moral hazard (Demski and Sappington 1991, Noldeke and Schmidt 1998, Edlin and Hermalin 2000). However, buyout options are impractical to implement in the context of joint product improvement effort for a number of reasons. First, most clients that cooperate with customer support centers are large and have multiple products in their portfolios; hence the revenues that they publicly declared consist of income from multiple streams, so it may not be possible to verify which revenues have been generated by the cooperative effort on any particular product. Second, few privately owned companies declare their revenues publicly, in which
case there may be adverse selection effects on the revenues declared by the client from the joint product improvement. Finally, buyout contracts rely on the assumption that the agent can buy the entire firm of the principal. But given that customer support centers are usually small, buyout option contracts are impractical in the cases that we study.

In contrast, gain-share and cost-plus contracts are both widely used in practice, and our analysis in the previous section showed that, while gain-share contracts are indeed optimal when efforts are unobservable, cost-plus contracts do not perform as well. When efforts are observable, we show that gain-share and cost-plus contracts can be used effectively in combination (through the use of options to choose either one of the two) to attain the first-best solution. The literature has most often studied single-sided moral hazard that arises when an agent implements an unverifiable action for the principal (Gopal and Sivaramakrishnan 2008, Dey et al. 2010, Susarla et al. 2010, Fitoussi and Gurbaxani 2011) and has found that these contracts perform well under different conditions. We show in a normative model that — in the context of double-sided moral hazard, where both parties invest in efforts toward joint product improvement and those efforts are observable — a combination of these widely used contracts achieves the first-best solution and also performs better than either contract individually. Implementing such an options contract should not be difficult in practice as the individual contract types are already widely used in practice. Implementing the contingency of the contractual structure (recall that the option is exercised following the observation of both parties’ efforts) has been modeled for other recourse options in the form of contract provisions (Chen and Bharadwaj 2009) and milestone-based contingent contracts (Dey et al. 2010).

4. Conclusions and Future Research

In this paper we study the cooperative product improvement effort of a client and a customer support center, where the client must incentivize the support center to make its first-best effort, and must also compensate the support center for its revenue loss caused by the fewer service requests following the joint product improvement effort. We model the problem as a sequential bilateral
game between the two parties with double-sided moral hazard. Our findings can be summarized
as follows. When efforts are unobservable: (i) the client should offer the customer support center
a gain-share contract as it yields the optimal solution; (ii) the optimal solution achieved by the
gain-share contract attains only the second-best solution; (iii) cost-plus contracts do not yield the
optimal solution and, moreover perform worse than the gain-share contracts.

When efforts are observable: (i) static contracts (including gain-share and cost-plus contracts) do
not yield the first-best solution because they cannot adequately incentivize both parties to invest
their first-best efforts; (ii) the optimal contract to be offered by the client is an options-based
contract, where the client offers to compensate the customer support center either by a gain-share
or a cost-plus contract, and the option will be exercised by the client after both parties have
sunk their efforts. Finally, we show that such a gain-share/cost-plus option contract can attain the
first-best solution for the client.

Our results have a number of implications. First, we provide theoretical support for the use of
gain-share and cost-plus contracts in combination in joint product improvement effort with double-
sided moral hazard when efforts are observable. The observability of efforts is a function of the
degree of cooperation between the client and the customer support center. If the two parties work
closely together, as we observed in the example cases of WNX and Travelcountry and of Bharti
Airtel and IBM, then the observability of efforts is a valid assumption because the client can closely
monitor the effort of the customer support center. However, if the two parties work in an arm’s-
length relationship then the unobservability of efforts would be the more valid assumption. In this
case we show that gain-share contracts are optimal and perform better than cost-plus contracts,
though no individual contract can achieve the first-best solution for the client.

Our results contribute to the extant literature in a number of ways. First, performance-based
contract design has been studied in the single moral hazard case in terms of the number of performance metrics used (Fitoussi and Gurbaxani 2011), the effect of task complexity on agency issues (Susarla et al. 2010), the kind of contracts to be used under different scenarios (Dey et al. 2010), and the vendor’s preferred contractual designs (Gopal and Sivaramakrishnan 2008). We add to this
literature by considering the issues of double-sided moral hazard and holdup, and we show that options-based combinations of gain-share and cost-plus contracts perform best when efforts are observable, whereas specific performance-based contracts (gain-share) perform best when efforts are unobservable. We also add to the economic literature by showing that options-based contracts that are not based on buyout but rather on contract types that are widely used in practice can coordinate the two parties’ efforts to yield the first-best solution.

This paper looks at the practice of joint product improvement efforts and models the impact of double-sided moral hazard on the contracts described in the literature and observed in practice between clients and customer support centers. Our findings indicate that clients could make better decisions when designing contracts for customer support centers, and the framework proposed in this paper can serve as a guide in this regard.

References


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**Appendix**

**Proof of Proposition 1**: Assume that $f(\cdot) = f_\circ(\cdot)$ is the optimal contract for the client and also assume that, for the optimal contract, $\hat{\theta}, \hat{s}$ are interior points. We will show later that our assumptions ensuring that $\theta^*, s^*$ are interior points are sufficient to ensure that $\hat{\theta}, \hat{s}$ are interior points. Therefore,

\[
\frac{\partial E[m(\theta, s)]}{\partial \theta} \bigg|_{\theta=\hat{\theta}} - \frac{\partial I_m(\theta)}{\partial \theta} \bigg|_{\theta=\hat{\theta}} - \frac{\partial E[f_\circ(u(\theta, s))]}{\partial \theta} \bigg|_{\theta=\hat{\theta}} = 0, \tag{11}
\]

\[
\frac{\partial E[f_\circ(u(\hat{\theta}, s))]}{\partial s} \bigg|_{s=\hat{s}} - cV \frac{\partial p(\hat{\theta}, s)}{\partial s} \bigg|_{s=\hat{s}} - \frac{\partial I(s)}{\partial s} \bigg|_{s=\hat{s}} = 0. \tag{12}
\]

Suppose we have a linear gain-share contract $E[f(u(\theta, s))] = aV[p_0 - p(\theta, s)] + b$. Set the value of $a$ such that,

\[
a = \frac{1}{V} \left[ \sum_{x=0}^{V} \left( V \atop x \right) f_\circ(x)p(\hat{\theta}, \hat{s})^{x-1}(1 - p(\hat{\theta}, \hat{s}))^{V-x-1}(-x + Vp(\hat{\theta}, \hat{s})) \right]
\]

and the value of $b$ such that

\[
b = v - aV[p_0 - p(\theta, s)] + cVp(\hat{\theta}, \hat{s}) + I(\hat{s}).
\]

Our claim is that such a linear gain-share contract will replicate the optimal contract $f_\circ(\cdot)$. For the linear gain share contract, the first-order conditions are

\[
\frac{\partial E[m(\theta, s)]}{\partial \theta} - \frac{\partial I_m(\theta)}{\partial \theta} + aV \frac{\partial p(\theta, s)}{\partial \theta} = 0,
\]

\[-aV \frac{\partial p(\theta, s)}{\partial s} - cV \frac{\partial p(\theta, s)}{\partial s} - \frac{\partial I(s)}{\partial s} = 0.
\]

Substituting the values of $a$ yields

\[
\frac{\partial E[m(\theta, s)]}{\partial \theta} - \frac{\partial I_m(\theta)}{\partial \theta} - \left[ \sum_{x=0}^{V} \left( V \atop x \right) f_\circ(x)p(\hat{\theta}, \hat{s})^{x-1}q(\hat{\theta}, \hat{s})^{V-x-1}(-x + Vp(\hat{\theta}, \hat{s})) \right] \frac{\partial p(\theta, s)}{\partial \theta} = 0, \tag{13}
\]

\[
\left[ \sum_{x=0}^{V} \left( V \atop x \right) f_\circ(x)p(\hat{\theta}, \hat{s})^{x-1}q(\hat{\theta}, \hat{s})^{V-x-1}(x - Vp(\hat{\theta}, \hat{s})) \right] \frac{\partial p(\theta, s)}{\partial s} - cV \frac{\partial p(\theta, s)}{\partial s} - \frac{\partial I(s)}{\partial s} = 0. \tag{14}
\]
where \( q(\theta, s) = 1 - p(\theta, s) \). It is easy to see that (13) and (14) are satisfied at \( \{\tilde{\theta}, \tilde{s}\} \). It is also easy to check that the second-order conditions are satisfied, and hence \( \{\tilde{\theta}, \tilde{s}\} \) are the outcome of the linear gain share contract. Furthermore, the constant term of the linear gain-share contract is set such that no additional surplus is paid to the customer support center; hence the linear gain-share contract can replicate the optimal contract. Next we show that, given our assumptions on the relevant functions, \( \tilde{\theta}, \tilde{s} \) are interior points. Our assumptions on the cost functions \( I_m(\theta) \) and \( I(s) \) rule out \( \infty \), so we need only show that \( \tilde{\theta}, \tilde{s} \neq 0 \). First let us assume that \( \tilde{\theta} = 0 \). This implies that \( \tilde{s} = 0 \), as when the client exert no effort, the support center’s effort yields no improvement in the product and the client’s profit is \( m_0 - f_o(Vp_0) \). Now let us consider a different contract \( f(u(\theta, s)) = cu(\theta, s) + T \). Under this contract the support center’s optimal effort is \( s = 0 \). However, we note that \( \frac{\partial E[m(\theta, 0)]}{\partial s} - \frac{\partial I_m(\theta)}{\partial s} - cV \frac{\partial p(\theta, 0)}{\partial \theta} > 0 \) at \( \theta = 0 \). Hence under this contract the client’s optimal effort is \( \theta > 0 \). Set \( T \) such that \( T = f_o(Vp_0) - cVp_0 \). Then the client’s expected profit under this contract is \( E[m(\theta, 0)] - I_m(\theta) - cVp(\theta, 0) - T > Vm_0 - f_o(Vp_0) \); which yields a contradiction. Now let us assume that \( \tilde{s} = 0 \) and \( \tilde{\theta} > 0 \). The client’s expected profit is then, \( E[m(\tilde{\theta}, 0)] - I_m(\tilde{\theta}) - E[f_o(u(\tilde{\theta}, 0))] \), and this implies that \( \frac{\partial E[f_o(u(\tilde{\theta}, s))]}{\partial s} - cV \frac{\partial p(\tilde{\theta}, s)}{\partial s} - \frac{\partial I(s)}{\partial s} \leq 0 \) \( \forall s > 0 \). Let us consider a different contract \( f(u(\theta, s)) = T \). Under this contract, \( \frac{\partial E[m(\theta, s)]}{\partial s} - \frac{\partial I_m(s)}{\partial s} > 0 \) at \( \theta = 0 \) \( \forall s \). Hence under this contract the client’s optimal effort is \( \theta > 0 \), which implies that \( -cV \frac{\partial p(\theta, s)}{\partial s} - \frac{\partial I(s)}{\partial s} > 0 \) at \( s = 0 \). In this case, the optimal effort of the support center is \( s > 0 \). Now set \( T \) such that \( T = E[f_o(u(\tilde{\theta}, 0))] \). Then the client’s expected profit under this contract is \( E[m(\theta, s)] - I_m(\theta) - T \geq E[m(\tilde{\theta}, s)] - I_m(\tilde{\theta}) - T > E[m(\tilde{\theta}, 0)] - I_m(\tilde{\theta}) - E[f_o(u(\tilde{\theta}, 0))] \), which also yields a contradiction. Therefore, a contract that induces zero effort from either party cannot be optimal, and there exists at least one contract that leads to interior solutions for the efforts. This completes the proof.

**Proof of Proposition 2:** By Proposition 1, we know that the linear gain-share contract is optimal. So to prove Proposition 2 it is sufficient to show that no linear gain-share contract will attain the first-best outcome. Let us assume that this is not true and \( \exists \) a linear gain-share contract \( \{a_o, b_o\} \) that does attain the first-best outcome. This would imply that

\[
\frac{\partial E[m(\theta, s^*)]}{\partial \theta} \bigg|_{\theta = \theta^*} - \frac{\partial I_m(\theta)}{\partial \theta} \bigg|_{\theta = \theta^*} + aV \frac{\partial p(\theta, s^*)}{\partial \theta} \bigg|_{\theta = \theta^*} = 0, \tag{15}
\]

\[\square\]
\[-aV \frac{\partial p(\theta^*, s)}{\partial s} \bigg |_{s=s^*} - cV \frac{\partial p(\theta^*, s)}{\partial s} \bigg |_{s=s^*} - \frac{\partial I(s)}{\partial s} \bigg |_{s=s^*} = 0. \quad (16)\]

From the definition of \{\theta^*, s^*\} we know that
\[\frac{\partial E[m(\theta, s^*)]}{\partial \theta} \bigg |_{\theta=\theta^*} - \frac{\partial I_m(\theta)}{\partial \theta} \bigg |_{\theta=\theta^*} - cV \frac{\partial p(\theta^*, s^*)}{\partial \theta} \bigg |_{\theta=\theta^*} = 0, \quad (17)\]
\[\frac{\partial E[m(\theta^*, s)]}{\partial s} \bigg |_{s=s^*} - cV \frac{\partial p(\theta^*, s)}{\partial s} \bigg |_{s=s^*} - \frac{\partial I(s)}{\partial s} \bigg |_{s=s^*} = 0. \quad (18)\]

Comparing (15) and (17) yields that \(a = -c\). However, if \(a = -c\) then (16) cannot be true because \(s^*\) is an interior point. This contradiction completes our proof.

**Proof of Lemma 1:** Let the outcome of the effort game between the client and the support center be \{\theta_C, s_C\} under the cost-plus contract \((E[f(u(\theta, s))] = cVp(\theta, s) + T)\), where the first-order conditions for the client’s and support center’s effort game are (respectively)
\[V \frac{\partial E[m(\theta, s_C)]}{\partial \theta} \bigg |_{\theta=\theta_C} - \frac{\partial I_m(\theta)}{\partial \theta} \bigg |_{\theta=\theta_C} - cV \frac{\partial p(\theta, s_C)}{\partial \theta} \bigg |_{\theta=\theta_C} = 0, \quad (19)\]
\[-\frac{\partial I(s)}{\partial s} \bigg |_{s=s_C} = 0. \quad (20)\]

By (20), \(s_C = 0\). From the proof of Proposition 1, we know that the optimal second-best efforts are interior points. Therefore, the cost-plus contract cannot attain the optimal second-best.

**Proof of Proposition 3:** Assume that a static contract \(f_o(\cdot)\) is the optimal static contract. Since the client observes the support center’s effort, the client’s effort is given by
\[\tilde{\theta}(s) = \arg\max_{\theta} E[m(\theta, s)] - I_m(\theta) - E[f(u(\theta, s))]. \quad (21)\]

The support center’s optimal effort is
\[\tilde{s} = \arg\max_{s} E[f(u(\tilde{\theta}(s), s))] - cVp(\tilde{\theta}(s), s) - I(s). \quad (22)\]

To complete our proof, it is sufficient to show that either \(\tilde{\theta}(s^*) \neq \theta^*\) or \(\tilde{s} \neq s^*\). For this it is enough to show that the first-order conditions under the static contract do not align with the first-order conditions for coordination. The first-order condition for the client under contract \(f_o(\cdot)\) is
\[\frac{\partial E[m(\theta, \tilde{s})]}{\partial \theta} \bigg |_{\theta=\tilde{\theta}} - \frac{\partial I_m(\theta)}{\partial \theta} \bigg |_{\theta=\tilde{\theta}} - \frac{\partial E[f_o(u(\theta, \tilde{s}))]}{\partial \theta} \bigg |_{\theta=\tilde{\theta}} = 0. \quad (23)\]
For $\tilde{\theta}(s^*) = \theta^*$ we need that
\[
\frac{\partial E[f_o(u(\theta, s^*))] }{\partial \theta} |_{\theta = \theta^*} = cV \frac{\partial p(\theta, s^*)}{\partial \theta} |_{\theta = \theta^*}.
\] (24)

We can rewrite equation (24) as
\[
c = \frac{1}{V} \left[ \sum_{x=0}^{V} \left( V \prod_{x=0}^{V} f_o(x)p(\theta^*, s^*)^{x-1}(1 - p(\theta^*, s^*))^{V-x-1}(x - Vp(\theta^*, s^*)) \right) \right].
\] (25)

The first-order condition for the support center under contract $f_o(\cdot)$ is
\[
\left[ \left( \frac{\partial E[f_o(u(\theta, s^*))]}{\partial \theta} - cV \frac{\partial p(\theta, s^*)}{\partial \theta} \right) |_{\theta = \tilde{\theta}} \frac{\partial \tilde{\theta}(s^*)}{\partial s} + \frac{\partial E[f_o(u(\tilde{\theta}, s^*))]}{\partial s} \right] - cV \frac{\partial p(\tilde{\theta}, s^*)}{\partial s} - \frac{\partial I(s^*)}{\partial s} \right] |_{s^*} = 0.
\]

For $\tilde{s} = s^*$ and $\tilde{\theta}(s^*) = \theta^*$ we need that
\[
\left[ \left( \frac{\partial E[f_o(u(\theta, s^*))]}{\partial \theta} - cV \frac{\partial p(\theta, s^*)}{\partial \theta} \right) |_{\theta = \theta^*} \frac{\partial \theta(s^*)}{\partial s} + \frac{\partial E[f_o(u(\theta^*, s^*))]}{\partial s} \right] - cV \frac{\partial p(\theta^*, s^*)}{\partial s} - \frac{\partial I(s^*)}{\partial s} \right] |_{s^*} = 0.
\]

Replacing (24) and (25) yields
\[
- \frac{\partial I(s^*)}{\partial s} |_{s^*} = 0.
\] (26)

Because $s^*$ is an interior point, (26) implies that the conditions for $\tilde{s} = s^*$ and $\tilde{\theta}(s^*) = \theta^*$ are not satisfied. Therefore, an optimal static contract cannot attain the first-best solution.

**Proof of Proposition 4**: Under the gain-share option (Option 1) the support center’s expected profit function is $\Pi_s(\theta, s) = aV(p_0 - p(\theta, s)) + b - I(s) - cVp(\theta, s)$; and the client’s expected profit is $\Pi_m(\theta, s) = E[m(\theta, s)] - I_m(\theta) - aV(p_0 - p(\theta, s)) - b$. Similarly under the cost-plus option (Option 2) the expected profit’s are $\Pi_s(\theta, s) = cVp(\theta, s) + F - I(s) - cVp(\theta, s)$; and $\Pi_m(\theta, s) = E[m(\theta, s)] - I_m(\theta) - cVp(\theta, s) - F$. We will show that a gain-share/cost-plus option contract based on the contracts described above will yield the first-best outcome for the client. Set $a$ such that the client’s best response under Option 1 for any $s \in [0, s^*]$ is $\theta = 0$. First we will show that a finite $a$ will achieve this. We want
\[
\frac{\partial E[m(\theta, s)]}{\partial \theta} + aV \frac{\partial p(\theta, s)}{\partial \theta} - \frac{\partial I_m(\theta)}{\partial \theta} \leq 0 \ \forall \theta, \forall s \in [0, s^*].
\] (27)
Observe that, for $a > 0$, (27) holds $\forall \theta \geq \tilde{\theta}(s)$, where

$$\tilde{\theta}(s) = \arg_{\theta} \frac{\partial E[m(\theta,s)]}{\partial \theta} - \frac{\partial I_m(\theta)}{\partial \theta} = 0.$$  \hfill (28)

It can be shown via the implicit function theorem that $\partial \tilde{\theta}(s)/\partial s \geq 0$. Furthermore by our assumptions on relevant functions we know that $s^* < \infty$ and $\tilde{\theta}(s^*) < \infty$. Hence the relevant domain to show on which the inequality (27) is $\theta \in [0, \tilde{\theta}(s^*)]$, $s \in [0, s^*]$. Therefore, (27) is satisfied if we set $a = \max_{\theta \in [0, \tilde{\theta}(s^*)], s \in [0, s^*]} \frac{-\partial E[m(\theta,s)]}{\partial \theta} + \frac{\partial I_m(\theta)}{\partial \theta} + V \frac{\partial p(\theta,s)}{\partial \theta}.$  \hfill (29)

It is easy to check that $0 < a < \infty$. This implies that the best response of the client under Option 1 is $\theta = 0$ for any action $s \in [0, s^*]$ by the support center. Set $F = I(s^*) + v$. Then we can rewrite the profit functions as follows:

$$\Pi_s = -cVp_0 - I(s) + b \quad \text{Option 1}$$  \hfill (30)
$$= I(s^*) + v - I(s) \quad \text{Option 2}$$  \hfill (31)

$$\Pi_m = m_0 - b \quad \text{Option 1}$$  \hfill (32)

$$= E[m(\theta,s)] - I_m(\theta) - cVp(\theta,s) - I(s^*) - v \quad \text{Option 2}$$  \hfill (33)

Now set $b$ such that,

$$m_0 - b + \epsilon = E[m(\theta^*, s^*)] - I_m(\theta^*) - cVp(\theta^*, s^*) - I(s^*) - v,$$  \hfill (34)

where $\epsilon \to 0^+$. In this case the client will use Option 2 if the support center’s action $s = s^*$. Note that the support center will not choose $s > s^*$, since that would not satisfy the support center’s reservation value. The reason is that here the client’s profit $\Pi_m \geq E[m(\theta^*(s), s)] - I_m(\theta^*(s)) - cVp(\theta^*(s), s) - I(s^*) - v > E[m(\theta^*, s^*)] - I_m(\theta^*) - cVp(\theta^*, s^*) - I(s^*) - v$, and the support center’s profit is therefore $\Pi_s = \Pi_c - \Pi_m < \Pi_c - \Pi_m < v$, where $\Pi_c$ is the joint profit of the two parties. If the support center chooses $s = s^*$, then the client will use Option 2 and choose $\theta = \theta^*$; under this condition, the support center will earn $v$ and the client’s profit is maximized. If the support center instead chooses $s < s^*$, then the client will use Option 1 and choose $\theta = 0$. This option is clearly not
incentive compatible for the support center, since $\Pi_s = -cVp_0 - I(s) + b = -cVp_0 - I(s) + m_0 + \epsilon - E[m(\theta^*, s^*)] + I_m(\theta^*) + cVp(\theta^*, s^*) + I(s^*) + v < v$. The support center will therefore choose $s = s^*$, inducing the client to use the Option 2 contract and choose $\theta = \theta^*$. Note that once the support center has exerted an effort $s^*$, the client may hold up the support center and not choose the existing cost-plus option and renegotiate it to a lower fixed-fee. However, since the exercise date of the options contract follows the investment made by the client, the client cannot credibly hold up the support center. After the client exerts an effort $\theta$, the support center is guaranteed a profit of $aV(p_0 - p(\theta, s^*)) - I(s^*) - cVp(\theta, s^*) + b$ under the gain-share option. Thus the maximum profit that the client can earn by not choosing the cost-plus option and offering the support center a renegotiated contract is $E[m(\theta, s^*)] - I_m(\theta) - aV(p_0 - p(\theta, s^*)) - b$. We know from equation (29) that $E[m(\theta, s^*)] - I_m(\theta) - aV(p_0 - p(\theta, s^*)) - b \leq m_0 - b$. Therefore any renegotiation due to hold up will not be profitable for the client. Hence the options contract described in Proposition 4 is renegotiation-proof.