

Volume 1, Paper 9  
November 2000

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## Structuring IS Outsourcing Contracts for Mutual Gain: An Approach to Analyzing Performance Incentive Schemes

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**Noel (Kweku-Muata) Bryson**

Virginia Commonwealth University, U.S.A.

[Kweku.Muata@isy.vcu.edu](mailto:Kweku.Muata@isy.vcu.edu)

**Ojelanki K. Ngwenyama**

Virginia Commonwealth University, U.S.A., and

Aalborg University, Denmark

[OJELANKI@ISY.VCU.EDU](mailto:OJELANKI@ISY.VCU.EDU)

### Abstract

As information systems managers come under increasing pressure to improve the cost performance of information processing, outsourcing has become an important management strategy. Although information systems outsourcing is now a major industry, it is still a new decision problem for many managers. As managers gain more and more experience with IS outsourcing, satisfaction with vendor performance is becoming a major issue. Key to managing outsourcing relationships is the outsourcing contract. These contracts assign responsibilities and rewards for the parties. However, improperly or incompletely written contracts have lead to adverse problems. How then are managers to choose from a set of options that which is most appropriate for their firm? Outsourcing problems are complex and

entail considerable implications for the strategy of the firm. Although many articles have appeared on outsourcing, few have extended the discussion beyond simple cost-benefit analysis. Contracts that encourage vendor performance and discourage under-performance are clearly of interest to managers. In this paper, an approach to analyzing incentive schemes and structuring outsourcing contracts for the mutual gain of the parties is presented. The approach provides managers with a strategy and techniques for analyzing some of the more subtle issues they may face when dealing with complex outsourcing decision problems.

## I. INTRODUCTION

During the last several years, information systems outsourcing has emerged as a major issue for IS managers. The primary motivation for outsourcing portions of the IS portfolio is the perceived potential for cost savings by the outsourcer. It is claimed that IS outsourcing vendors can achieve economies of scale and specialization because their only business is information processing. IS outsourcing vendors can purchase equipment at a lower cost and allocate fixed cost more favorably. The potential for cost savings has lead many senior managers to enter into various types of contracts with IS outsourcing vendors. However, while some firms have achieved their cost reduction goals by outsourcing, others have had various degrees of failure (Due 1992; Lacity and Hirschheim 1993a, 1993b; Rochester and Douglas 1990, 1993). Many firms have had to prematurely terminate contracts and re-established their data centers (Lacity and Hirschheim 1993a, 1993b; Reponen 1993). Others have had to seek out new vendors and write new contracts. Although the price of entry into IS outsourcing can be low relative to in-house cost, it can rise steeply after the outsourcer is "locked-in." A recent empirical study (Lacity and Willcocks 1995) found that in 53 out of 61 outsourcing cases, managers reported an unsatisfactory outcome. One explanation for some of the failures is the complexity of IS outsourcing transactions (Lacity and Hirschheim 1993a; Loh and Venkatraman 1992). Another explanation that has been given for

IS outsourcing failures is the limited selection of decision models and tools to help managers systematically analyze outsourcing decisions (Alpar and Saharia 1995; Chaundry et al. 1992<sup>1</sup>; Ngwenyama and Bryson 1999; Reponen1993). Another recent survey (Ward et al. 1996) found that nearly 75% of IS managers believed that their analysis and planning methods failed to adequately quantify relevant benefits from specific investments in IT. As Ngwenyama and Bryson point out, IS outsourcing management and decisions are complex, involving many factors, such as (1) selecting one or more reliable outsourcing vendor, (2) entering and managing a long term relationship with one or more outsourcing vendor, (3) exposing vital organization assets to the control of external agents, (4) coordinating between internal users and outsourcing vendors, (5) monitoring vendors and inducing them to deliver on performance requirements, and (6) defining viable backup and recovery options. This paper responds to a gap in the management literature that has not systematically addressed these issues until now. We propose an approach and some decision analysis techniques for analyzing incentive schemes and structuring outsourcing contracts that are mutually beneficial to the outsourcer and vendor. In the following sections, we present the basic concepts of our model, which is based on transaction cost theory, and illustrate its use with an example. Our approach seeks to help senior managers in answering the following questions:

- (1) What are the risks and benefits of different outsourcing incentive schemes?
- (2) What is the potential vulnerability to the firm if the vendor under-performs on the contracted activity?
- (3) How can the firm protect itself from opportunistic bargaining by its vendor(s)?
- (4) How should incentive schemes be structured to ensure reliable vendor performance?

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<sup>1</sup>Although Chaundry et al. labeled IS outsourcing a mixed integer programming problem, they provide no model or analysis.

## II. OUTSOURCING STRATEGIES AND CONTRACTS

In the general literature on outsourcing, two basic strategies—single vendor and multiple vendor—have been suggested. However, in their econometric analysis, Ngwenyama and Bryson (1999) pointed out that setup and coordination costs inhibit IS managers from adopting the multiple vendor strategy. Empirical studies also support this analysis; the most common form of IS outsourcing is the single vendor approach (Rochester and Douglas 1990). We will, however, give a brief review of the arguments (for a detailed analysis of economic implications of single and multiple vendor strategies see, Ngwenyama and Bryson).

The multiple vendor strategy can be traced to Porter's (1985) recommendation on using several competing vendors to insure low cost, high performance, and quality. Porter suggests that an outsourcer can increase his bargaining power by contracting with a number of vendors who are in competition with each other. The argument posits that the ever present threat of losing business to one another will induce each vendor to provide a higher level of performance and quality than it otherwise would. In the single vendor outsourcing strategy, the outsourcer develops a strong relationship with one vendor. Although the single vendor strategy leaves a firm open to opportunistic bargaining and performance failure vulnerability, some have argued that it can be effective in some situations. Deming (1986) suggests that developing a highly integrated long-term relationship with a single vendor can considerably reduce cost and improve quality. According to Deming, poor vendor performance is the result of poor communication and coordination. He argues that it is more costly to monitor and coordinate the activities of multiple vendors than for a single vendor. Consequently, single vendor outsourcing minimizes performance assurance costs and, therefore, total cost.

Contracts are an important part of the analysis of outsourcing decisions. They can provide effective mechanisms for managing the outsourcing relationship and early termination provisions in cases of under-performance. Generally, there are two classes of outsourcing contracts: fixed fee and incentive. In a simple fixed fee

contract, the payment to the vendor is fixed but the vendor can negotiate additional payments for variations. Under the fixed fee contract (FFC), the vendor is responsible for all of the risk of cost overruns, but if efficiency can be improved, a higher profit can be made. In practice, however, when there are cost overruns the vendor can engage in opportunistic bargaining. That is, the client can be pressured to pay the overruns if the client is outsourcing to a single vendor and there is no credible option of switching. A second type of fixed fee arrangement is the cost plus contract (CPC), which involves the risk of cost overruns that would be borne solely by the client. The second type of contract, incentive contracts, attempts to share the risks and rewards between the client and the vendor. Generally, these contracts specify an expected level of service and penalties for under-performance and incentives for various levels of performance. Penalties and incentives are important features of any type of IS outsourcing contract; they serve as inducements to the vendor and as mechanisms by which the outsourcer can manage shirking in the relationship. There are two main types of incentive contracts: fixed price incentive contracts (FPIC) and variable price incentive contracts (VPIC). These two types of contracts differ in how they treat vendor under-performance and cost overruns. Later in this paper, we will show how the manager can analyze and structure incentive schemes for these two types of contracts.

### **III. BASICS CONCEPTS OF OUTSOURCING**

Contracting out information processing activities entails significant loss of control over the performance of the activities. Associated with this loss of control are two basic risks: shirking and opportunistic bargaining. Shirking refers to the vendor's under-performance on the contracted activities; opportunistic bargaining refers to a vendor's ability to demand higher than market prices. An outsourcer can be subjected to opportunistic bargaining when "locked-in" to a single vendor and considerable costs would be incurred by switching to another vendor (Ngwenyama and Bryson 1999). To minimize the risks of shirking, the outsourcer can invest in

monitoring and coordinating mechanisms. Often, an outsourcer sets up an organizational unit to coordinate the interactions between its end-users and the vendor and to monitor the vendor's performance.<sup>2</sup> Depending on the size and complexity of the outsourced activities, this unit can be quite large and costly. On the other hand, minimizing the risk of opportunistic bargaining is a more complicated issue. For example, Porter (1985) has suggested that the ever present threat of losing business to multiple competing vendors will induce the vendors to deliver acceptable performance and bargain fairly with the outsourcer. However, as Ngwenyama and Bryson have shown, outsourcing information processing activities to multiple vendors is infeasible in all but a few cases, because the total cost of outsourcing to multiple vendors exceeds the return. Further, information systems outsourcing is an indefinite horizon game. Given these conditions, it is common practice for firms to outsource their information processing to a single vendor. The question for the manager, then, is how to analyze and manage the risks of outsourcing to a single vendor.

In single vendor outsourcing, if there are no costs for switching vendors (or insourcing<sup>3</sup>), the outsourcer can induce the vendor to provide the agreed upon level of service because there is a credible threat of losing the contract. However, if the outsourcer has made specific investments in the single vendor or cannot switch to another vendor (or insource due to lack of capacity) without further outlay, the credible threat of losing business is diminished and the vendor has room to determine the level of performance it will provide. If the outsourcer's switching cost exceeds the vendor's cost of providing low performance, the vendor can provide low performance and increase his profits without fear of losing the contract. Thus, the vendor can shirk to a degree determined by the outsourcer's switching cost. The

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<sup>2</sup>The outsourcer must monitor several aspects of vendor performance: MTBF of systems, systems response time, vendor interactions with end-users, and so on.

<sup>3</sup>The insourcing case assumes that the outsourcer has the capacity to provide the information processing in house.

outsourcer might decide to invest in higher levels of monitoring and coordinating to minimize vendor shirking. But the outsourcer must take into account the vendor's choice of level of performance (Ngwenyama and Bryson 1999).

## **DIMENSIONS OF THE PROBLEM**

Several issues must be examined when analyzing incentive schemes, but the primary objective of managers making IS outsourcing decisions is to minimize total cost and maximize total value to the firm. Two important questions are:

- (1) What are the ranges of costs and values of various levels of vendor performance?
- (2) How can they be measured and analyzed?

The cost of outsourcing a set of information processing activities is relatively easy to define; the difficulty lies in defining the costs and values of different levels of performance. This is because the techniques for defining the value of information are not well developed, much work is still needed to provide foundational concepts and methods of analysis (Ahituv 1980; Alpar and Kim 1990; Clemons 1991; Feltham 1968; Hitt and Brynjolfsson 1994). In the remainder of this section of the paper, we attempt to make some headway on this difficult issue. We outline two approaches: the first for defining the value of information processing activities and the second for defining the value of various levels of vendor performance. For the purpose of our analysis, we make the following assumptions:

- (1) The interactions between the outsourcer and vendor are an indefinite horizon game.
- (2) An incentive contract that specifies the price to be paid (in installments), the period, service and expected level of performance is agreed upon by the parties.
- (3) The vendor provides the service at a certain level of performance.

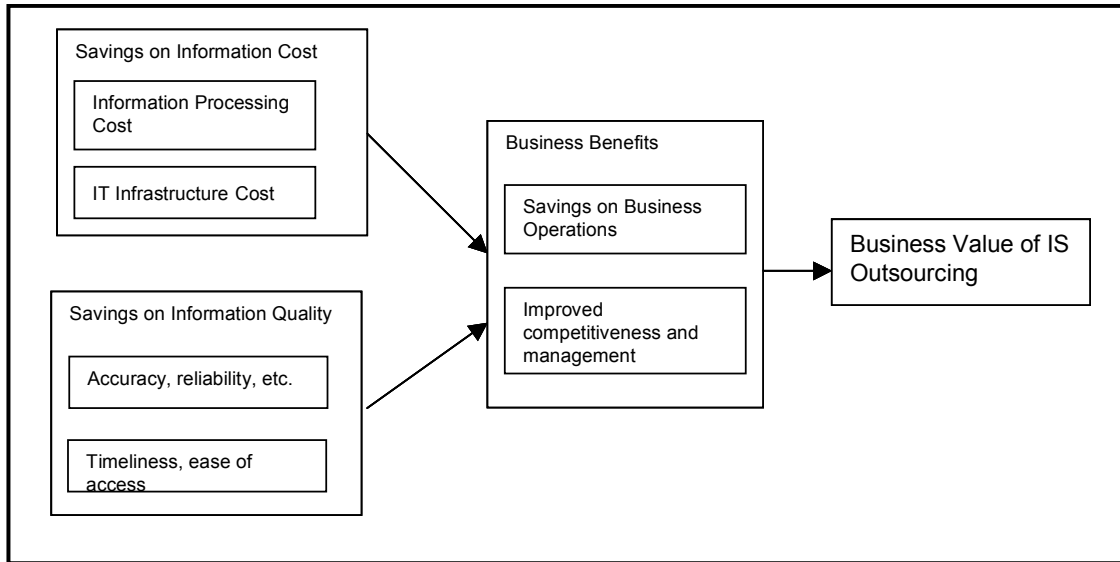
- (4) The outsourcer monitors the performance and determines the final payment to be made to the vendor and whether to renew the contract or switch to another vendor.

In considering the level of performance to provide, the vendor must weigh the possibility of losing a profit and the contract for the remainder of the game. We also assume that both parties have relevant information and knowledge of each other's objective function and costs and that each period in the indefinite horizon is identical. In the next section, we outline a model for analyzing outsourcing incentive schemes.

### **Defining the Business Value of Outsourcing**

Since a primary objective of the outsourcer is to maximize return on information processing, it is important to understand the various components of the value function. Although there are no standard models for this analysis, the attributes information cost and information quality are widely accepted as key components of the value function (Ahituv 1980; Ballou and Pazer 1995; Feltham 1968; Kriebel 1979; Redman 1992; Salmela 1997). Each of these attributes is composed of many components. Figure 1 graphically depicts the main components of the outsourcer's value function. Information cost concerns the cost of acquiring, processing, and using the information, while information quality is concerned with such issues as accuracy, reliability, completeness, relevance, consistency, and contextuality. Both information cost and quality are important attributes in determining the business value of investments in IS outsourcing. One objective of the IS manager is to continually improve the quality and reliability of the information that is provided to end-users. This can be done by making information more accurate, reliable, complete, precise, current, and easy to access and understand. By improving the quality of information the IS manager can improve business value by reducing the cost of operating the business.





**Figure 1. Components of the IS Outsourcing Value Function**

Timely, accurate, and relevant information can result in improved management and competitiveness (Porter and Miller 1985). For example, accurate information about inventory or production capacity can help a firm reduce capital invested in inventory and improve production planning. Furthermore, information quality and reliability can be improved to better manage relationships with customers and suppliers. Timeliness and ease of access to information also reduce the cost of conducting business activities. For example, badly designed user interfaces and difficult navigation paths around the information systems can lead to user frustration and mistakes in interpreting information. Together, improvements in information quality, reliability, timeliness, and ease of access can contribute to savings in business operations, improve management decision making and competitiveness (King et al. 1989; McFarlan 1984; Porter and Miller 1985; Sethi et al. 1993; Simmons 1996).

Information processing cost includes capital investments in infrastructure, overhead, user time, and IS personnel time. Information processing requires a complex infrastructure of computers, data storage devices, communication networks,

office space, and so on. All of these require large capital investments. Another component of information processing costs is IT personnel. Information processing departments require a wide variety of technical specialists to build, implement, and maintain information systems. Further, the labor cost of IT professionals has risen over the past 10 years due to market conditions (Gallivan 1997). A third component is the hidden costs of using information systems. According to Heikkila (1995), one of the most important costs of business operations is the time that users spend searching for and interpreting information for decision making. Poor user interface design, inefficient use processes, and the need to rely on manual backup systems increase the time users need to perform their information processing tasks and organizational decision making activities. Therefore, if the outsourcer can lower the unit cost of information processing and improve quality and reliability of the information, the greater the business value obtained. In general, the primary objectives of the IS manager considering outsourcing are to:

- reduce the labor cost of IS personnel,
- reduce user cost,
- reduce cost of IS infrastructure and capital investments, and
- improve information quality and reliability.

### **BASIC CONCEPTS OF THE MODEL**

The total cost of IS outsourcing can be broken down into

- (1) The cost of the information processing service, which can be estimated from the market.
- (2) Set-up/contracting cost, which includes search related cost to find a vendor, negotiation fees, legal fees, and other labor charges incurred to institutionalize the relationship.

- (3) The cost of monitoring and coordinating the activities of the vendor(s), which includes labor and equipment.<sup>4</sup>
- (4) Switching cost, the cost to change vendors in situations of under-performance or failure.

Let us assume that the contract under consideration is based on  $q$  units to be processed and that all contract periods are identical in a multi-period scenario. We present the analysis in two stages. In the first stage, we determine both the outsourcer's and the vendor's maximum possible profits when a fixed set of coordinating and monitoring strategies are utilized. Given that this is a single vendor situation and the outsourcer's threat to switch vendors is diminished, the vendor's maximum profit is computed with the assumption that shirking will take place. In the second stage of the analysis, we determine the outsourcer's expected profit<sup>5</sup> given the probability that the vendor will shirk. We then estimate the probability of the vendor shirking on a specified performance requirement given the price of the contract and the coordination strategy of the outsourcer. Next we outline an algorithm for computing the highest profit the outsourcer can expect to achieve under the single vendor strategy of outsourcing. We provide an example to illustrate the analysis. The following is the formal description of the model:

### ***Definition of Terms***

- **A** is the set of coordination strategies that the outsourcer is considering with the vendor;
- **g(a)** is the coordination cost to the outsourcer if coordination strategy  $a \in A$  is used.

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<sup>4</sup>This also includes the cost to set up and run an organizational unit to monitor and coordinate the interactions between the outsourcer and the vendor as described earlier.

<sup>5</sup>Although cost savings is the term of common usage, transaction cost theory uses the general term profit to describe the gains obtained by entering into a specific transaction.

- $\mathbf{E}$  is the set of monitoring strategies that the outsourcer could use with the vendor;
- $\mathbf{f}(\mathbf{e})$  is the cost to the outsourcer if monitoring strategy  $\mathbf{e} \in \mathbf{E}$  is used.
- $\mathbf{s}$  is the outsourcer's setup costs.
- $\sigma$  is a measure of the quality of the vendor's performance;
- $\mathbf{v}_o(\sigma)$  is a measure of the value to the outsourcer if the vendor's performance is  $\sigma$ ;
- $\mathbf{c}_D(\sigma, \mathbf{a})$  is the vendor's cost to maintain a performance of  $\sigma$  under coordination strategy  $\mathbf{a}$ ;
- $\mathbf{p}(\mathbf{a}, \mathbf{e})$  is the price that the outsourcer pays the vendor under coordination strategy  $\mathbf{a}$  and monitoring strategy  $\mathbf{e}$ .
- $\theta_D$  is the minimum profit rate acceptable to the vendor.
- $\phi_D$  is the relative increase in the vendor's profit.
- $\Pi_O(\sigma, \mathbf{a}, \mathbf{e}, \mathbf{p})$  is the outsourcer's profit if the vendor's performance is  $\sigma$  and price is  $\mathbf{p}$ .
- $\Pi_D(\sigma, \mathbf{a}, \mathbf{e}, \mathbf{p})$  is the vendor's profit when his performance is  $\sigma$  and price is  $\mathbf{p}$ .

### **Assumptions**

For a given coordination strategy  $\mathbf{a}$ ,  $\mathbf{v}_o(\sigma)$ , and  $\mathbf{c}_D(\sigma, \mathbf{a})$  are step functions such that:

$$\xi 1: \quad \begin{aligned} \mathbf{v}_o(\sigma) &= \mathbf{v}_k & \sigma \in [\sigma_k, \sigma_{k+1}), \quad k = 1, 2, \dots, K. \\ \mathbf{c}_D(\sigma, \mathbf{a}) &= \mathbf{c}_k & \sigma \in [\sigma_k, \sigma_{k+1}), \quad k = 1, 2, \dots, K \end{aligned}$$

where  $\mathbf{v}_k \geq \mathbf{v}_{k+1}$  and for a given coordination strategy  $\mathbf{a}$  the values  $\mathbf{v}_k$  and  $\mathbf{c}_k(\mathbf{a})$  are known constants.

Let us also assume that  $\mathbf{a}$  (coordinating costs) and  $\mathbf{e}$  (monitoring costs) are fixed. We will, therefore, temporarily drop our references to these variables. Thus the outsourcer's and vendor's profits are defined by the following relationships:

$$\xi 2: \quad \Pi_o(\sigma, p) = v_o(\sigma) - p - g - f - s.$$

$$\Pi_D(\sigma, p) = p - c_D(\sigma)$$

### Computing Outsourcer's Maximum Profit

In the single vendor situation, we need to take into account the objectives of both outsourcer and vendor. If there are no costs to switch vendors, the outsourcer can induce the vendor to provide a specified level of performance. However, the vendor can refuse or renege on the contract if it is unprofitable. Thus the maximum profit that the outsourcer can realize is subject to the vendor realizing his minimum acceptable profit rate  $\theta_D$ . The outsourcer's maximum profit can be computed as:

$$\xi 3: \quad \Pi_o(\sigma_o, p_o) = \quad \text{Max } \Pi_o(\sigma, p) = v_o(\sigma) - p - g - f - s.$$

$$\text{s.t. } \Pi_D(\sigma, p) = p - c_D(\sigma) \geq \theta_D p.$$

This may be expressed as the following mixed integer programming problem:

$$\xi 4: \quad \Pi_o(\sigma_o, p_o) = \quad \text{Max } \sum_k v_k y_k - p - g - f - s$$

$$\text{s.t.} \quad p - \sum_k c_k(a) y_k \geq \theta_D p$$

$$\sum_k y_k = 1$$

$$y_k \in \{0, 1\}$$

where  $\theta_D$  is a fixed constant; and  $p$  and the  $y_k$ 's are the variables.

The solution to this problem will provide the optimum price  $p_o$  that the outsourcer should pay the vendor and the corresponding maximum profit  $\Pi(\sigma, \mathbf{a}, \mathbf{e}, \mathbf{p})$  and performance level  $\sigma_o$  that the outsourcer will receive. Let  $\mathbf{v}_o$  and  $\mathbf{c}_o$  be the value and cost associated with the optimal solution of this problem. Then given that  $\mathbf{g}$ ,  $\mathbf{f}$ , and  $\mathbf{s}$  are fixed, it follows that:

$$\xi 5: \quad (v_o - p_o) = \quad \text{Max } \{ (v_k - p_o) : k = 1, 2, \dots, K \}$$

where  $p_o \geq c_o / (1 - \theta_D)$ . It follows that  $p_o = c_o / (1 - \theta_D)$ , and so

$$(v_o - p_o) = \text{Max } \{ (v_k - c_k(a) / (1 - \theta_D)) : k = 1, 2, \dots, K \}.$$

Thus it is not necessary to explicitly solve the mixed integer programming problem.

### Computing Vendor's Maximum Profit

If the outsourcer has made specific investments (set-up costs) in a single vendor relationship and faces switching cost, the vendor is free to provide a level of performance that maximizes profits without fear that the outsourcer will switch. Now if the price is fixed at the outsourcer's optimum  $p_o$ , then given the setup cost  $s$ , the optimal profit that the vendor can realize without causing the outsourcer to switch to another vendor is given by the solution of the following problem:

$$\xi 6: \quad \Pi_D(\sigma_D, p_o) = \text{Max } \Pi(\sigma, p_o) = p_o - c_D(\sigma)$$

$$\text{s.t.} \quad \Pi_o(\sigma_o, p_o) - \Pi_o(\sigma, p_o) \leq s.$$

This may be expressed as the following mixed integer programming problem:

$$\xi 7: \quad \Pi_D(\sigma_D, p_o) = \text{Max } p_o - \sum_k c_k(a)y_k$$

$$\text{s.t.} \quad v_o - \sum_k v_k y_k \leq s$$

$$\sum y_k = 1$$

$$y_k \in \{0, 1\}$$

It should be noted that the optimal solution for this problem is associated with the index  $D$  where  $c_D = \text{Min } \{c_k : v_o - v_k \leq s; k > 0\}$ . Thus  $(v_o - v_D)$  is the potential shirking cost if the outsourcer pays the vendor  $p_o$  but the vendor performs at level  $\sigma_D$ . The vendor's profit in this case is  $\Pi_D(\sigma_D, p_o) = (p_o - c_D)$ , the increase being  $(c_o - c_D)$ .

### Computing Outsourcer's Expected Profit

In the single vendor situation, the presence of switching costs allows the vendor some degree of shirking. The total cost to the outsourcer includes set-up costs, shirking costs, and expenditures for monitoring and coordination. Therefore, the outsourcer's profit is affected to the degree that the vendor is able to determine level of performance. Thus, in seeking to maximize the outsourcer's expected profit we must take into account the vendor's choice. The outsourcer's expected profit under shirking can be modeled and analyzed as follows: let  $h_o$  be the probability

that the vendor will shirk given the contract requirement for performance level  $\sigma_o$  and price  $p_o$  and coordination strategy  $\mathbf{a}$ . The outsourcer's expected profit may thus be expressed as:

$$\xi 8: \quad E[\Pi_o(\sigma_o, p_o)] = (1 - h_o) \Pi_o(\sigma_o, p_o) + h_o \Pi_o(\sigma_D, p_o)$$

$$E[\Pi_o(\sigma_o, p_o)] = \Pi_o(\sigma_o, p_o) - h_o (v_o - v_D)$$

**Definition**

A coordination strategy  $a_{i2}$  is superior to  $a_{i1}$  iff:

$$\text{Max } E[\Pi_o(\sigma_k, p_k, a_{i2})] > \text{Max } E[\Pi_o(\sigma_k, p_k, a_{i1})]$$

**Remark 1**

If  $(c_o - c_D) < h_o (v_o - v_D)$ , then an incentive policy that pays the vendor  $(c_o - c_D)$  if the performance level is  $\sigma_o$  is superior to a policy that is based on taking the risk that the vendor will not shirk.

**Analyzing Incentive Schemes**

So far, our discussion has assumed that vendor shirking is possible and likely. We now turn our attention to an analysis of the incentive schemes and contracts that can make shirking unattractive to the vendor. Our approach to structuring these incentive contracts involves specifying penalty and reward components. The vendor is penalized for performing below the agreed-upon performance level and is rewarded for performing at or above the agreed upon performance level. Below we describe two such incentive contracts, fixed price (FPIC) and variable price (VPIC).

**Preliminary Assumptions**

Let  $\theta_D$  be the minimum profit rate acceptable to the vendor and let  $\theta_T$  be the minimum profit rate acceptable to the outsourcer. Given setup costs  $s$ , then

associated with each performance level  $k$  is an associated vendor shirking level  $k_d$  such that  $k_d = \text{Max} \{k_r: v_k - v_{k_r} \leq s; k < k_r\}$ .

### **Case 1: Fixed Price Incentive Contracts**

If in a fixed price contract the cost  $c_k$  for performing at level  $k$  is constant, but the vendor actually performs at level  $k_d$ , then in the absence of any penalty the vendor increases his profit by  $(c_k - c_{k_d})$ . This under-performance results in a corresponding decrease in outsourcer's profit by  $(v_k - v_{k_d})$ . If the vendor was paid  $p_k = c_k/(1 - \theta_D)$  for performing at level  $k$ , then the relative increase in the vendor's profit is  $\phi = (1 - \theta_D)(c_k - c_{k_d})/p_k = (c_k - c_{k_d})/c_k$ . In such a situation, the outsourcer can follow one of two incentive schemes to induce the vendor to perform as agreed in the contract. This approach requires that the outsourcer conduct a performance audit. In each of these incentive schemes, we define a penalty component and an incentive component to ensure that there is a cost to the vendor for under-performing and a profit motive for performing to the contract.

#### *Incentive Scheme 1:*

##### The Penalty Component

If the post-contract audit exposes that the vendor actually performed at level  $k_d$ , then the vendor would pay the outsourcer the amount of  $(v_k - v_{k_d})$ . This incentive scheme involves a carrot and stick approach.

##### Incentive Component

Let  $\tau_{NO}$ ,  $\tau_{YES}$  (such that  $0 \leq \tau_{NO} < \tau_{YES}$ ) be threshold parameters such that the vendor will definitely shirk if  $\phi > \tau_{YES}$ , will definitely not shirk if  $\phi < \tau_{NO}$ , and may or may not shirk if  $\tau_{NO} \leq \phi \leq \tau_{YES}$ . Given that the outsourcer desires that the performance level be  $k$ , an incentive contract would involve paying the vendor  $p_k$  for performing at level  $k$ . If  $\phi > \tau_{YES}$ , then the vendor would be paid an additional



incentive amount of  $(c_k - c_{kd})$  if the post-contract audit confirms that the vendor performs at level k. If condition  $\tau_{NO} \leq \phi \leq \tau_{YES}$  holds, then the vendor would be paid an additional incentive amount of  $(c_k - c_{kd})\phi/(\tau_{YES} - \tau_{NO})$  if the post-contract audit confirms that the vendor performs at level k.

### *Incentive Scheme 2*

#### Penalty Component of Incentive Contract

If the contract requires the vendor to perform at level k, then a penalty of  $(v_k - v_{kd})$  is charged to the vendor if performance is below level k. This amount would partially compensate the outsourcer for the decrease in his profit that would result from shirking.

#### Reward Component of Incentive Contract

If the contract requires the vendor to perform at level k, then payment to the vendor is in two portions:  $p_{kA}$ , which occurs before completion of the contract, and  $p_{kB}$ , which occurs after a performance level audit has been done on completion of the contract. Here  $p_{kA} = \text{Max}\{c_{kE}, p_{kd}\}$  and  $p_{kB} = (p_k - p_{kA})(1+r)$  if the vendor actually performs at level k and  $p_{kB} = 0$  if the vendor does not actually perform at level k. The initial amount  $p_{kA}$  is chosen to be the maximum of the actual project cost and the payment that the vendor would receive for performing at the corresponding shirking level kd. The amount  $(p_k - p_{kA})(1+r)$  represents the future value of the amount  $(p_k - p_{kA})$ , where 100% is the relevant risk-free interest rate. This amounts to placing the sum  $(p_k - p_{kA})$  in an escrow account at the beginning of the contract.

#### Observation

The expected profit of Incentive Scheme 1 to the outsourcer is never greater than the expected profit of Incentive Scheme 2.

## Justification

If the vendor shirks under Incentive Scheme 1, the outsourcer would have paid the entire amount  $p_k = c_{kE}/(1 - \theta_D)$ , while under Incentive Scheme 2 the outsourcer would have paid the amount  $p_{kA} = \text{Max}\{c_{kE}, p_{kd}\} < p_k$ . In both cases, the penalty to the vendor is the same.

If the vendor does not shirk then under Incentive Scheme 1, the outsourcer pays no less than  $p_k = c_{kE}/(1 - \theta_D)$ , while under Incentive Scheme 2 the outsourcer pays exactly  $p_k$ .

### **Case 2: Variable Price Incentive Contracts**

In this case, although the vendor will still attempt to perform at the lowest possible cost for a given performance level, there is still uncertainty about the actual project cost. Let  $c_k$ , the cost associated with level  $k$ , be a random variable that follows a triangular distribution with parameters  $c_{kL}$ ,  $c_{kM}$ ,  $c_{kU}$  such that  $\text{Min}(c_k) = c_{kL} \leq c_{kM} \leq c_{kU} = \text{Max}(c_k)$  and  $c_{kM}$  is associated with the highest point on the probability density function of  $c_k$ . Let  $c_{kE}$  be the expected value of  $c_k$ , then  $c_{kE} = (c_{kL} + c_{kM} + c_{kU})/3$ . If  $c_{kL} = c_{kU}$ , then  $c_k$  is a constant. We assume that  $(v_k - v_{k+1}) > (c_{kE} - c_{(k+1)E})$  for relevant  $k$ , although it is possible that  $(v_k - v_{k+1}) \leq (c_{kU} - c_{(k+1)L})$ .

Since we assume that for each performance level, cost follows a triangular distribution with parameters  $c_{kL}$ ,  $c_{kM}$ ,  $c_{kU}$  then the relevant probability density functions  $t_k(c_k)$  and probability functions  $T_k(c_k)$  are defined as follows:

$$\begin{aligned} t_k(c_k) &= 2(c_k - c_{kL})/(c_{kM} - c_{kL})(c_{kU} - c_{kL}) & \text{if} & \quad c_{kL} \leq c_k \leq c_{kM} \\ t_k(c_k) &= 2(c_{kU} - c_k)/(c_{kU} - c_{kM})(c_{kU} - c_{kL}) & \text{if} & \quad c_{kM} \leq c_k \leq c_{kU} \\ T_k(c_k) &= (c_k - c_{kL})^2/(c_{kM} - c_{kL})(c_{kU} - c_{kL}) & \text{if} & \quad c_{kL} \leq c_k \leq c_{kM} \\ T_k(c_k) &= 1 - (c_{kU} - c_k)^2/(c_{kU} - c_{kM})(c_{kU} - c_{kL}) & \text{if} & \quad c_{kM} \leq c_k \leq c_{kU} \end{aligned}$$

For our contract, we will initially assume that the vendor will be paid the amount of  $p_k = c_{kE}/(1 - \theta)$  in order to perform at level  $k$ . In this case, the vendor will make a profit if  $(p_k - c_k) > 0$ , although there is uncertainty about the value of  $c_k$ . Thus there is no guarantee that the vendor will actually have a profit. Now while a penalty

cost may force the vendor to perform at the agreed-upon level if the contract is accepted, a penalty cost cannot induce the vendor to accept certain contractual terms. The vendor, like the outsourcer, is motivated by profit; thus, if the penalty is certain, the likelihood of profit should be viewed by the vendor as being relatively high.

### *Penalty Component of Incentive Contract*

In the event of cost uncertainty, can a contract force the vendor to perform at the contracted performance level? One notes that even if the vendor was charged a penalty of  $(v_k - v_{kd})$  if the vendor fails to perform at level  $k$ , it may still be possible that  $(c_k - c_{kd}) > (v_k - v_{kd})$ , and so the vendor could still earn a profit after paying the penalty. Thus a risk-taking vendor might still shirk if  $\text{Prob}[(c_k - c_{kd}) > (v_k - v_{kd})] > 0$ . Given that  $c_k \in [c_{kL}, c_{kU}]$  and  $c_{kd} \in [c_{kdL}, c_{kdU}]$ , it follows that  $(c_k - c_{kd}) \leq (c_{kU} - c_{kdL})$ . Thus  $\text{Prob}[(c_k - c_{kd}) > (c_{kU} - c_{kdL})] = 0$ . The penalty amount that would make shirking unattractive to the vendor while still meeting any decrease in outsourcer profit were the vendor to shirk anyway is  $\text{Max}\{(v_k - v_{kd}), (c_{kU} - c_{kdL})\}$ .

### *Reward Component of Incentive Contract*

Despite the uncertainty in costs, the vendor would still like to have a good profit. While it may not be in the best interest of the outsourcer to guarantee the vendor a profit for every possible cost, the outsourcer should be able to offer the vendor a reasonably high probability of profit. Let  $\gamma$  be the minimum probability that the vendor might find acceptable. Then we would require that  $\text{Prob}[c_k \leq p_k = c_{kE}/(1 - \theta_D)] \geq \gamma$ . If  $\gamma$  is fixed, then the value of  $\theta_D$  that would guarantee this probability could be derived using the probability distribution function  $T_k(c_k)$ .

$$\text{Prob}[c_k \leq p_k = c_{kE}/(1 - \theta_D)] = T(c_{kE}/(1 - \theta_D))$$

$$\text{Prob}[c_k \leq p_k = c_{kE}/(1 - \theta_D)] = 1 - (c_{kU} - c_{kE} / (1 - \theta_D))^2 / (c_{kU} - c_{kM})(c_{kU} - c_{kL}) \geq \gamma$$

Alternatively, one could determine the corresponding probability of the vendor making a profit that corresponds to various values of  $\theta_D$ . Obviously this probability increases as  $\theta_D$  increases, but it also results in a decrease in the outsourcer's profit rate. The outsourcer thus has to trade off his desire to provide a high probability of profit to the prospective vendor while still maintaining his own minimum profit rate.

The outsourcer's actual profit rate for level k is  $(v_k - c_{kE}/(1 - \theta_D))/v_k$ . If the outsourcer's minimum acceptable profit rate is  $\theta_T$ , then we have:

$$(v_k - c_{kE}/(1 - \theta_T))/v_k \geq \theta_D \Rightarrow \theta_D \leq 1 - c_{kE}/(v_k(1 - \theta_T)).$$

However, since the maximum value  $c_{kE}/(1 - \theta_D)$  is  $c_{kU}$ , then we also have the relation:

$$c_{kE}/(1 - \theta_D) \leq c_{kU} \Rightarrow \theta_D \leq 1 - c_{kE}/c_{kU}.$$

And  $\theta_D \leq \text{Min}\{1 - c_{kE}/(v_k(1 - \theta_T)), 1 - c_{kE}/c_{kU}\}$

Since the outsourcer's maximum possible profit rate occurs when the vendor has no profit, then

$$\theta_T \leq (v_k - c_{kE})/v_k$$

Thus by setting  $\theta_D = \text{Min}\{1 - c_{kE}/(v_k(1 - \theta_T)), 1 - c_{kE}/c_{kU}\}$  and varying the values of  $\theta_T$ , we can compute the corresponding probabilities of the vendor making a profit as well as the corresponding expected vendor profit (i.e.,  $\theta_D c_{kE}/(1 - \theta_D)$ ) and outsourcer profit.

Up to this point we have assumed that the payment that the outsourcer makes to the vendor is fixed. But let  $\theta_D$  be the minimum acceptable profit rate for the vendor and let  $\theta_{D\gamma}$  be the profit rate that will result in a  $\gamma$  probability of the vendor making a profit. We assume that  $\theta_{D\gamma} \geq \theta_D$ . Associated with these profit rates are amount  $p_{kE} = c_{kE}/(1 - \theta_D)$  and  $p_{k\gamma} = c_{kE}/(1 - \theta_{D\gamma})$ . If the vendor is paid  $p_{k\gamma}$  by the outsourcer, then the probability of the vendor making a profit is  $\gamma$ . However, if the vendor is paid according to the following rule

$$p_k = p_{kE} \quad \text{if} \quad c_k \leq c_{kE}$$

$$p_k = \text{Min}\{c_k + \theta_D p_{kE}, p_{k\gamma}\} \quad \text{if} \quad c_{kE} < c_k < p_{k\gamma}$$

$$p_k = p_{k\gamma} \quad \text{if} \quad c_k \geq p_{k\gamma}$$

then the probability of the vendor realizing a profit is still  $\gamma$  but the cost to the outsourcer could be as low as  $p_{kE}$ , and as high as  $p_{k\gamma}$ . In fact the expected cost to the outsourcer is less than  $p_{k\gamma}$ . Under this rule the vendor earns the highest profit when  $c_k \leq c_{kE}$ , with the minimum acceptable profit rate only guaranteed for  $c_k \leq c_{kE}$ , even though the same absolute profit amount could be earned for some higher cost values also. The vendor thus has an incentive to keep costs as low as possible. Under our decision rule the vendor would again be paid in two parts  $p_{kA} = p_{kE}$ , and  $p_{kB} = p_k - p_{kA}$ , with  $p_{kA}$  being paid during the contract and  $p_{kB}$  being paid after the actual cost has been determined.

Under this contractual scheme, the expected cost to the outsourcer  $E(p_k)$  is as follows:

$$E(p_k) = p_{kE}T(c_{kE}) + \text{Min}\{((c_{kU}p_{k\gamma}^2 - c_{kU}c_{kE}^2) - 2/3(p_{k\gamma}^3 - c_{kE}^3))/(c_{kU} - c_{kM})(c_{kU} - c_{kL}) + \theta_D p_{kE}(\gamma - T(c_{kE})), p_{k\gamma}(\gamma - T(c_{kE}))\} + p_{k\gamma}(1 - \gamma)$$

and the outsourcer's expected profit for performance level k is:

$$E(\Pi_{kO}) = v_k - E(p_k) - s - (g + f)$$

Similarly, the vendor's expected profit for performance level k is:

$$E(\Pi_{kD}) = E(p_k) - E(c_k)$$

Given a minimum vendor rate of profit  $\theta_D$ , and a desired probability of profitability  $\gamma$ , the outsourcer would determine which performance level results in the highest value of  $E(\Pi_k)$ .

## VI. PROCEDURE AND CASE ILLUSTRATION

We will now present a two-phase process for implementing and using the approach and models outlined above. Phase 1 is concerned with the business value analysis. Phase 2 is concerned with analyzing the outsourcing situation, determining the incentive scheme, and trade-off analysis. We outline the procedures for each

phase of the analysis and present a case illustration to clarify specific issues for the reader.

## **PHASE 1: BUSINESS VALUE ANALYSIS**

The approach to defining the business value of IS outsourcing follows from our discussion in section II. Here the manager is concerned with determining the levels of performance that will be expected of the vendor, the value of each performance level to the outsourcer, and the cost of each performance. The procedure for determining these is as follows:

### **Step 1.1: Define Performance Levels**

- (a) Define the highest and lowest performance levels for the relevant IS function that is to be outsourced. These definitions are from the perspective of the outsourcer. Factors relevant to the definition of these levels include the components of information quality (e.g., response time, accuracy of data, ease of access, reliability) and end-user information processing costs. For the numeric factors, it is likely that interval estimates rather than point estimates will be used. For example, the response time of the highest level may be defined as less than 30 seconds, while the response time of the lowest performance level may be defined as greater than three minutes.
- (b) Define intermediate performance levels using the same factors as in 1.1(a). These intermediate performance levels could be defined using any degree of granularity that the outsourcer deems to be appropriate.

### **Step 1.2: Estimate the Value of Each Performance Level**

- (a) Estimate the value of the highest and lowest performance levels. The estimated values are the associated business benefits that result from the corresponding information quality.
- (b) Estimate the value of the intermediate performance levels.



### **Step 1.3: Estimate the Cost of Each Performance Level**

For each performance level, estimate the highest, lowest, and most likely cost. This is similar to the approach used in PERT for eliciting the time of each activity. Some of the information relevant to the determination of these estimates could be obtained from the bids of various vendors. The outsourcer could present various performance level scenarios to prospective vendors and request estimates of corresponding costs, as well as the additional vendor activities and IT resources that would be needed to make the transition between different performance levels.

## **PHASE 2: OUTSOURCING OPTIONS ANALYSIS**

In this phase, we demonstrate the main aspects of the outsourcing analysis. This outsourcing analysis is conducted for two scenarios: (1) a fixed price incentive contract, where the costs of information processing are certain, and (2) a variable priced incentive contract, where the information processing costs are uncertain. The procedure for implementing this phase is outlined below.

### **Step 2.1: Specify Vendor Profit Rate**

The outsourcer specifies a value for the vendor's profit rate  $\theta_D$  that s/he believes would be acceptable to the vendor.

### **Step 2.2: Generate Expected Profit Values**

For each performance level, values for the outsourcer's expected profit and the vendor's expected profit are automatically generated for various situations (e.g., Table 2 below with certain cost, Figures 4 and 5 below with uncertain cost).

### **Step 2.3: Trade-Off Analysis**

Using the data generated in step 2.3, the outsourcer conducts a tradeoff analysis to determine the performance level and vendor probability of profitability that would be the most advantageous to the outsourcer and still sufficiently attractive



to the vendor. The outsourcer may choose to do a focussed trade-off analysis for a subset of the data and may choose to have this data displayed in a tabular form (e.g., Table 4 below). At the end of this step, the outsourcer would have made at least a tentative decision on the desired performance level, as well as vendor probability of profitability for the scenario when vendor cost is uncertain.

#### **Step 2.4: Specify Incentive Contract**

The reward component, penalty component, and payment rules of the incentive contract would be automatically generated based on the choice of outsourcer in step 2.3.

It should be noted that steps 2.1 through 2.4 could be repeated for different values of the vendor profit rate. Steps 2.3 through 2.4 also could be repeated multiple times for the same value of the vendor profit rate.

#### ***The Case Examples***

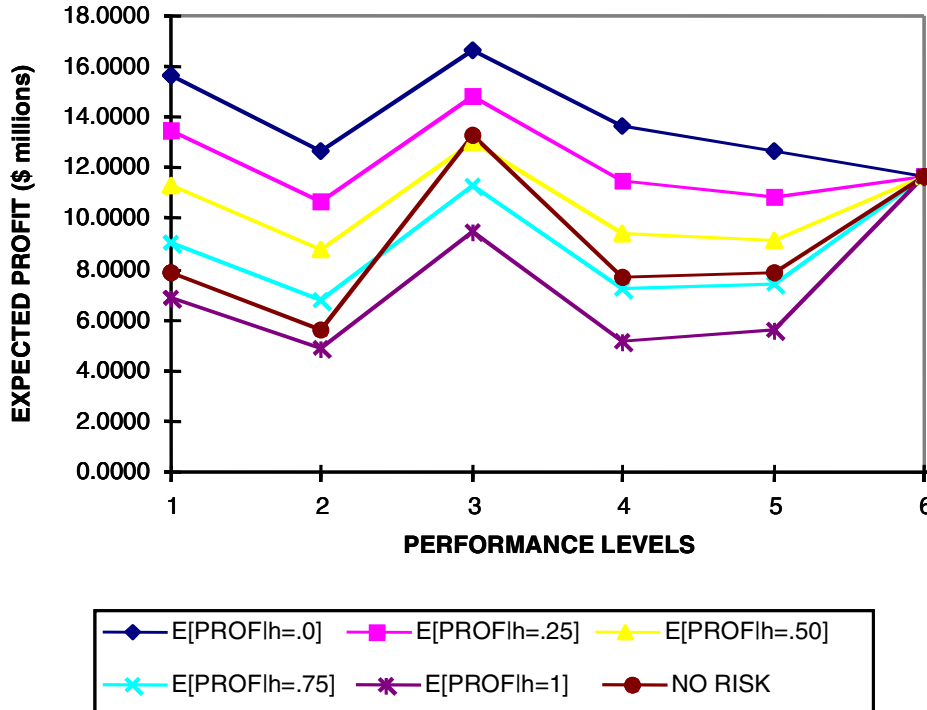
After years of dissatisfaction with poor returns on its expenditure for information processing, the management of MSM Corp. has concluded that it should consider outsourcing most of these activities to an information processing services vendor. Janet, the CEO of MSM, has instructed Joe, the MIS manager, to conduct an analysis for the performance requirements, and determine an incentive scheme as the basis for an indefinite multi-period outsourcing contract with a single vendor. Specifically, Janet is interested in determining answers to the following questions: What profit (cost savings) can be expected by outsourcing the information processing activities? What price should be offered the vendor? What is the probability that the vendor will shirk, and how would vendor shirking affect her profit? What type of incentive scheme can be defined to induce the vendor to maintain a performance level that is optimum for MSM business operations? After preliminary discussions with IPS Corp., a reputable outsourcing vendor, Joe has a letter of intent from IPS that they would consider a fixed or variable price incentive contract

at a 20% profit margin ( $\theta_D = 0.20$ ). Joe has determined that the basic cost to establish the relationship,  $\mathbf{s}$ , which includes legal fees, contracting, setup costs etc., would be around \$1,464,844.00 and monitoring and coordination cost ( $\mathbf{g} + \mathbf{f}$ ) for each contract period would be in the area of \$234,375.00. However, he has decided to conduct a careful analysis to determine the effects of various levels of vendor performance and their financial implications in order to specify appropriate incentive schemes for both fixed and variable price contracts. Because of the nature of its business, one of the primary performance requirements of MSM is simultaneous reliable database access by 500 users, low response times (15 to 40 seconds) for their transaction processing, and minimum service disruptions. In keeping with these and other criteria, Joe has defined six levels of performance ( $\mathbf{K} = 6$ ): the most desirable performance in which all the criteria are met to the least desirable in which few of the criteria are met. He is certain of the costs  $\mathbf{c}_k$  of information processing and is able to estimate values  $\mathbf{v}_k$  and  $\mathbf{p}_k$  the gross payments for each of the  $\mathbf{k}$  performance levels that IPS delivers (see Table 1). These data will be used later to compute the expected profit that MSM can expect and the incentives it might be willing to pay for a given level of performance.

**Table 1. Costs, Values and Gross Payment for Various Levels of Performance**

<b>Performance Level k</b>	<b>Value <math>\mathbf{v}_k</math></b>	<b>Vendor Cost <math>\mathbf{c}_k</math></b>	<b>Vendor Price <math>\mathbf{p}_k</math></b>	<b>Shirking Level k</b>
1	8,570,278.00	4,108,797.00	5,135,996.25	3
2	7,685,678.00	3,697,917.00	4,622,396.25	4
3	7,713,438.00	3,328,125.00	4,160,156.25	4
4	6,995,423.00	2,995,313.00	3,744,141.25	5
5	5,958,595.00	2,396,250.00	2,995,312.50	6
6	5,259,352.00	1,917,000.00	2,396,250.00	6

On analyzing the data in Table 1, Joe has determined that the best possible profit that MSM can achieve from outsourcing its information processing to IPS is  $\Pi_o(\sigma_3, p_3) = \$7,713,438.00 - \$4,160,156.25 - \$1,464,844.00 - \$234,375.00 = 1,854,062.75$ . This return assumes that IPS does not shirk on performance of the contract and receives a price,  $P_3$ , of \$4,160,156.25, from which IPS yields a profit,  $\Pi_D(\sigma_3, p_3)$ , of \$832,031.30. However, since this is a single vendor situation and there is no credible threat that MSM can conveniently switch to another vendor or take its processing back in-house, we know that IPS can increase its profit by shirking. Thus Joe must now determine the impact of any IPS shirking on MSM profit. Upon further analysis, he finds that by shirking IPS can make a profit,  $\Pi_D(\sigma_4, p_3)$ , of  $(p_3 - c_4) = \$1,164,843.25$ . All else being equal MSM's profit will drop to  $\Pi_o(\sigma_4, p_3)$ , which is \$1,136,047.75. Thus the net increase in IPS's profit is  $(c_3 - c_4) = (\$3,328,117.00 - \$2,995,313.00) = \$332,812.00$ , and the net decrease in MSM's profit is  $(v_3 - v_4) = (\$7,713,438.00 - \$6,995,423.00) = \$718,015.00$ . Joe now computes that MSM's expected profit at performance level  $\sigma_3$  is  $E[\Pi_o(\sigma_3, p_3)] = 16640630 - h(7523438 - 6807423)$ . But what is the likelihood that IPS will shirk? Figure 2 graphically illustrates IPS's potential for increasing its profit under various probabilities of shirking.



**Figure 2. MSM's Expected Profit for Various Levels Performance by IPS**

Now that it is clear that IPS is likely to shirk, the question that Joe must answer is how to construct an appropriate incentive scheme that would induce IPS to deliver the optimum performance required by MSM. In the simplest form the incentive scheme could be (as described in Case 1, Incentive Scheme 1) to conduct a post audit. If it is found that IPS has performed at the level  $k_d$  instead of  $k$ , then IPS would be required to pay MSM the sum  $(v_k - v_{k_d})$ , which is the decrease in MSM's profit due to the underperformance. However, Joe thinks it will be difficult to recoup any losses from IPS, and he decides on a "carrot and stick" strategy. Consequently, he structures a payment scheme, which includes pre-audit and post-audit payments, and a penalty for underperformance. Using the techniques described in Case 1, Incentive Scheme 2, Joe computes the pre-audit, post-audit payments and the financial implications for MSM and IPS, for each performance level with and without shirking (see Table 2). For example, we can see from Table 2 that MSM agrees to pay IPS \$4,160,156.25,  $(p_{kA})$ , for a level 1 performance and an

additional amount of \$975,840.00, ( $p_{kB}$ ), if an audit ascertains that IPS did perform as per the contract. But if IPS shirks and does not deliver the agreed upon performance, MSM deducts a penalty ( $p_{kB}$ ) from the post-audit payment. In the case where IPS performs at level 3 instead of level 1, MSM assesses a penalty of \$856,840 and, therefore, pays IPS a post-audit payment of only \$119,000.00, which results in a deduction in IPS's profit.

A fundamental question for Joe is: Would IPS consider entering such a contract with an incentive scheme? Table 2 shows the amount of profit that IPS can make by delivering various levels of performance for a given vendor profit rate. In this case, it is the vendor profit rate that would provide a motivation for IPS to enter into such a contract. Joe would, therefore, need to evaluate the effects of various vendor profit rates on both IPS's profit and MSM's profit.

### **WHEN INFORMATION PROCESSING COSTS ARE UNCERTAIN**

Now the previous analysis assumed a fixed price incentive contract and that the costs of information processing were certain. However, Joe has decided to extend his analysis to include the condition of cost uncertainty. He has decided that a variable priced incentive might be appropriate if IPS cannot precisely determine the cost of the information processing activities. Using the estimates from Table 1, Joe begins his analysis by estimating a range of costs for each level of performance in which he is interested. As described above in Case 2: Variable Price Incentive Controls, Joe assumes that the cost of processing  $c_k$ , associated with each level of performance  $k$ , is a random variable that follows a triangular distribution with parameters  $c_{kL}$ ,  $c_{kM}$ , and  $c_{kU}$ . He also assumes that the ranges follow the form  $\text{Min}(c_k) = c_{kL} \leq c_{kM} \leq c_{kU} = \text{Max}(c_k)$ ; and that  $c_{kE}$ , the expected value of  $c_k$ , is equal to  $(c_{kL} + c_{kM} + c_{kU})/3$ . Based on these assumptions, Joe generates the range of costs for each level of performance (see Table 3). The question then is, given these ranges for the cost of processing, what payment and incentive scheme is appropriate?

**Table 2. Financial Implications of Various Levels of Under-Performance**

Performance Level		Payment		Outsourcer's Profit		Vendor's Profit		Penalty
Contracted	Shirking	P <sub>kA</sub>	P <sub>kB</sub>	With Shirking	Without Shirking	With Shirking	Without Shirking	
1	3	4,160,156.25	975,840.00	<b>3,567,742.75</b>	1,735,062.75	-24,808.75	<b>1,027,199.25</b>	856,840.00
2	4	3,744,141.25	878,255.00	2,932,572.75	1,364,062.75	58,573.25	924,479.25	690,255.00
3	4	3,744,141.25	416,015.00	2,988,092.75	<b>1,854,062.75</b>	30,813.25	832,031.25	718,015.00
4	5	2,995,313.00	748,828.25	3,337,719.00	1,552,062.75	-437,765.00	748,828.25	1,036,828.00
5	6	2,396,250.00	599,062.50	2,562,369.00	1,264,063.50	-219,993.00	599,062.50	699,243.00
6	6	2,396,250.00	0.00	1,163,883.00	1,163,883.00	<b>479,250.00</b>	479,250.00	0.00

**Table 3. Ranges of Cost for Each Performance Level**

Performance Level k	$v_k$	$c_{kL}$	$c_{kM}$	$c_{kU}$	$c_{kE}$
1	8,570,278.00	2,732,350.01	3,903,357.15	5,690,683.85	4,108,797.00
2	7,685,678.00	2,662,500.24	3,328,125.30	5,103,125.46	3,697,917.00
3	7,713,438.00	2,687,460.94	3,161,718.75	4,135,195.31	3,328,125.00
4	6,995,423.00	2,036,812.84	2,396,250.40	4,552,875.76	2,995,313.00
5	5,958,595.00	1,725,300.00	2,156,625.00	3,306,825.00	2,396,250.00
6	5,259,352.00	1,380,240.00	1,725,300.00	2,645,460.00	1,917,000.00

As we have shown above in Case 2, there is no guarantee that the vendor can make a profit when the cost of information processing is uncertain. Further, while a penalty for shirking may induce the vendor to perform at the agreed upon level when costs are fixed and known, it cannot induce the vendor to accept (or continue with) an unprofitable contract. Thus the question becomes, what incentive can the vendor be given to enter into a VPI contract and perform at the expected level? It follows then that the outsourcer must at least guarantee the vendor a high probability of making an acceptable profit on the contract. It is not in MSM's best interest to guarantee the vendor a profit for the entire range of information processing cost. Therefore, Joe is interested in determining the minimum probability ( $\gamma$ ) of profit that the IPS might find acceptable. From Case 2 above, Joe uses the following relationships for this analysis:

$$\theta_D = \text{Min}\{1 - c_{kE}/(v_k(1 - \theta_T)), 1 - c_{kE}/c_{kU}\}$$

$$\text{Prob}[c_k \leq p_k = c_{kE}/(1 - \theta_D)] = 1 - (c_{kU} - c_{kE})^2 / ((1 - \theta_D)(c_{kU} - c_{kM})(c_{kU} - c_{kL})) > \gamma$$

Figure 3 shows the probability of IPS making a profit for some possible profit rates of MSM. It is clear from this graph that IPS can make an acceptable profit.

As can be seen from Figure 3, as IPS's probability of profitability increases, there is a decrease in the MSM's profit rate. Figure 4 displays, for each performance level, IPS's probability of profitability and the corresponding expected profit to MSM. On the other side of the coin, Figure 5 displays IPS's probability of profitability and the corresponding expected profit. Now in defining the terms of the contract, Joe

must trade off MSM's desire for a high return and IPS's interest in making an acceptable profit.

### What Should the Vendor Be Paid?

The final questions that Joe must now answer are:

- (1) What level of profit can IPS expect?
- (2) What is the level of certainty that IPS can make that profit?
- (3) What incentive would IPS have to perform at a specified level?

So far we have assumed that the payment that MSM makes to IPS is fixed. Since, in this case, information processing costs are uncertain, Joe can only fix the profit rate ( $\theta_D$ ) that IPS will receive. He has decided to guarantee IPS a minimum profit rate of 5%. Using the equation  $E(\Pi_{kD}) = E(p_k) - E(c_k)$  discussed in Case 2 above, Joe computes IPS's expected profit for various levels of certainty, and for every level of performance. Figure 5 shows the results.

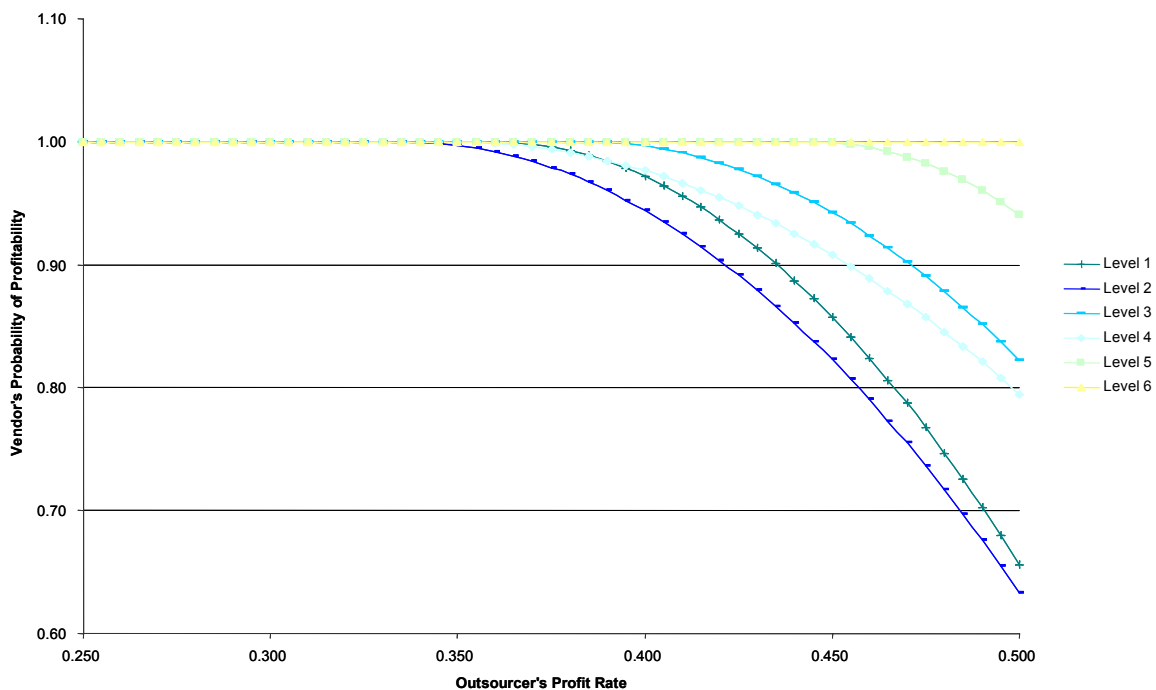
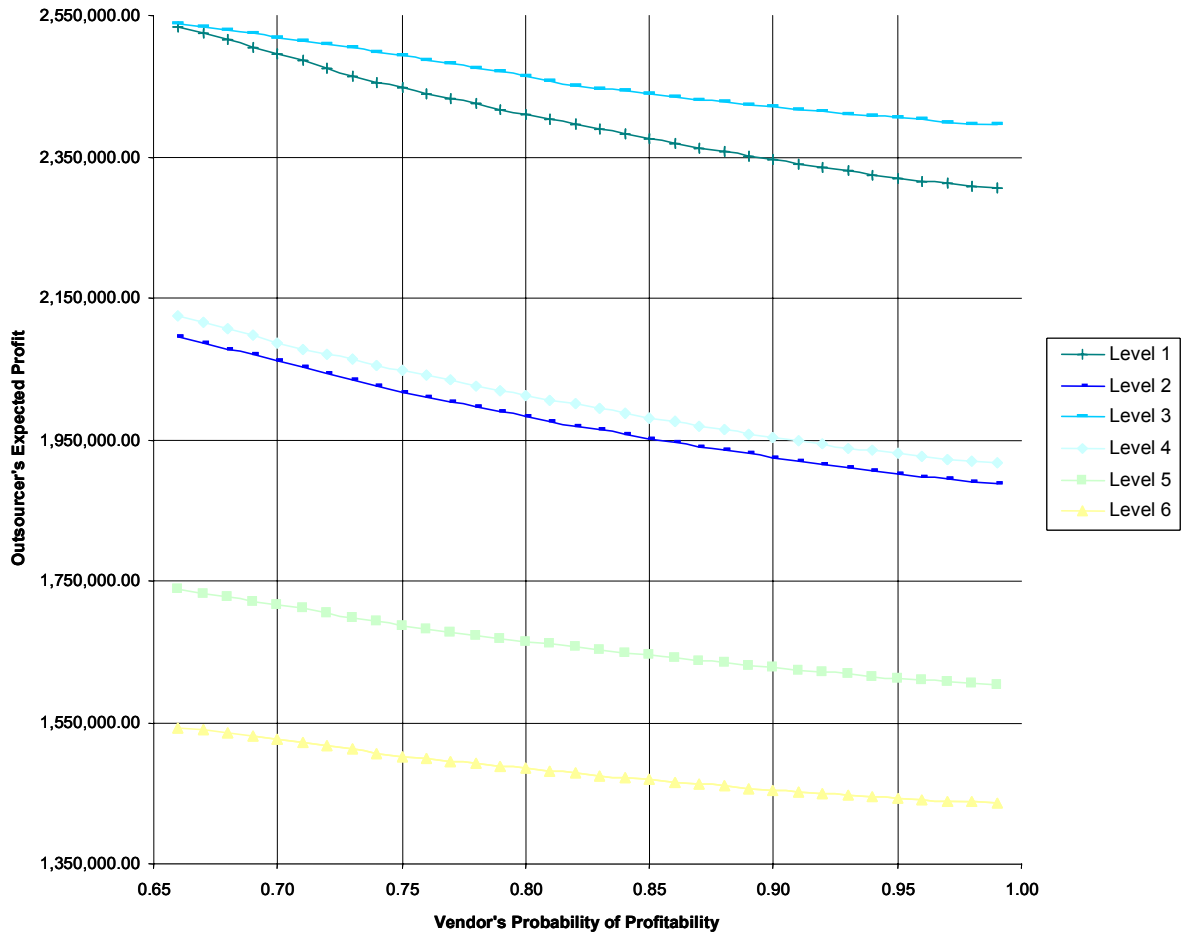
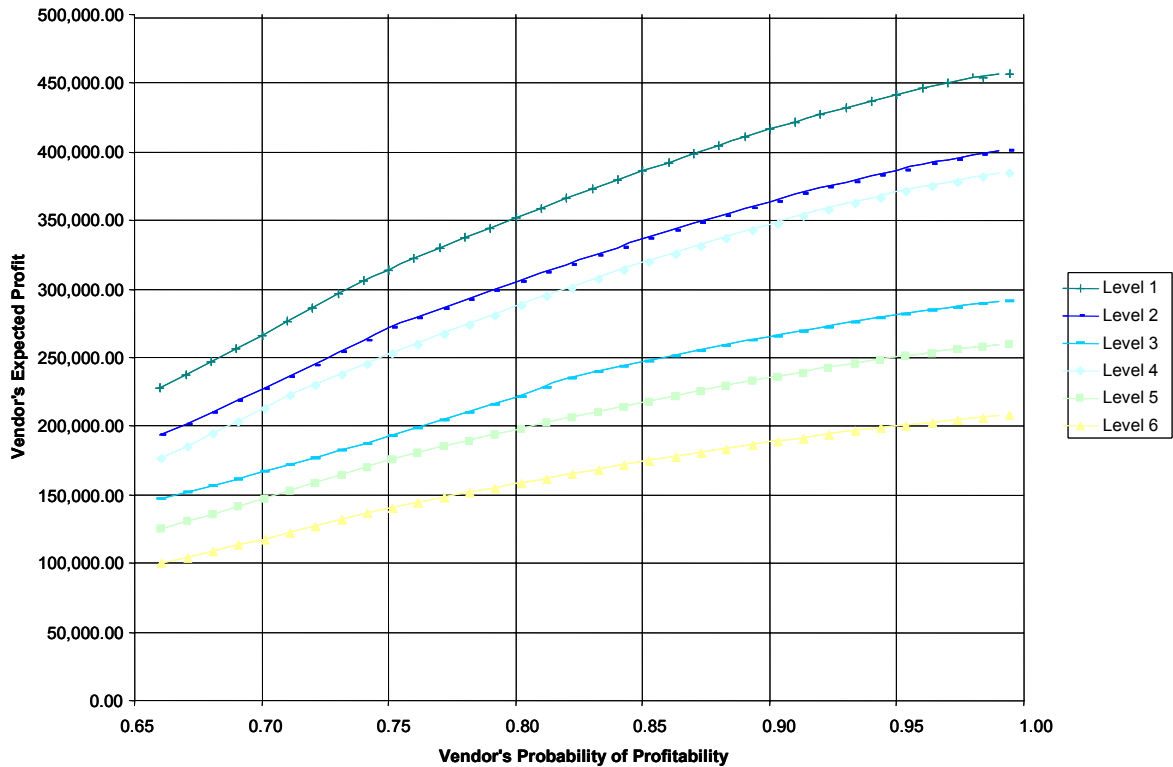


Figure 3. The Probability That IPS Will Make a Profit





**Figure 4. IPS's (Vendor) Probability of Profitability and MSM's (Outsourcer) Expected Profit**



**Figure 5. IPS's (Vendor) Expected Profit and Probability of Achieving It**

Using the data behind both Figures 4 and 5, Joe generated for selected values of IPS's (i.e. vendor's) probability of profitability, the corresponding expected profit values for both MSM (i.e., outsourcer) and IPS (i.e., vendor). Table 4 displays these values. Joe then used the values in Table 4 to analyze the trade-off between MSM's expected profit versus IPS's expected profit in order to determine the performance level and vendor probability of profitability that would be the most advantageous to MSM while being sufficiently attractive to IPS.

**Table 4. Vendor's Probability of Profitability and Corresponding Expected Profits**

Vendor's Probability of Profitability	Party	Expected Profit					
		Performance Level 1	Performance Level 2	Performance Level 3	Performance Level 4	Performance Level 5	Performance Level 6
<b>0.75</b>	Outsourcer	2,447,865.57	2,017,061.43	2,493,214.90	2,048,329.12	1,687,206.61	1,502,397.49
	Vendor	314,396.43	271,480.57	192,879.10	252,561.88	175,919.39	140,735.51
<b>0.80</b>	Outsourcer	2,410,284.91	1,983,090.73	2,464,252.30	2,013,107.11	1,665,193.60	1,484,787.08
	Vendor	351,977.09	305,451.27	221,841.70	287,783.89	197,932.40	158,345.92
<b>0.85</b>	Outsourcer	2,376,027.80	1,952,126.69	2,438,881.05	1,981,213.69	1,645,128.90	1,468,735.32
	Vendor	386,234.20	336,415.31	247,212.95	319,677.31	217,997.10	174,397.68
<b>0.90</b>	Outsourcer	2,345,661.44	1,924,681.75	2,420,474.81	1,953,201.83	1,627,344.58	1,454,507.86
	Vendor	416,600.56	363,860.25	265,619.19	347,689.17	235,781.42	188,625.14
<b>0.95</b>	Outsourcer	2,320,215.51	1,901,685.51	2,404,762.59	1,930,058.84	1,612,443.02	1,442,586.61
	Vendor	442,046.49	386,856.49	281,331.41	370,832.16	250,682.98	200,546.39
<b>0.99</b>	Outsourcer	2,305,283.28	1,888,186.89	2,395,346.53	1,916,773.87	1,603,695.91	1,435,588.93
	Vendor	456,978.72	400,355.11	290,747.47	384,117.13	259,430.09	207,544.07

Now, since IPS is guaranteed a fixed rate of profit, Joe decides that IPS needs some kind of incentive policy that would induce IPS to perform at the agreed upon level of performance. He decides that the incentive scheme should be based on the following decision rule. IPS will be paid  $p_k$  subject to the following constraints:

$$\begin{aligned}
 p_k &= p_{kE} && \text{if } c_k \leq c_{kE}; \\
 p_k &= \text{Min} \{c_k + \theta_D p_{kE}, p_{k\gamma}\} && \text{if } c_{kE} < c_k < p_{k\gamma}; \\
 p_k &= p_{k\gamma} && \text{if } c_k \geq p_{k\gamma}.
 \end{aligned}$$

Under this incentive scheme, MSM will pay IPS in two installments,  $p_{kA} = p_{kE}$  and  $p_{kB} = p_k - p_{kA}$ , with  $p_{kA}$  being paid during the contract and  $p_{kB}$  being paid after the actual cost has been determined. This policy ensures IPS a minimum level of profit and MSM the lowest possible cost for the information processing. However, the policy also provides an incentive for IPS to keep information processing costs as low as possible. Under this incentive scheme, IPS earns the highest profit when  $c_k \leq c_{kE}$ , with the minimum acceptable profit rate guaranteed for  $c_k \leq c_{kE}$ . Although IPS can earn the same absolute profit amount for some higher cost values, IPS has an incentive to keep costs as low as possible.

### Would the Vendor be Inclined to Shirk?

ISP would be inclined to shirk only if there would be a resulting increase in profit. Given that the penalty for shirking is  $\text{Max} \{(v_k - v_{kd}), (c_{kU} - c_{kdL})\}$ , Table 5 displays the corresponding penalty amount for each contracted performance level. From Figure 6, we see that in every case the vendor would have a reduction in profit if he/she shirked, and so we can conclude that the vendor would not shirk. Similarly, the outsourcer's profit would increase if the vendor shirked.

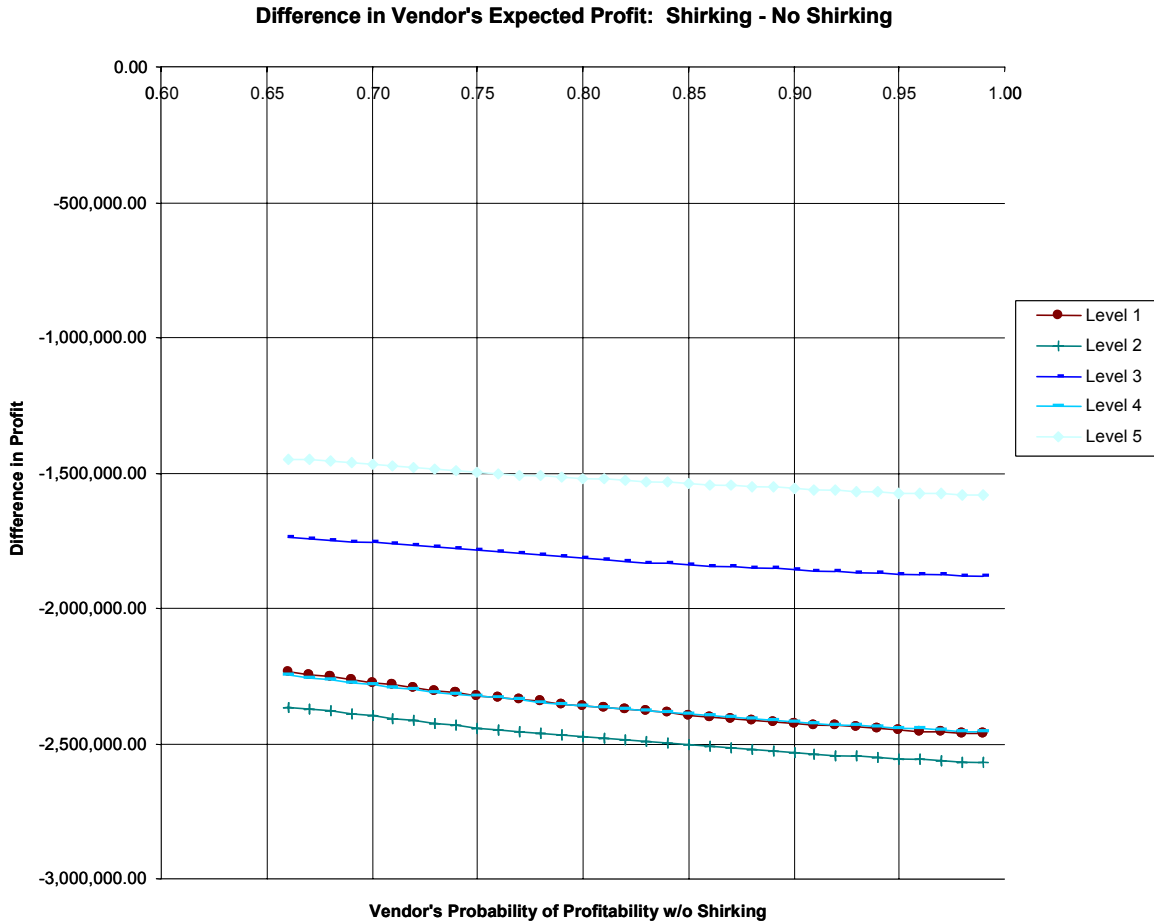


Figure 6. Vendor Profit with Shirking — Vendor Profit Without Shirking

Table 5. Penalty for Shirking

Contracted Performance Level k	Shirking Performance Level k	$(v_k - v_{kd})$	$(c_{kU} - c_{kdL})$	Penalty
1	3	856,840.00	3,003,222.91	3,003,222.91
2	4	690,255.00	3,066,312.62	3,066,312.62
3	4	718,015.00	2,098,382.47	2,098,382.47
4	5	1,036,828.00	2,827,575.76	2,827,575.76
5	6	699,243.00	1,926,585.00	1,926,585.00

## V. CONCLUDING COMMENTS

In this paper, we presented an approach to analyzing key aspects of information systems outsourcing decision-problems and constructing incentive schemes for improving vendor performance, an area that is not well researched. Building upon transaction cost theory concepts, we presented an approach to modeling and analyzing key business value and vendor performance issues. We presented a set of techniques for modeling incentive schemes when information processing costs are fixed and known and when they are unknown. We demonstrated how the decision-maker can model incentive schemes to find the minimum cost and maximum possible profit for the outsourcer. An important focus of our model is on determining the probability of vendor shirking under different incentive schemes and the cost of such shirking to the outsourcer. This type of analysis can inform the outsourcer about the degree of risk he/she is likely to encounter with the outsourcing contract. It also provides information that can be used to structure incentive schemes to induce the vendor to achieve higher levels of performance. Further, our model can assist the outsourcer in identifying conditions that can lead to opportunistic bargaining by the vendor. Understanding these conditions can help the outsourcer in crafting appropriate incentive contracts to combat shirking and opportunistic bargaining. The model will enable decision-makers to conduct a more comprehensive analysis of IS outsourcing decision problems. We would advise that the models and analysis procedures illustrated above be implemented as a spreadsheet application. Such an application would simplify implementation for the manager and remove most of the burden of the computations.

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## VII. ABOUT THE AUTHORS

**Noel Kweku-Muata Bryson** is Professor of Information Systems and Research Fellow of the Information Systems Research Institute at Virginia Commonwealth University. Before coming to VCU, he was Professor of Information Systems and Decision Sciences in the School of Business at Howard University and Research Area Manager in the Howard University Future Aerospace Science and Technology Center. His areas of expertise include database systems, data reengineering, data warehousing, data mining, disaster recovery planning, decision support systems, and decision analysis. He has also worked as an information systems practitioner in both government and industry. Dr. Bryson serves on the Editorial Board of *Computers & Operations Research*. His articles have appeared in a variety of journals including *Computers & Operations Research*, *Decision Support Systems*, *Information Systems*, *Information Processing and Management*, *European Journal of Operational Research*, *Journal of the Operational Research Society*, *Annals of Operations Research*, *Computer & Mathematical Modeling*, and *Journal of Multiple Criteria Decision Analysis*.



**Ojelanki Ngwenyama** is Professor of Information Systems and Director of Research and Education in the Center of Excellence in Enterprise-Wide Systems Research at Virginia Commonwealth University, which has been his home university since fall 1997. He is also Extraordinary Professor in the Department of Informatics, Faculty of Management Sciences, and Member of the Board of Directors of the School of Information Technology, University of Pretoria; Docent (Research Professor) at University of Jyväskylä, Finland; and Visiting Research Professor at Aalborg University, Denmark. His research papers have been published in a wide range of international journals. In 1997, he and Allen Lee won the *MIS Quarterly* Best Paper Award. He is a member of the Editorial Board of the *Journal of the Association of Information Systems* and Associate Editor of the *Information Technology and People*. He is co-editor of the *Transforming Organizations with Information Technology: Information Technology and New Emergent Forms of Organizations* (North Holland, 1994) and *New Information Technologies in Organizational Processes: Field Studies and Theoretical Reflections on the Future of Work* (Kluwer, 1999)

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