Decision Support

Managing risks in information systems outsourcing: An approach to analyzing outsourcing risks and structuring incentive contracts

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Abstract

Information systems outsourcing is now almost standard practice for many companies. Outsourcing the information processing activities is a complex issue that entails considerable implications for the strategy of the firm. An important mechanism for managing the performance of outsourcing vendors is incentive contracts. But to develop an outsourcing contract the IS manager must quantify risks and benefits. However methods and tools for analyzing and quantifying outsourcing risks that IS managers have at their disposal are rudimentary. In this paper we offer a method and some mathematical models for analyzing risks and constructing incentive contracts for IS outsourcing. We are aware that most managers do not like to use mathematical models, consequently we have minimized the technical discussion and have illustrated how this model could be implemented using spreadsheet software for ease of use.

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1. Introduction

Information systems (IS) outsourcing has become a major issue for IS managers. The primary motivation for outsourcing portions of the IS portfolio is the potential for cost savings by the outsourcer. It is claimed that IS outsourcing vendors can achieve economies of scale and specialization because their only

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business is information processing. IS outsourcing vendors can purchase equipment more cheaply, 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; Rochester and Douglas, 1990, 1993; Lacity and Hirschheim, 1993a). Many firms have had to prematurely terminate contracts and re-established their data centers (Lacity and Hirschheim, 1993b; Reponen, 1993). Others have had to seek out new vendors and write new contracts. And 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 survey by 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 incomplete analysis of outsourcing decision problems, and the limited selection of decision models to support managers in analyzing the risks and benefits (Alpar and Saharia, 1995; Chaundry et al., 1992; Reponen, 1993; Ngwenyama and Bryson, 1999). Another survey 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 (1999) point out IS outsourcing management and decisions are complex, involving many factors, such as: (a) selecting one or more reliable outsourcing vendors; (b) entering and managing a long-term relationship with one or more outsourcing vendors; (c) exposing vital organization assets to the control of external agents; (d) coordinating between internal users and outsourcing vendors; (e) monitoring vendors and inducing them to deliver on performance requirements; and (f) defining viable backup and recovery options. This paper responds to a gap in the management literature. We present an approach to help IS managers in analyzing outsourcing risks and structuring incentive schemes that are mutually beneficial to the outsourcer and vendor.

2. Risks in IS outsourcing contracts

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, and opportunistic bargaining refers to a vendor’s ability to demand higher than market prices. An outsourcer can be subjected to opportunistic bargaining when she/he is ‘locked-in’ to a single vendor and would have to incur considerable cost to switch to another (Ngwenyama and Bryson, 1999). To minimize the risks of shirking, the outsourcer can invest in monitoring and coordinating mechanisms. Often, outsourcers setup an organizational unit to coordinate the interactions between its end-users and the vendor and to monitor the vendor’s performance. 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. The primary of the IS manager is to minimize these risks and maximize the return on outsourcing to the firm. In analyzing outsourcing decisions IS managers should consider the following questions: (1) What are the risks and benefits of different outsourcing strategies? (2) What is the potential vulnerability to the firm if the vendor fails to perform the activity as contracted? (3) How to protect the firm from opportunistic bargaining by its vendor(s)? (4) How should outsourcing contracts be structured to ensure reliability and quality? (5) What level of competence should be retained for the purpose of monitoring external entities?

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 the risk of cost overruns, but if s/he can improve efficiency s/he can make a higher profit. In practice however, when there are cost overruns the vendor can engage in opportunistic bargaining. That is s/he can pressure the client to pay the overruns if the client is outsourcing to a single vendor and there is no credible option of switching. Another 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, incentive contracts, attempts to share the risks and rewards between the client and the vendor. Generally, they 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 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). Both types of contracts carry an incentive and a penalty provision. But they differ in how they manage the risks of vendor under-performance. A FPIC is used when both the outsourcer and the vendor know the cost of information processing. The outsourcer agrees to pay the vendor a portion of the agreed upon price in advance of the performance of the activity. A post-performance audit is carried out. If it is found that the vendor under-performs a penalty is charged to the vendor. If the vendor performs to the specified level he is paid the balance on the contract. The outsourcer can also offer additional incentive payments for higher levels of performance. This incentive scheme can induce the vendor to perform at higher levels that the outsourcer might find advantageous to her business operations. A VPIC is used when the cost of the information processing activities are unknown. In this case the outsourcer must guarantee the vendor a minimum rate of profit and the opportunity to increase it by operating at higher levels of performance and cost reductions. In this situation the outsourcer agrees upon a specific rate of profit for a given level of performance. But she also defines higher levels of performance that are advantageous to her business operations, and offers to pay the vendor an incentive for achieving any of them. In this case there is a post-performance audit of both the level of performance as well as the cost of information processing. The results of this audit are used to determine whether a penalty is accessed or an incentive is paid. We will show later how the manager can analyze and structure incentive schemes for these two types of contracts.

2.1. Quantifying costs and benefits

Accurately assessing costs and benefits of IS outsourcing decisions is crucial to structuring an outsourcing contract and the relationship with the vendor. The difficulty in defining cost of outsourcing a set of information processing activities lies in defining the costs and values of different levels of performance. Estimates of the outsourcer’s business value for the different performance levels and the corresponding vendor cost are often not known by either outsourcer or vendor. The fact that these values are not known by either party is not simply because there is a desire to withhold information. Given this incomplete information both outsourcer and vendor make assumptions, sometimes only implicitly, about the values of these variables. However, outsourcer and vendor decisions during the pre-award period and later during the contract period are all based on these assumptions. Both parties have an interest in the successful performance of the contract because both parties could lose significantly if the contract fails. Consequently, the structure and negotiation of an IS outsourcing contract cannot be based on a zero-sum game philosophy; a win–win philosophy is more appropriate. For example, if the vendor has no reasonable estimate of the business value of each performance level, or makes an inaccurate estimate of these values and switching cost then the vendor might shirk. If the vendor overestimated the shirking cost and underestimated the difference in the business value of the contracted and shirking performance levels then the outsourcer might switch from that vendor, and still penalize the vendor. Thus, the vendor has an interest in obtaining reasonable estimates of the business values and shirking costs. Similarly the outsourcer has an interest in obtaining realistic estimates of the
vendor’s cost since it is in the outsourcer’s best interest for the vendor to obtain a reasonable profit and also have a high probability of being profitable. Therefore, it appears to us to be advantageous for there to be sharing of information that is relevant to the estimation of both outsourcer business value and vendor cost.

In line with this win–win philosophy, we outline an approach for defining the value of information processing activities and for defining the value of various levels of vendor performance in a manner that is transparent to both outsourcer and vendor. For the purpose of our analysis we make the following assumptions: (a) The relationship between the outsourcer and vendor has an indefinite horizon. (b) The vendor provides the service at a certain level of performance. (c) An incentive contract specifies the price to be paid (in installments), the period, service and expected level of performance is agreed upon by the parties. (d) 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.

2.1.1. Defining the business value of outsourcing

The more difficult aspect of the cost-benefit analysis lies in defining the value of the information processing activities, specifically information cost and information quality. In the following we outline a model and some heuristics for estimating the value of information processing based on the work of Ngwenyama and Bryson (1999) and Salmela (1997). Fig. 1 graphically depicts the key components of the business value of information. 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 means 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.

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

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![Fig. 1. Components of the IS outsourcing value function.](image-url)
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 its 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 system can lead to user frustration and mistakes in interpreting information. Together, improvements in system and information quality (cf. Appendix B), reliability, timeliness and ease of access can contribute to savings in business operations, improve management decision making and competitiveness (Ngwenyama and Bryson, 1999; 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 ten 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 objective of the IS manager considering outsourcing is to:

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

3. Method for quantifying costs and benefits

We will now present a two-phase process for implementing and using the approach and models we 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. In the following 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 the IS outsourcing follows from our discussion in Section 2. 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 3 minutes.

(b) Define intermediate performance levels, using the same factors as 1.1a. These intermediate perfor-
mance 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 valued of the associ-
ated business benefits that result from the corresponding information quality.

(b) Estimate the value of the intermediate performance levels.

Appendix B describes one approach that could be used to derive these estimates.

**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 ap-
proach used in PERT for eliciting the time of each activity. Some of the information relevant to the deter-
mination 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, and also what additional vendor activities and IT resources would be needed to make the transition
between different performance levels.

**Phase 2: Incentive Scheme Analysis**

In this phase we conduct the main aspects of the incentive scheme analysis. This 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 proce-
dure 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. Determination of the value of $\theta_D$ is done in consultation with the vendor.

**Step 2.2: Generate expected profit values**

Given the data that was obtained in Steps 1.2, 1.3 and 2.1, values for the outsourcer’s expected profit and
the vendor’s expected profit are automatically generated for each performance level (e.g. Table 1 for cost
certainty, and Table 3 and Fig. 1 for cost uncertainty).

<table>
<thead>
<tr>
<th>Performance level $k$</th>
<th>Value $v_k$</th>
<th>Vendor cost $c_k$</th>
<th>Vendor price $p_k$</th>
<th>Shirking level $k$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>8,570,278.00</td>
<td>4,108,797.00</td>
<td>5,135,996.25</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>7,685,678.00</td>
<td>3,697,917.00</td>
<td>4,622,396.25</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>7,713,438.00</td>
<td>3,328,125.00</td>
<td>4,160,156.25</td>
<td>4</td>
</tr>
<tr>
<td>4</td>
<td>6,995,423.00</td>
<td>2,995,313.00</td>
<td>3,744,141.25</td>
<td>5</td>
</tr>
<tr>
<td>5</td>
<td>5,958,595.00</td>
<td>2,396,250.00</td>
<td>2,995,312.50</td>
<td>6</td>
</tr>
<tr>
<td>6</td>
<td>5,259,352.00</td>
<td>1,917,000.00</td>
<td>2,396,250.00</td>
<td>6</td>
</tr>
</tbody>
</table>
Step 2.3: Trade-off analysis

Using the data generated, the outsourcer conducts a trade-off 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 IS manager may choose to do a trade-off analysis for a subset of the data and may choose to have this data displayed in a tabular form (e.g. Table 2). At the end of this step the outsourcer would have made at least a tentative decision on the desired performance level, and also of 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 decision of the outsourcer in Step 2.3.

The reader should note that if the data that is collected in Steps 1.2, 1.3 and 2.1 were entered into a spreadsheet, then the computations of Steps 2.2–2.4 could be automatically generated if the relevant formulas were also entered and stored in the spreadsheet.

3.1. The case illustration

E-Business Corporation (EBC) is an internet-based sales and distribution company physically located in the mid-western United States. EBC depends heavily on information technology to operate its business. After three years of dissatisfaction with poor returns and rising expenditure for its in-house information processing, the senior management of EBC has decided to investigate outsourcing most of IT activities to an information processing services vendor. Rachael, the CEO of EBC, has informed Thabo, the IT manager she is interested in determining answers to the following questions: What cost savings can be expected by outsourcing the information processing activities? What price should be offered the vendor? What would be the cost implications if the vendor under-performs or fails to perform all together? What type of incentive scheme can be defined to induce the vendor to maintain a performance level that is optimum for EBC?
business operations? After some discussion with his boss Thabo sets out to: (1) determine the costs and benefits of outsourcing the information processing; (2) determine the performance requirements the vendor must meet to effectively support EBC’s business strategy; (3) determine an incentive scheme to ensure that the vendor is induced to attain the required levels of performance; (4) determine the level of risks and cost implications to EBC if the vendor under-performs on the contract.

**Phase 1: Business Value Analysis**

After several weeks of investigation of the market and analyzing some contracts from similar size companies Thabo has been able estimate that the price of the contract \( (P) \) could be around $4,160,156.00 for a 12-month period. This price includes the cost of information processing and a 20% vendor profit margin \((p_D = 0.20)\), which is the standard for the outsourcing industry. Joe has estimated that the basic setup cost \( s \) for a multi-period contract to be around $1,464,844.00 per period (12 months). This cost can be broken down into: (1) contracting cost, including bidding costs, negotiation fees, legal fees, and other charges that might be incurred to set up the relationship; (2) the cost of transitioning to the vendor(s), that includes labor and equipment. He has also been able to estimate the cost of coordinating the outsourcing activities monitoring the vendor’s performance each contract period \((g + f)\) would be in the area of $234,375.00.

Having estimated the basic cost of the outsourcing contract Thabo is now interested in estimating the benefit that would accrue to EBC if they were to go ahead with such a contract. He believes that there will be some benefits from cost savings on overhead and IT infrastructure, salaries and benefits, training, and searching for and hiring IT professionals. However, because of the nature of EBC business operations, benefits can vary with the level performance of the information processing. EBC main criteria of performance are simultaneous reliable database access by 500 users and low response times (15–40 seconds) for their transaction processing and minimum service disruptions. Thabo has decided that he needs to quantify the business value of various levels of performance. In keeping with these criteria Thabo has defined 6 levels of performance \((K = 6)\); the most desirable performance in which all the criteria are met to the least desirable in which few of the criteria are met. Table 1 shows the estimated vendor costs \(c_k\) of information processing, the estimated values \(v_k\), to EBC, and the price \(p_k\) that EBC would be willing to pay the vendor for each of the \(K\) performance levels.

From analysis of the data in Table 1 Thabo has determined that the best possible benefit that EBC can achieve from outsourcing its information processing is \((7,713,438.00 - 4,160,156.25 - 1,464,844.00 - 234,375.00 = 1,854,062.75)\). This return assumes an average level of performance and no shirking by the vendor. For this guaranteed level of performance EBC would pay a price of $4,160,156.25, from which the vendor would yield a profit of $832,031.30. Since EBC will outsource to a single vendor and will have little leverage (because EBC cannot easily take the processing back in-house or transfer to another service), Thabo knows that the vendor would be tempted to shirk on performance to increase his profit margin. The key question Thabo must answer is, is it possible for the vendor to increase profits by shirking on performance? Upon further analysis Thabo finds that by shirking, the vendor can make a profit of $1,164,843.25. All the vendor needs to do is to drop performance from the average level \((k = 3\) in Table 1) to the lower level. By doing so the vendor would lower his information processing cost \((c_3 - c_4)\); \((3,328,117.00 - 2,995,313.00)\) and yield a net increase in the vendor’s profit of $332,812.00. All else being equal, EBC would experience a drop in information value \((v_3 - v_4) = (7,713,438.00 - 6,995,423.00)\) of $718,015.00.

**Phase 2: Incentive Scheme Analysis**

Now that it is clear that the vendor can increase his profits by shirking on performance Thabo needs to determine how to construct an appropriate incentive scheme that would induce the vendor to deliver the optimum performance required by EBC. Since he is certain of the costs of information processing activities, Thabo decides on a simple incentive scheme. The vendor would be paid a portion of the contract price in advance; at the end of the period a post performance would be conducted a post audit. If the vendor per-
forms at a level below the requirements of the contract (ex. at level “‘kd’” instead of “‘k’”) the vendor would be required to pay EBC the sum of the decrease in EBC’s benefit due to the under-performance (ex. \(v_k - v_{kd}\)). However, Thabo thinks it will be difficult to recoup any loses from the vendor, so he decides on a ‘carrot and stick’ strategy. He structures a payment scheme, which includes pre-audit and post-audit payments, and a penalty for under-performance. Table 2 outlines the financial implications of this incentive scheme for both EBC and the vendor. For example, we can see from Table 2 EBC agrees to pay the vendor $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 the vendor did perform as per the contract. But if the vendor shirks and does not deliver the agreed upon performance, EBC deducts from the post-audit payment \((p_{kB})\), a penalty. In the case where the vendor performs at level 3 instead of level 1 EBC assesses a penalty of $856,840, and therefore pays the vendor a post-audit payment of only $119,000.00, which results in a reduction in his profit.

A fundamental question for Thabo is: Would the vendor consider entering such a contract with an incentive scheme? Table 2 shows the amount of profit that the vendor can make by delivering various levels of performance for a given vendor profit rate. In this case, the opportunity for increase profits would provide a motivation for the vendor to enter in such a contract. But would the vendor be similarly inclined to enter into such a contract if the costs of performing the information processing activities were not certain?

### Incentive scheme when information processing costs are uncertain

Now the previous analysis assumed a fixed price incentive contract and that the costs of information processing are certain. However, Thabo has decided to extend his analysis for the case in which the information processing costs are uncertain. He has decided that a variable priced incentive might be appropriate if the vendor cannot precisely determine his information processing cost. Using the estimates from Table 1, Thabo begins this analysis by estimating a range of costs for each level of performance that EBC is interested in. Thabo 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: \(c_{kL}, c_{kM}, c_{kU}\). 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 assumption Thabo can generate 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?

Generally, there is no guarantee that the vendor can make a profit when the cost of information processing is uncertain. Thus the simple ‘carrot and stick’ approach is unworkable. When costs and profits are uncertain a penalty for under-performance 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 EBC must at least guarantee the vendor a high probability of making an acceptable profit on the contract. But it is not in EBC’s best interest to guarantee the vendor a profit for the entire range of information processing cost. Therefore, Thabo must determine the minimum probability of profit that the vendor might find acceptable. Fig. 2 shows the probability of the vendor making a profit for some possible profit rates of EBC. It is clear from this graph that the vendor can make an acceptable profit.

As can be seen from Fig. 2 as the vendor’s probability of profitability increases, there is a decrease in the EBC’s profit rate. Now in defining the terms of the contract Thabo must trade off EBC’s desire for a high return and the vendor’s interest in making an acceptable profit. Thus Thabo must now determine: (1) The level of profit the vendor can expect. (2) The level of certainty that the vendor can make that profit. (3) The incentive that would induce the vendor to perform at a specified level. So far we have assumed that the payments that EBC makes to the vendor are fixed. However, since information processing costs are uncertain Thabo can only fix the profit rate \((\theta_p)\) that the vendor will receive. EBC needs to guarantee the vendor a minimum profit rate, of say, 5%, and offer the opportunity to increase it beyond 20% by delivering on specified higher levels of performance. Table 4 gives probability of profitability, the corresponding expected profit.
values for both EBC and the vendor. Thabo can now use the values in Table 4 to do trade-off analysis to determine an incentive scheme that would be sufficiently attractive to the vendor and most advantageous to EBC.

Table 5 contains a list of decision rules that Thabo has devised to induce the vendor to perform at higher levels. The table outlines the conditions, payments and penalties for a given level of performance. This policy would ensure the vendor a minimum level of profit and EBC the lowest possible cost for the information processing. However, the policy also provides an incentive for the vendor to keep information processing cost as low as possible. Under this incentive scheme the vendor earns the highest profit when $c_k \leq c_{kE}$, with

![Fig. 2. The probability that the vendor will make a profit.](image)

**Table 4**
Vendor's probability of profitability and corresponding expected profits

<table>
<thead>
<tr>
<th>Vendor's probability of profitability</th>
<th>Party</th>
<th>Expected profit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Performance level 1</td>
</tr>
<tr>
<td>0.75</td>
<td>EBC</td>
<td>2,447,865.57</td>
</tr>
<tr>
<td></td>
<td>Vendor</td>
<td>314,396.43</td>
</tr>
<tr>
<td>0.80</td>
<td>EBC</td>
<td>2,410,284.91</td>
</tr>
<tr>
<td></td>
<td>Vendor</td>
<td>351,977.09</td>
</tr>
<tr>
<td>0.85</td>
<td>EBC</td>
<td>2,376,027.80</td>
</tr>
<tr>
<td></td>
<td>Vendor</td>
<td>386,234.20</td>
</tr>
<tr>
<td>0.90</td>
<td>EBC</td>
<td>2,345,661.44</td>
</tr>
<tr>
<td></td>
<td>Vendor</td>
<td>416,600.56</td>
</tr>
<tr>
<td>0.95</td>
<td>EBC</td>
<td>2,320,215.51</td>
</tr>
<tr>
<td></td>
<td>Vendor</td>
<td>442,046.49</td>
</tr>
<tr>
<td>0.99</td>
<td>EBC</td>
<td>2,305,283.28</td>
</tr>
<tr>
<td></td>
<td>Vendor</td>
<td>456,978.72</td>
</tr>
</tbody>
</table>
the minimum acceptable profit rate guaranteed for $c_k \leq c_{kE}$. Although the vendor can earn the same absolute profit amount for some higher cost values, he has an incentive to keep costs as low as possible.

**Would the vendor be inclined to shirk?**

The final question is: would the vendor be inclined to under perform on the contract? The vendor would only be inclined to shirk 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 6 displays the corresponding penalty amount for each contracted performance level. From Fig. 3, 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.

### Table 5

<table>
<thead>
<tr>
<th>Condition</th>
<th>Amount to be paid to vendor</th>
<th>Rationale</th>
</tr>
</thead>
<tbody>
<tr>
<td>$c_k \leq c_{kE}$</td>
<td>Payment ($p_k$) that corresponds to the vendor’s cost being the expected cost</td>
<td>Encourage vendor efficiency by offering an opportunity to increase profit without shirking</td>
</tr>
<tr>
<td>$c_k \geq p_k\gamma$</td>
<td>Payment ($p_k$) is the amount ($p_k\gamma$) corresponding to the vendor having the specified probability of profitability ($\gamma$)</td>
<td>Aggressively discourage vendor inefficiency by offering no opportunity for profit in situations of unreasonable, excessive costs</td>
</tr>
<tr>
<td>$c_{kE} &lt; c_k &lt; p_k\gamma$</td>
<td>Payment is the smaller of the two amounts: (a) actual vendor cost plus profit amount that is based on expected cost rather than actual cost; (b) amount ($p_k\gamma$) corresponding to the vendor having the specified probability of profitability ($\gamma$)</td>
<td>Provide the opportunity for the vendor profit making even when costs are above expectation while still discouraging vendor inefficiency by varying profit in a manner that decreases as vendor costs increases</td>
</tr>
</tbody>
</table>

### Table 6

<table>
<thead>
<tr>
<th>Contracted performance level $k$</th>
<th>Shirking performance level $k$</th>
<th>$(v_k - v_{kd})$</th>
<th>$(c_{kU} - c_{kdL})$</th>
<th>Penalty</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3</td>
<td>856,840.00</td>
<td>3,003,222.91</td>
<td>3,003,222.91</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
<td>690,255.00</td>
<td>3,066,312.62</td>
<td>3,066,312.62</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>718,015.00</td>
<td>2,098,382.47</td>
<td>2,098,382.47</td>
</tr>
<tr>
<td>4</td>
<td>5</td>
<td>1,036,828.00</td>
<td>2,827,575.76</td>
<td>2,827,575.76</td>
</tr>
<tr>
<td>5</td>
<td>6</td>
<td>699,243.00</td>
<td>1,926,585.00</td>
<td>1,926,585.00</td>
</tr>
</tbody>
</table>

In this paper we presented an approach to analyzing risks in information systems outsourcing and structuring incentive schemes for improving vendor performance. Our perspective is that an effective IS outsourcing relationship cannot be based on a zero-sum philosophy; rather it should be based on win–win philosophy. It is advantageous for the outsourcer and vendor to share information that is relevant to
the estimation of both outsourcer business value and vendor cost. Consequently, we have presented an approach for structuring incentive contracts for outsourcing that can result in a win–win situation if the estimation of outsourcer business value and vendor cost is done in a manner that is transparent to both

---

**Table B.1**
Example of hierarchical decomposition of value estimation problem

---

**Fig. 3.** Vendor profit with shirking–vendor profit without shirking.
outsourcer and vendor. This paper attempts to make accessible to managers, the mathematical theory and methods we have developed for modeling and analyzing key business value and vendor performance issues. In general, analytical models serve an important function in helping decision makers to articulate and analyze aspects of a problem domain that may not be easily identifiable and articulable. Our experiences with IS managers both in practice and the classroom suggest that while they are aware of the risk of vendor shirking and the potential of incentive contracts to combat this, they are unaware of how to model and analyze these decision problems. Our model can assist them in structuring their thinking around these problems. An important focus of our analytical approach is determining the likelihood of vendor shirking on performance under different incentive schemes and the cost of such shirking to the outsourcer. It can help managers to identify the shirking level associated with each performance level, the associated incentive and penalty to avoid shirking.

We present a set of techniques for modeling the incentive schemes when the costs of information processing are fixed and known, and when they are unknown. We illustrate how the IS manager can perform the analysis and develop incentive schemes to find the minimum cost and maximum possible profit for the outsourcer. Our model can also be used to identify the conditions under which the vendor is likely to be profitable. It should be noted that in many real-world contractual environments (e.g. government contracting) the vendor is assured a profit as a percentage of cost, which assumes that the outsourcer has a reasonably accurate estimate of vendor cost. If the vendor has no reasonable estimate of the business value of each performance level, and makes an inaccurate estimate of these values plus switching cost then the vendor might shirk and be penalized. Both the outsourcer and vendor have an interest in obtaining reasonable estimates of the business values of the activity, the vendor’s cost to perform and the shirking costs. This type of analysis can inform the IS manager 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 appropriate incentive schemes that can induce the vendor to achieve higher levels of performance. The use of the model to analyze the problem situation and structure incentive contracts could certainly help managers to avoid the source (e.g. shirking) of some outsourcing failures. Further, our approach can assist IS managers 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 both shirking and opportunistic bargaining. The model can enable IS managers to conduct a more comprehensive analysis of IS outsourcing decision problems. We have implemented these models and procedures in a user-friendly spreadsheet application, the results of which were displayed in our illustrative example. Our rationale for taking this approach is to ensure that managers would not have to deal directly with the mathematical formulas. Consequently, our application (model and procedures) can support IS managers in conducting the analysis with little of the burden of structuring the problem and building the mathematical model.

Appendix A. Theory and method of analysis

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;
- $E$ is the set of monitoring strategies that the outsourcer could use with the vendor;
- $f(e)$ is the cost to the outsourcer if monitoring strategy $e \in E$ is used;
- $s$ is the outsourcer’s setup costs;
- $\sigma$ is a measure of the quality of the vendor’s performance;
- $v_P(\sigma)$ is a measure of the value to the outsourcer if the vendor’s performance is $\sigma$;
- $c_D(\sigma,a)$ is the vendor’s cost to maintain a performance of $\sigma$ under coordination strategy $a$;
\( p(a, e) \) is the price that outsourcer pays the vendor under coordination strategy \( a \) and monitoring strategy \( e \);

- \( \theta_D \) is the minimum profit rate acceptable to the vendor;

- \( \phi_D \) is the relative increase in the vendor's profit.

- \( \Pi_o(\sigma, a, e, p) \) is the outsourcer's profit if the vendor's performance is \( \sigma \) and price is \( p \);

- \( \Pi_o(\sigma, a, e, p) \) is the vendor's profit when his performance is \( \sigma \) and price is \( p \).

**Assumptions**

For a given coordination strategy \( a \), \( v_o(\sigma) \) and \( c_D(\sigma, a) \) are step functions such that

\[
\xi_1: \quad v_o(\sigma) = v_k, \quad \sigma \in [\sigma_k, \sigma_{k+1}), k = 1, 2, \ldots, K,
\]

\[
c_D(\sigma, a) = c_k, \quad \sigma \in [\sigma_k, \sigma_{k+1}), k = 1, 2, \ldots, K,
\]

where \( v_k \geq v_{k+1} \); and for a given coordination strategy \( a \), the values \( v_k \) and \( c_k(a) \) are known constants.

Let us also assume that \( a \) (coordinating costs) and \( e \) (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:

\[
\xi_2: \quad \Pi_o(\sigma, p) = v_o(\sigma) - p - g - f - s,
\]

\[
\Pi_o(\sigma, p) = p - c_D(\sigma).
\]

**Computing outsourcer's maximum profit**

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

\[
\xi_3: \quad \Pi_o(\sigma_o, p_o) = \max \quad \Pi_o(\sigma, p) = v_o(\sigma) - p - g - f - s
\]

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

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

\[
\xi_4: \quad \Pi_o(\sigma_o, p_o) = \max \quad \sum_k v_k y_k - p - g - f - s
\]

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

\[ \sum_k y_k = 1, \]

\[ y_k \in \{0, 1\}, \]

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 \( \Pi_o(\sigma, a, e, p) \) and performance level \( \sigma_o \) that the outsourcer will receive. Let \( v_o \) and \( c_o \) be the value and cost associated with the optimal solution of this problem. Then given that \( g \), \( f \) and \( s \) are fixed, it follows that

\[
\xi_5: \quad (v_o - p_o) = \max \{ (v_k - p_o) : k = 1, 2, \ldots, K \},
\]

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

\[
(v_o - p_o) = \max \{ (v_k - c_k(a))/(1 - \theta_D) : k = 1, 2, \ldots, K \}.
\]

Thus it is not necessary to explicitly solve the mixed integer programming problem.
Computing vendor’s maximum profit

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:

\[
\xi_6 : \quad \Pi_D(\sigma_D, p_O) = \max_{\sigma_D, p_O} \quad \Pi_D(\sigma, p_O) = p_O - c_D(\sigma)
\]

s.t. \( \Pi_O(\sigma_O, p_O) - \Pi_O(\sigma, p_O) \leq s \).

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

\[
\xi_7 : \quad \Pi_D(\sigma_D, p_O) = \max_{\sigma, p} \quad p_O - \sum_k c_k(a) y_k
\]

s.t. \( v_O - \sum_k v_k y_k \leq s \),

\( \sum_k y_k = 1 \),

\( y_k \in \{0, 1\} \).

It should be noted that the optimal solution for this problem is associated with the index \( D \) where \( c_D = \min \{ c_k : v_O - v_k \leq s; k \geq 0 \} \). 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

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 \( a \). 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

\[
\max E[\Pi_O(\sigma, p, a_{i2})] > \max E[\Pi_O(\sigma, p, a_{i1})].
\]

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.

A.1. Analyzing incentive schemes

Preliminary assumptions

Let \( \theta_D \) be the minimum profit rate acceptable to the vendor, and let \( \theta_O \) 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 \( k_d = \max \{ kr : v_k - v_{kr} \leq s; k < kr \} \).

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 \( (c_k - c_{kd}) \). This under performance results in a corresponding decrease in outsourcer’s profit by \( (v_k - v_{kd}) \). 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 \( \phi = (1 - \theta_D)(c_k - c_{kd})/p_k = (c_k - c_{kd})/c_k \). 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 performs 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 actual performed at level “kd”, then the vendor would pay the outsourcer the amount of \((v_k - v_{kd})\). This incentive scheme involves a carrot and stick approach.

Incentive component. Let \(\tau_{NO}, \tau_{YES}\) (such that \(0 \leq \tau_{NO} \leq \tau_{YES}\)) be threshold parameters such that the vendor will definitely shirk if \(\phi > \tau_{YES}\), will not 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 s/he performs 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 \(p_{kA}, p_{kB}\) 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 percent 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 case 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 \(\bar{c}_{kE}\) 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:

\[
\begin{align*}
t_k(c_k) & = 2(c_k - c_{kL})/(c_{kM} - c_{kL})(c_{kU} - c_{kL}) & \text{if } c_{kL} \leq c_k \leq c_{kM}, \\
t_k(c_k) & = 2(c_{kU} - c_k)/(c_{kU} - c_{kM})(c_{kU} - c_{kL}) & \text{if } c_{kM} \leq c_k \leq c_{kU}, \\
T_k(c_k) & = (c_k - c_{kL})^2/((c_{kM} - c_{kL})(c_{kU} - c_{kL})) & \text{if } c_{kL} \leq c_k \leq c_{kM}, \\
T_k(c_k) & = 1 - (c_{kU} - c_k)^2/((c_{kU} - c_{kM})(c_{kU} - c_{kL})) & \text{if } c_{kM} \leq c_k \leq c_{kU}.
\end{align*}
\]
For our contract we will initially assume that the vendor will be paid the amount of $p_k = c_{kE}/(1 - \theta_D)$ 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 to level if s/he accepts the contract, 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, then the likelihood of profit should be viewed as being relatively high by the vendor.

**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 $(ve_k - v_{kd})$ if the vendor fails to perform at level “$k$” that it may still be possible that $(c_k - c_{kd}) > (ve_k - v_{kd})$, and so the vendor could still earn a profit after paying the penalty. Thus a risk-taking vendor might still shirk if Prob[$(c_k - c_{kd}) > (ve_k - v_{kd})] > 0$. 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 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 Max{$(ve_k - v_{kd})$, $(c_{kU} - c_{kdL})$}.

**Reward component of incentive contract**

Let $\gamma$ be the minimum probability that the vendor might find acceptable. Then we would require that 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 $T_k(c_k)$.

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

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

Alternately, 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 expected profit rate for level $k$ is $(ve_k - c_{kE}/(1 - \theta_D))/ve_k$. If the outsourcer’s minimum acceptable profit rate is $\theta_T$, then we have

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

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

$$\theta_D \leq \min\{1 - c_{kE}/(ve_k(1 - \theta_T)), 1 - c_{kE}/c_{kU}\}.$$  

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

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

Thus by setting $\theta_D = \min\{1 - c_{kE}/(ve_k(1 - \theta_T)), 1 - c_{kE}/c_{kU}\}$ 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 expected 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 $\theta_{D_T}$ be the profit rate that will result in a $\gamma$ probability of the vendor making a profit. We assume that $\theta_{D_T} \geq \theta_D$. Associated with these profit rates
are amount \( p_{kE} = c_{kE}/(1 - \theta_D) \) and \( p_{k_7} = c_{k_7}/(1 - \theta_D) \). If the vendor is paid \( p_{k_7} \) by the outsourcer then the probability of the vendor making a profit is \( \gamma \). However if the vendor is paid \( p_{kE} \) according to the following rule:

\[
\begin{align*}
p_k &= p_{kE} \quad & \text{if } c_k \leq c_{kE}, \\
p_k &= \min\{c_k + \theta_D p_{kE}, p_{k_7}\} \quad & \text{if } c_{kE} < c_k < p_{k_7}, \\
p_k &= p_{k_7} \quad & \text{if } c_k \geq p_{k_7},
\end{align*}
\]

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 \( p_{k_7} \). In fact the expected cost to the outsourcer is less than \( p_{k_7} \). 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:

\[
E(p_k) = p_{kE} T(c_{kE}) + \min\{((c_{kU} - c_{kL})^2 - c_{kU} c_{kL}) - 2/3(p_{k_7}^2 - c_{kE}^2)\}/(c_{kU} - c_{kL})(c_{kU} - c_{kL}) + \theta_D p_{kE} (\gamma - T(c_{kE})), p_{k_7} (\gamma - T(c_{kE}))\} + p_{k_7}(1 - \gamma),
\]

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 \( E(\Pi_k) \).

**Appendix B. Estimating business value**

Various researchers have explored the impact between various properties of IS and their impact on organizational performance. DeLone and McLean (1992) presented a theoretical model that hypothesized a set causal of links between the independent factors (i.e. System Quality, Information Quality), mediator factors (i.e. System Utilization, User Satisfaction, Individual Impact), and organizational performance. DeLone and McLean (2002) report that several studies have attempted to do empirical verification of one or more of these relationships, although no single study has attempted to verify all of these relationships. The study of Teo and Wong (1998) did, however, System Quality, Information Quality as predictors of both the mediator factor Individual Impacts and the dependent factor Organizational Impact. These studies thus allow us to identify properties of information systems that could be used to predict organizational performance and thus estimate the value of various performance levels of the information system. This might suggest that a predictive modeling technique could be used to estimate the value of various performance levels. However, use of the predictive modeling technique requires that data is collected on all the relevant variables for sufficient periods to deduce a predictive model with a high degree of accuracy. However, in many cases organizations do not collect the relevant data, not because they are unavailable, but because the value of doing so is not apparent to the relevant decision makers. In such a situation it is not possible to do predictive modeling, a reasonable alternative approach would involve subjective estimation of business value by relevant organizational experts. The analytic hierarchy process (AHP) of Satty (1980) has been recognized and widely used for situations requiring subjective estimation in problems such as ours, and we propose its use.
Hierarchical decomposition of the value estimation problem where the criteria are the predictor variables and the alternatives are the performance levels (e.g. Table B.1).

2. Pairwise comparisons are then done in order to elicit from the evaluators the relevant weights for each criteria level, and also the relevant weights for the set of performance levels with regards to each criteria (i.e. predictor variable).

3. The relevant weights for each level of the hierarchy are then generated using a weight vector generator technique (e.g. Saaty’s eigenvector method). Let \( \mathbf{u} = (u_1, u_2, \ldots, u_n) \) be the normalized weight vector for the set of criteria, and \( \mathbf{z} = (z_1, z_2, \ldots, z_k, \ldots, z_{|C|}) \) be the normalized weight vector for the performance levels with regards to criterion \( j \).

4. These sets of weights are then combined using the AHP combination rule resulting in an overall weight vector \( \mathbf{w} = (w_1, w_2, \ldots, w_k, \ldots, w_{|C|}) \) where \( w_k = \sum_j \frac{z_j}{w_j} \).

5. The evaluators then identify the performance level (say \( r \)) for which they are most comfortable with providing an estimate of its value. We will refer to this performance level \( r \) as the anchor level, and its value as \( v_r \). The value of the other performance levels are then estimated to be \( v_k = v_r \cdot (\frac{w_k}{w_r}) \).

It is possible that the evaluators may be more comfortable estimating the \( v_k \)’s as random variables that follows a triangular distribution with parameters \( v_{kL}, v_{kM}, v_{kU} \) such that \( \text{Min}(v_k) = v_{kL} \leq v_{kM} \leq v_{kU} = \text{Max}(v_k) \), and \( v_{kM} \) is associated with the highest point on the probability density function of \( v_k \). Let \( v_{kE} \) be the expected value of \( v_k \), then \( v_{kE} = (v_{kL} + v_{kM} + v_{kU})/3 \). In such a case once the weight vector has been generated \( \mathbf{w} \), the evaluators would then be asked to identify the anchor \( r \), and its parameter values \( v_{rL}, v_{rM}, v_{rU} \). The corresponding parameters for other performance levels could then be computed as: \( v_{kL} = v_{rL} \cdot (\frac{w_k}{w_r}) \), \( v_{kM} = v_{rM} \cdot (\frac{w_k}{w_r}) \), and \( v_{kU} = v_{rU} \cdot (\frac{w_k}{w_r}) \). Given these parameters the corresponding \( v_{kE} \) could then be computed. It should be noted that if the \( v_k \)’s are viewed as being random variables then the identification of shirking level would involve the use of the \( v_{kE} \)’s.

References


