Contracts in Offshore Software Development: An Empirical Analysis

Anandasivam Gopal • Konduru Sivaramakrishnan • M. S. Krishnan
Tridas Mukhopadhyay

Robert H. Smith School of Business, University of Maryland, College Park, Maryland 20742
Bauer College of Business, University of Houston, Houston, Texas 77204
University of Michigan Business School, University of Michigan, Ann Arbor, Michigan 48109
Graduate School of Industrial Administration, Carnegie Mellon University, Pittsburgh, Pennsylvania 15213

agopal@rhsmith.umd.edu • konduru.sivaramakrishnan@mail.uh.edu
mskrishnan@bus.umich.edu • tridas@andrew.cmu.edu

We study the determinants of contract choice in offshore software development projects and examine how the choice of contract and other factors in the project affect project profits accruing to the software vendor. Using data collected on 93 offshore projects from a leading Indian software vendor, we provide evidence that specific vendor-, client-, and project-related characteristics such as requirement uncertainty, project team size, and resource shortage significantly explain contract choice in these projects. Our analysis suggests that contract choice significantly determines project profit. Additionally, some ex ante vendor-, client-, and project-related characteristics known at the time of choosing the contract continue to significantly influence project profits after controlling for contract choice. We also provide evidence to show that project duration and team size affect project profits.

1. Introduction

Offshore software development has seen tremendous growth in the last few years. This particular kind of outsourcing occurs when the contracting parties are in different countries and the software is developed in the developer’s country, and then shipped to the buyer’s organization. Spurred by the trend toward globalization in the business world, countries like India, Ireland, and Israel have seen impressive growth in their software industries. Offshore software development also poses significant challenges because lack of proximity hampers a client’s ability to monitor its vendors and coordinate development activities closely. Therefore, viability and profitability of vendor-client relationships depend crucially on the efficacy of contractual arrangements both parties make at the outset (Lacity and Willcocks 1998).

We investigate the determinants of offshore contractual arrangements, and the manner in which contract choice affects project performance. Our research site is a leading Indian software developer with an extensive network of clients in Asia, Europe, and North America. The size of the Indian software industry was $8.1 billion in 2002. Most of the revenue comes from turnkey development and maintenance projects under different contractual arrangements, ranging from individual contracts for individual projects to long-term (10-year) contracts for dedicated offshore centers. The size of the Indian industry, the offshore setting, and the availability of relevant data provide a unique opportunity to study contracts in this market.

In a world of complete information, it does not matter which type of contract is chosen; parameters of different types of contracts can always be chosen to make them ex ante welfare equivalent. However, most real-world settings are characterized by incomplete information (Hart and Moore 1988), and the software
Contracts in Offshore Software Development

context is no exception. It seems unreasonable to assume that contracting parties can foresee all future contingencies at the time of contracting. All else being the same, a risk-averse agent prefers a contract that protects him from risk ex post to a contract that does not adequately compensate for risk ex ante because of incomplete information. Analyzing how contracts are formed, and the extent to which contracts account for risks and uncertainties, is therefore important in understanding the dynamics behind what drives success. Since offshore development involves contracting between parties from different economies in differing political and cultural climates, it provides a unique opportunity in this regard.

Based on this motivation, we examine the adoption of the two prevalent forms of contracting in the software industry—fixed-price contracts and time-and-material contracts. The major portion of the development risk is borne by the vendor under a fixed-price contract, and the client under a time-and-materials contract. While a risk-neutral vendor would be indifferent between these contractual forms, a risk-averse vendor (client) would prefer a time-and-materials (fixed-price) contract, all else equal. A testable implication of this premise is that with a risk-averse vendor, the preference for a time-and-materials contract is increasing in task uncertainty. We test this implication using a data set containing details of a single software vendor’s contractual arrangements with 93 offshore clients. We identify a set of vendor-, client-, and project-related characteristics to explain the choice of the contractual form.

Our contributions are threefold. First, our paper is one of the first attempts to empirically study the determinants of contract choice in the software industry. Although there is some discussion of the importance of outsourcing contracts in the trade press (King and Hoffman 1998, Binstock 1999), extant literature offers little by way of when a particular contractual form would prevail. Second, our paper builds on the growing body of research on the Indian offshore software industry (Banerjee and Duflo 2000). Although this literature focuses on industry-wide practices and business issues, little work has been conducted at the project or organization level.

Finally, we address the linkage between contract choice and project profits, and identify other variables that determine project profits in offshore software projects. Although project performance has been measured in terms of costs, schedules, and quality metrics in past research (Krishnan et al. 2000, Gopal et al. 2002), this is the first time absolute project profits has been used to characterize project performance.

The rest of the paper is organized as follows. In §2, we develop our research hypotheses pertaining to contract choice. In §3, we describe the data collection methodology and the variables used to test our hypotheses. Section 4 describes the data analysis, while we discuss the results from our model in §5. In §6, we present a model of project profits to test the validity of our operating assumptions and identify other drivers of project performance. In §7, we present an analysis of our model on project profits and discuss our findings. The final section concludes the paper with directions for future research.

2. Research Hypotheses

Contracts found in the offshore software development area can be broadly classified into two categories—fixed-price contracts and time-and-material contracts (Figure 1). Banerjee and Duflo (2000) show that in a market characterized by highly uncertain reputations of clients and vendors, these two contractual types strictly dominate other mixed or hybrid contract types. Other arrangements that exist are variations of these two broad types. Fixed-price contracts include a fixed fee for the software negotiated before the start of the project. The vendor bears the major part of the risk in this case. In a time-and-materials contract, the vendor contracts out his services at a certain rate. The client is responsible for monitoring progress on the project, and thus bears the cost of over-runs.

In developing testable implications regarding contract choice, we assume that the decision makers for

1 We thank an anonymous referee for suggesting a shift in emphasis from risk aversion to task uncertainty, especially given that our sample pertains to just one software vendor.

2 In testing this implication, we implicitly assume that the vendor is risk averse. While lack of support to the hypothesized association between task uncertainty and the choice of the contract form is inconclusive, evidence supporting this association would validate this assumption.
the client and the vendor are risk averse. Most Indian vendors are financially smaller than their European or North American clients. Therefore, the financial burden of a terminated contract to the vendor is considerable. In addition, the decision makers for both the vendor and the client are aware of a loss of personal reputation in the case of terminated or unsuccessful projects. From the client side, nondelivery of the required software could result in loss of revenues and time. We categorize the factors of interest in the following manner to facilitate discussion and clarity.

**Software Development Risks**

Software development is an inherently uncertain process. Barki et al. (1993) identify requirements uncertainty and project size as significant variables that characterize risk in a software project. Thus, projects that are large and projects with greater requirements uncertainty pose greater risks and task uncertainty. As a result, we would expect a risk-averse vendor to prefer time and material contracts in such cases.

**Hypothesis 1.** Increased perceived requirements uncertainty is associated with a higher probability of a time-and-materials contract.

**Hypothesis 2.** Larger projects are associated with a higher probability of a time-and-materials contract.

The importance of people in software development activities has also been stressed in past research (Gopal et al. 2002). The lack of trained software engineers is a major problem in most software companies, and this is particularly so in the Indian context (Nidomolu and Goodman 1993). Attrition in the software industry remains high as the market for software engineers continues to present attractive prospects for trained personnel. Projects requiring specific training impose even greater risk because training costs are often not recovered. The availability of trained personnel to work on a project is therefore a risk that adversely affects task uncertainty, leading us to the following hypothesis.

**Hypothesis 3.** Higher perceived risk of availability of trained personnel is associated with a higher probability of a time-and-materials contract.

**Client Knowledge Set**

In an outsourcing arrangement, the role of the client cannot be overlooked. We try to capture certain aspects of the client’s knowledge and evaluate their impact on chosen contract type. In the transaction costs literature, it is accepted that the ability to foresee future contingencies reduces transactions costs and improves contracting efficiencies (Williamson 1979). Clients with greater experience in handling offshore outsourcing contracts can be expected to have greater ability to specify contractual terms more precisely, which mitigates task uncertainty from the vendor’s point of view. Also, system specifications tend to be more precise and well defined, and monitoring the vendor would be more efficient and less expensive. Anecdotal evidence of the importance of client knowledge and competence in managing the software
development activity exists (Lacity and Hirschheim 1993). Consequently, the vendor may be more inclined to accept a fixed-price contract since the overall risk of the project is reduced. Additionally, more experienced clients are, all else being equal, potential repeat customers. Therefore, there are incentives for the vendor to accept a fixed-price contract for the current project.

**Hypothesis 4.** Perceptions of higher client MIS experience are associated with higher probabilities of a fixed-price contract.

**Hypothesis 5.** Perceptions of higher client experience with outsourcing are associated with higher probabilities of a fixed-price contract.

**Bargaining Power**

The contract choice depends on the relative bargaining power of the two parties. Given our earlier premise that both the client and the vendor are risk averse on the margin, each party would prefer a contract form that would shield them from the risks inherent in the contractual arrangement, all else being equal. In our context, the client would prefer a fixed-price contract that transfers the risk to the vendor, and the vendor would prefer a time-and-materials contract. Bargaining power weakens the association between task uncertainty and contract choice. A vendor (client) with considerable bargaining power would be able to negotiate a time-and-materials (fixed-price) contract independent of task uncertainty. Studying bargaining power variables in this setting will improve our understanding of how these affect contract choice.

Some common indicators of bargaining power in our context include the reputation of the parties, future business potential and the relative size of the parties (Banerjee and Duflo 2000). The reputation of the client increases the bargaining power and can be leveraged by the client during the contracting process. Similarly, the possibility of future business with the client can also increase the client’s bargaining power. Size of the client relative to the vendor is an important variable that has been studied in other outsourcing contexts and strongly increases client’s bargaining power (Mjoen and Tallman 1997).

A variable that can arguably reduce the client’s bargaining power is the importance of the project to the client. The more important the project is to the client, the less the client will be using her bargaining power. Clearly, vendor reputation and size are also important; however, we have data from only one vendor. Based on these arguments, we propose the following.

**Hypothesis 6.** Perceptions of higher client reputation are associated with higher probabilities of a fixed-price contract.

**Hypothesis 7.** Perceptions of higher future business potential are associated with higher probabilities of a fixed-price contract.

**Hypothesis 8.** Larger clients are associated with higher probabilities of a fixed-price contract.

**Hypothesis 9.** Perceptions of greater project importance to the client are associated with higher probabilities of a time-and-materials contract.

**Market Conditions**

Competition in the offshore software industry provides the client with an alternative, thereby preventing the vendor from locking in the customer (Lacity and Hirschheim 1993). Williamson (1979) discusses the effects of having alternative suppliers on the contracts formed and the transaction costs. Thus, the presence of competition reduces the vendor’s bargaining power. On the other hand, if the vendor has already completed several projects for the client and has an established relationship, then the transactions costs of switching to an alternative vendor can be an issue for the client.

**Hypothesis 10.** Perceptions of greater competition will be associated with higher probabilities of a fixed-price contract.

**Hypothesis 11.** A higher number of projects completed by the vendor for the client will be associated with higher probabilities of a time-and-materials contract.

3. Methodology and Data Collection

3.1. Research Site

The data for this paper were collected on 93 projects completed between 1995 and 1998 by a leading
offshore software developer in India. The firm employs around 5,000 people with its primary area of expertise being software development and maintenance of business systems. It has five primary development centers in India and offices in Europe, the United States, and Japan. We developed a questionnaire after discussions with the senior management at the research site and tested it before administrating to project personnel.

In some cases, the project was in development during questionnaire administration and in others, the project was close to completion. To minimize recall bias, data for different aspects of the project was sought from different persons, and in certain cases, two or more people answered the same questionnaire items for the same project independently. If there was a clear gap between the two responses, the project was dropped from the analysis. The respective project managers provided the project-specific details and the marketing or business unit manager provided the client- and contract-specific information. The perceptual information was gathered through the questionnaire and the project information was extracted from the company database. The sample consists of 55 time-and-materials and 38 fixed-price contracts. The projects in the sample were completed for 32 clients, with the highest number of projects per client being 4; 10 projects were maintenance; 34 were development; and 49 were re-engineering projects.

3.2. Variable Descriptions

The data for this study were tested for reliability and principal component analysis was used to identify patterns within the individual questionnaire items. To ensure validity, wherever possible, we created several questionnaire items for each of the perceptual variables. Using multiple items for a variable increases the validity of the variable, and it also becomes possible to assess the reliability of the measurement. The variable descriptions are given in Table 1. To assess reliability of the multiple-item factors, we calculated Cronbach’s alpha for each of these factors. In general, the items had good reliability scores, as shown in Table 2.

Most of the variables using multiple questionnaire items were taken from previous work in software outsourcing and software development (Barki et al. 1993, Nidomolu 1995). Therefore, confirmatory factor analysis (principal components) was performed on these questionnaire items prior to subsequent use.3 The principal components were calculated and used in subsequent analysis rather than the individual items to conserve the degrees of freedom. The principal components used were thus a smaller set of factors capturing the maximum possible variance in the original set of questionnaire items.

Among the variables studied, new measures were created for two variables (client experience and client

---

3 Some of the items are reverse scored and were reversed before being used in analysis. Also, some of the variables used have single-question items and do not have factor loadings in Table 3.
MIS experience) based on Lacity and Hirshheim (1993) and discussions with project managers. These two multiple-item variables showed good validity and reliability measures. The human resources variables were adapted from previous research (Gopal et al. 2002). No factor analysis was performed on single-item variables or binary variables. Some of our measures are single item and are therefore potentially susceptible to measurement problems. The summary statistics are shown in Table 2.

### 3.3. Data Analysis

We hypothesized that the contract choice is a function of information available to the parties during the contracting stage. We use regression analysis to test our hypotheses. Since the dependent variable contract is binary, we cannot use ordinary least squares as OLS estimates are inefficient and cannot be restricted to the [0, 1] interval. Therefore we use a probit regression specification to test our hypotheses.

\[ C = f(X'\beta + \bar{u}) \]  

(1)

where C equals zero if the contract is a time-and-materials contract and one if it is a fixed-price contract. The exogenous variables are listed in Table 3.

Since effort and client size are interval variables and are large compared to other variables, we standardize these variables. The probit specification was estimated using maximum likelihood and the results are shown in Table 4. Note that since project type is used as a

### Table 2  Summary Statistics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Unit/scale</th>
<th>Mean</th>
<th>Std dev</th>
<th>C.A.</th>
<th>Var(1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MIS experience</td>
<td>5-point scale</td>
<td>3.121</td>
<td>0.850</td>
<td>0.77</td>
<td>0.61</td>
</tr>
<tr>
<td>Client experience</td>
<td>5-point scale</td>
<td>3.101</td>
<td>0.989</td>
<td>0.56</td>
<td>0.68</td>
</tr>
<tr>
<td>Effort</td>
<td>Person-days</td>
<td>995.21</td>
<td>1,345.74</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Requirements uncertainty</td>
<td>5-point scale</td>
<td>2.192</td>
<td>1.023</td>
<td>0.90</td>
<td>0.77</td>
</tr>
<tr>
<td>HRR training risk</td>
<td>5-point scale</td>
<td>2.559</td>
<td>0.967</td>
<td>0.76</td>
<td>0.68</td>
</tr>
<tr>
<td>Project importance</td>
<td>5-point scale</td>
<td>4.070</td>
<td>0.864</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Client reputation</td>
<td>5-point scale</td>
<td>2.694</td>
<td>1.272</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Future business</td>
<td>5-point scale</td>
<td>1.777</td>
<td>0.942</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Client size</td>
<td>No. of employees</td>
<td>65,779</td>
<td>85,712</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Competition (vendor)</td>
<td>5-point scale</td>
<td>2.530</td>
<td>1.264</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Competition (client)</td>
<td>5-point scale</td>
<td>2.542</td>
<td>1.046</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Prior projects</td>
<td>No. of projects</td>
<td>7.858</td>
<td>13.147</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Project type</td>
<td>Categorical (1–3)</td>
<td>1.24</td>
<td>0.62</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Contract</td>
<td>Binary</td>
<td>0.40</td>
<td>0.49</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Project duration</td>
<td>Calendar days</td>
<td>356.46</td>
<td>290.73</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Employee turnover</td>
<td>5-point scale</td>
<td>1.902</td>
<td>0.804</td>
<td>0.73</td>
<td>0.78</td>
</tr>
<tr>
<td>Team size</td>
<td># of people</td>
<td>9.102</td>
<td>8.269</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Project profit</td>
<td>'000s, Indian Rs</td>
<td>191.41</td>
<td>528.34</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>


### Table 3  Probit Analysis Results

| Variable                | Coefficient | Std Error | Pr(|Z| > z) | Supported? |
|-------------------------|-------------|-----------|------------|------------|
| Requirements uncertainty| −0.90       | 0.33      | 0.006      | Yes        |
| Effort                  | −0.42       | 0.21      | 0.05       | Yes        |
| Human resources (training) | −0.90     | 0.28      | 0.001      | Yes        |
| MIS experience          | 0.80        | 0.29      | 0.006      | Yes        |
| Client experience       | 0.22        | 0.21      | 0.27       | ns         |
| Client reputation       | 0.05        | 0.16      | 0.73       | ns         |
| Future business         | 0.30        | 0.19      | 0.10       | ns         |
| Client size             | 0.59        | 0.26      | 0.02       | Yes        |
| Project importance      | −0.58       | 0.27      | 0.03       | Yes        |
| Competition (vendor)    | −1.37       | 0.34      | 0.0001     | Yes        |
| Competition (client)    | 0.83        | 0.32      | 0.01       | No         |
| Number of prior projects| −0.08       | 0.02      | 0.001      | Yes        |
| Project type            | −0.80       | 0.36      | 0.02       | NA         |

Notes. −2 Log \( L = 62.90 \). Model fit = 57.46 with 12 df, significant at \( p < 0.01 \). Association of predicted probabilities and observed responses = 90.2%. ns: Not significant. NA: Not applicable.

Contract: 0 = time-and-materials, 1 = fixed-price, \( N = 93 \).
of task uncertainty, thus making the outcomes of the project riskier (Jones 1994). Our results also indicate that projects involving considerable risk of getting and retaining trained personnel are associated with a time-and-materials contract.

The two hypotheses regarding the client knowledge set receive mixed support. Hypothesis 4 regarding the client MIS department experience receives strong support while Hypothesis 5 is not supported. The presence of a strong client MIS department reduces the risk for the vendor in the outsourcing relationship, as indicated by Lacity et al. (1995). Therefore, the vendor is more amenable to accepting a fixed-price contract. An experienced client MIS department also increases the bargaining power of the client by providing her with an alternative—to keep the software development in-house. Our discussions with the project managers at the research site support this reasoning, indicating that a capable MIS department would rather keep the project in-house than outsource offshore, and incur the costs of managing the project remotely.

Hypothesis 5 that relates client experience with outsourcing is not supported in our results. The insignificance of the coefficient can be attributed to low variance in the independent variable. Managers at the research site confirmed that clients in our data set did not have much prior experience in offshore outsourcing.

Turning our attention to the impact of bargaining power on contract choice, Hypotheses 6 and 7 are not supported. Hypothesis 6 pertains to client reputation and Hypothesis 7 pertains to future business. Although discussions with project managers indicated that these variables were influential in their decision making, we do not see a significant result. It is possible that since both variables were single-item measures, there is significant measurement error in these constructs. In addition, these two questions may also be measuring the same underlying phenomenon.

Hypothesis 8 is supported and pertains to the client size variable. The results show that larger clients are associated with a higher probability of a fixed-price contract. The size of the firm increases the client’s bargaining power and also indicates to the vendor a strong possibility of future business. Therefore,
Hypothesis 9, which refers to the importance of the project to the client, is also supported. We had hypothesized that the importance of the project to the client organization would reduce the client’s bargaining power. Therefore, an increase in this variable would be associated with an increasing probability of a time-and-materials contract. The client might also prefer a time-and-materials contract since it can control the development process of important projects.

Hypothesis 10, pertaining to the presence of competition, receives mixed support in our analysis. The coefficient for client-country competition is in the expected direction. Thus, the presence of alternative developers in the client country, by reducing the bargaining power of the vendor, is associated with an increase the probability of a fixed-price contract. The coefficient for vendor-country competition is opposite to our expectation and is significant. The presence of other vendors in India increases the probability of times-and-materials contracts.

We propose the following reason for this finding. All software vendors in India operate at approximately the same margins and costs. This reduces the influence of costs alone as the deciding factor between different Indian firms. Therefore, the choice between different vendors falls on past performance or reputation. The firm with the highest reputation and quality is able to leverage this factor and in effect, increase its bargaining power. Banerjee and Duflo (2000) confirm the influence of reputation in the Indian software industry. Thus, an increase in vendor-country competition indirectly increases the bargaining power of the vendor. This could be particularly true in our sample since our research site is a market leader in the Indian industry. Additionally, the fact that two single-item measures were used to characterize competition in this setting could lead to the ambiguous results. More research is required in creating valid measures for competition in the offshore market.

The final hypothesis pertains to the number of prior projects completed by the vendor for the same client, and receives strong support. An increase in the number of prior projects tends to increase the bargaining power of the vendor since this leads to a lock-in effect. The client would prefer to contract again with the same vendor rather than incur transaction costs of finding another vendor. In the Indian context in 1995, trust was a vital factor in the client’s decision making since the offshore market was perceived as being risky. Therefore, the client would be more amenable to a time-and-materials contract in repeat projects since the trust factor is higher.

5. Tests of Contract Efficiency—Framework

The results of the previous section established that a set of vendor-specific task uncertainty factors and client-specific characteristics help explain contract choice. These results underscore the incompleteness in the contracting environment. Our sample also presents us with a unique opportunity to test the efficiency of offshore contracts, which we present in this section.

It is important to recognize that an incomplete contract need not be inefficient with respect to available information at the time of contracting. If the parameters of the contract are chosen efficiently, any deviation of the actual performance under the contract from expected performance should only be a function of contingencies that were unanticipated; there should be no systematic and predictable association between realized performance under the contract and information upon which the contract is based.

To formalize these arguments, let $C$ be the type of contract chosen. Let

\[ EP = f(C, I_c), \]

where $EP =$ expected profit, $C =$ contract type and $I_c =$ information available during the contracting period.

Contract efficiency implies that the contract choice incorporates all available information known at the time of contracting. If the contracts were chosen efficiently with respect to the information variables $I_c$, then any deviation of the realized profit from the expected profit should be random. Let

\[ RP = EP + e, \]  

where $RP =$ realized profit and $e =$ random error term. Substituting for $EP$, we get

\[ RP = f(C, I_c) + e. \]
Expanding this equation and assuming a linear specification, we get the following.

\[ RP = \alpha_0 + \alpha_1 C + \alpha_2 I_c + \epsilon, \]  

(4)

where \( RP \) is the realized profit, \( C \) is the contract choice, and \( I_c \) represents the information set at the time of contracting. The results of the previous section suggest that \( \alpha_1 \) will be nonzero. In particular, if the vendor’s profits were to be higher under the preferred time-and-material contracts, we expect \( \alpha_1 < 0 \).

Since the contract is formed using the information variables known then, the effects of these variables should be limited to the contracting stage, and should have no effect on realized profits once the contract type is controlled for. In other words, once the contract type is controlled for, the information variables should be uncorrelated with the deviation of the realized profit from expected profit. Therefore, in Equation (4), the coefficient vector \( \alpha_2 \) should be zero. Even if one of the coefficients in \( \alpha_2 \) is not zero, then that variable influences the realized profits after controlling for the contract type, indicating that the contract was inefficient with respect to that variable.\(^4\)

Finally, to add power to these tests, we include some ex post “performance” variables in Equation (4) that would explain some of the deviation of the realized profit from expected profit (i.e., variables correlated with the error term \( \epsilon \)). A typical example of a development factor is the actual duration of the project (cycle time). Although the contracting parties may have expectations of the schedule of the project, the actual duration is susceptible to unforeseen circumstances such as rework that may have arisen during the development of the software. Therefore, this variable should be able to explain some of the variance in the profits that is part of the error term \( \epsilon \). Thus, we augment Equation (4) with these variables called \( D \) in the following manner.

\[ RP = \alpha_0 + \alpha_1 C + \alpha_2 I_c + \alpha_3 D + \epsilon, \]  

(5)

where \( D = \text{development factors (known ex post)} \).

\(^4\) Note that we could have devised more direct and perhaps stronger tests if we had access to price and expected profit information on the projects in our sample.

team size, and the level of employee turnover during the project.

All the three development variables are important variables from a software engineering perspective. The duration of a software project is an important aspect of a software project and has been used in the literature as a performance metric for a software project (Gopal et al. 2002, Harter et al. 2000).

Core team size refers to the core number of programmers that were assigned to the development team during the development of the project. Note that the actual number of people working on a project changes over time but the core team personnel remain on the project. The quality of programmers or project personnel also has been shown to have a positive effect on project performance. Krishnan et al. (2000) and Guinan et al. (1998) study the effects of programmer experience and quality on the performance in software projects. In our context, rather than use people skills, we use the core team size since our dependent variable is project profit rather than effort or quality.

The third variable is the effect of employee turnover in the project team during the project life cycle. Although the trade press has addressed this phenomenon in some detail (Mandell 1998, McGee 1998), there has been little empirical work in analyzing the effects of employee attrition in development projects. High attrition rates in software development firms are common in the Indian software industry as well (Nidomolu and Goodman 1993, Miller and Kaye 1999). Thus, the effects of employee attrition will significantly impact the profits of the vendor. Given the nature of attrition, it is difficult to capture an exact figure since people occupy different levels of importance in a project team. The loss of a project manager will be more keenly felt that the loss of a programmer. Therefore, instead of the number of employees quitting the firm during the project site, we use two questionnaire items that were filled out by the project manager.

6. Analysis and Results of Profit Model

To estimate Equation (5), the independent variables we use are the \( I_c \) variables, which we described in
the previous sections of this paper, the development factors, and the contract type (fixed-price or time-and-materials). The dependent variable is project profit measured in Indian rupees. Project profits are the net profits attributed to each project, and is calculated by subtracting all travel- and project-related costs from the total revenues attributable to the project. The profit was not converted into dollars to avoid confounding the analysis with currency exchange risks and other currency fluctuations that occurred in the market during the project.

In estimating Equation (5), it is important to keep in mind that one of the independent variables, \( C \), is an endogenous variable. The vendor has an expectation of profits from a given contract type, which drives his preference for a certain contract type. This creates an endogeneity problem in the estimation of Equation (5). It is well known that in the presence of endogeneity problem, OLS estimates are biased and inconsistent (Maddala 1983). We use the Heckman two-stage model to control for this endogeneity problem (Heckman 1976). In particular, we use the treatments effect model described in Barnow et al. (1981) to estimate Equation (5). In Stage 1 of this method, a probit regression is estimated of the reduced form contract choice equation, and inverse Mills ratios, referred to as \( \lambda_i \), are calculated for each of the data points.

Stage two of the procedure entails introducing the \( \lambda_i \) as an additional explanatory variable in Equation (5). This two-step procedure produces consistent and unbiased estimates of Equation (5). In particular, we estimate the following equation:

\[
RP = \alpha_0 + \alpha_1 C + \alpha_2 I_c + \alpha_3 D + \alpha_4 \lambda + \epsilon_H, \tag{6}
\]

where \( \epsilon_H \) is the Heckman-corrected error term.

Equation (6) can now be estimated using OLS, and the resulting coefficients are consistent and unbiased. Least square estimates of the standard errors are, however, biased and corrected errors are calculated using the estimator proposed in Heckman (1976). The coefficient \( \alpha_3 \) of the \( \lambda_s \) is used to control for endogeneity, and is indicative of the presence or absence of the effects of endogeneity or sample selection in the specification. Before estimating Equation (6) using OLS, we tested for the presence of multicollinearity (Belsley et al. 1980), outliers, and normality of errors (Shapiro and Wilks 1965), and no assumptions of the OLS model were rejected. The estimates from Heckman’s two-stage model are heteroskedastic in nature and our analysis automatically corrects the errors (Maddala 1983). The results of the estimation of Equation (6) are shown in Table 4. Note that the earlier probit results remain the same since the first stage of the Heckman procedure involves estimating a probit contract choice model.

Recall that one of the maintained hypotheses specified that the vendor prefers a time-and-materials contract. We see support for that hypothesis in this analysis. Our analysis indicates that after controlling for all other factors, time-and-materials projects are associated with higher profits. The coefficient \( \alpha_3 \) is significant in our model, indicating the presence of endogeneity. The contract variable is significant even after controlling for endogeneity and the presence of the lambdas. The contract variable indicates that vendor profits are Rs 748,000 (roughly $20,000) less in a fixed-price contract, all else being equal. Thus, the null hypothesis of contract equivalence can be dismissed. This finding is significant because it indicates that even in the presence of a risk premium that might have been charged for fixed-price projects, the vendor might still incur some losses due to unforeseen circumstances in fixed-price contracts.

We hypothesized that if the contract were efficient with respect to the \( I_c \) variables, there should be no significant effect of these variables on realized profits once the contract type was controlled for. The hypothesis of efficiency is rejected in our sample since several of the \( I_c \) variables are significant at the \( p = 0.05 \) level. Therefore, our analysis indicates that the contract is inefficient with respect to \( I_c \) variables. This result is also consistent with earlier empirical work in rational expectations that finds limited support for the rational expectations hypothesis (Lovell 1986). In our context, since we do not have expected profit information, we cannot conclusively reject the contract efficiency hypothesis. Although our results provide evidence in support of contract inefficiency, this result should be

\footnote{We thank an anonymous reviewer for pointing out the problem of endogeneity to us.}
interpreted with a caveat. Note that in our sample, contracts are of only two types. The significance of \( l_x \) variables in the profit model may also be due to this restriction of contract types.

Project effort is significant and is associated with increases of the project profits. This result is not surprising since effort is an integral part of the software engineering process, and is a strong driver of most performance measures in software development. Requirements uncertainty also affects project profits and this result is intuitive. Shaky requirements are the bane of most software development projects. A more surprising result from our analysis is the association between number of prior projects executed for the same client and project profits. Past research on software contracting in custom software development has shown vendors adopting a “low-balling” strategy, i.e., bid low at first and then hike rates once the client is locked in (Whang 1995). Hence it is argued that profits to the vendor will increase over time with more projects executed with the same client. The underlying reasoning behind this argument is the vendor’s learning about the client’s business domain, thereby leading to more efficient execution of later projects and, consequently, greater profits. However, in the present setting, we find the opposite effect, i.e., profits reduce in subsequent projects for the same client.

We discussed the above results with senior managers at our research site and identified several possible reasons for this finding. First, it was established that the vendor had signed long-term contracts on fixed billing rates with nominal adjustments for annual increments with large clients. The projects in our sample spanned from 1994 to 1998—a period of high growth in both global software and the Indian offshore market. Due to the strong demand for software services, the market rate for software services had increased much faster than the annual increments worked into long-term contracts with clients. This situation could have driven a decrease in profits in repeat projects for the vendor. In addition, we learned that in these long-term multiproject contractual arrangements, the vendor typically retained the same experienced staff in repeat projects with clients. This was to leverage the learning that had already taken place. The vendor was, however, forced to pay his experienced staff market-level compensation, thereby squeezing the vendor’s margins further. Thus, the vendor finds itself locked into a long-term contractual agreement with the client on one hand and an increasing cost of development on the other, leading to lower margins on such profits.

The decrease in profits with repeat projects may also be explained due to the intense competition among software vendors in the Indian software industry. It is possible that large clients may be benefiting from this competition and hence gaining more of the surplus in projects over time. The association of offshore competition variable with lower profits in our analysis further supports this argument.

The two competition variables are significant but with opposite signs. Offshore competition is associated with lower profits for the vendor. This result is intuitive since the presence of competition in the offshore market limits the price that the vendor can charge to a client and therefore, would have a negative effect on the vendor profit. The presence of onshore competition tends to increase the profit from a project. Project importance to the client reduces the profits from a project for the vendor, and this result is explained by the high level of interaction required in such projects between the client and vendor teams. Managers at the research site indicated that critical projects had a higher level of travel requirements, larger onsite teams for requirements and testing stages and increased costs of monitoring and reporting progress on the project. Since these activities are usually not specified in the contract but emerge during the development phase of the projects, their costs tend to drive down vendor profits on average. The intangible benefits gained from successful implementation of a critical project are, however, immense and accrue over a longer time period.

The other variable that is significant is the client MIS experience variable that tends to increase the profit of the vendor. As discussed in Lacity and Willcocks (1998), the presence of an experienced MIS department at the client side makes the outsourcing arrangement more efficient. Requirement ambiguity is reduced and open issues arising during the development phase are sorted out more quickly. This is
true for both contract types since the experienced MIS department provides quicker feedback and useful information that is uniformly beneficial for both parties. Discussions with project managers at the research site indicated that this is particularly true in the offshore context where the cultural and linguistic differences add to the technical complexity already present in the outsourcing process.

We had hypothesized that the three development factors would be significant. Team size and duration of the project are significant, but employee turnover is insignificant in our analysis. It is possible that the subjective nature of the turnover measure did not capture the whole impact of attrition on the project team. The core team size variable is significant and indicates that the vendor’s profit increases from an additional team member. Larger core teams tend to be more self-contained units with fewer interactions with noncore team members on average. Therefore, coordination time and effort with noncore team members are reduced. Additionally, larger-core teams are generally able to manage attrition from the team better since there are other members within the team who might be able to pick up the slack.

Our result with respect to the last development factor, project duration, is ambiguous because of the sign of the coefficient. The variable is statistically significant, indicating that longer projects are associated with greater vendor profits. This is usually true for time-and-materials projects since longer projects involve larger billings, which translate to larger profit. However, in fixed-price contracts, this result is contrary to what is expected. In a fixed-price project, the vendor has an incentive to shorten the duration of a project since the price is fixed. This result could again be driven by our sample where time-and-materials projects are larger than fixed-price projects. In addition a t-test on effort between the two contract types indicates that time-and-materials projects are statistically larger than fixed-price projects ($t = 2.861, p < 0.005$).

7. Conclusions and Future Research

In this paper, we have empirically studied how contracts are chosen in offshore software development projects. We use prior theory in task uncertainty, incomplete contracts, and bargaining power to determine the influence of information known to the contracting parties during contracting on the chosen contract type. The results support both our underlying assumptions regarding the different contract preferences the two contracting parties have and the hypotheses made on the actual contract chosen.

In subsequent analysis, we study the efficiency of the contract by examining the effect of the information known during contracting on project profits. We also introduce three development factors to improve the fit of the regression analysis. We also interpret these results in the context of prior contributions in the software engineering literature. Although we are hampered by the lack of some data, our results indicate that the vendor does make higher profits from time-and-materials contracts, controlling for project specific variables such as project type and effort. Moreover, we see evidence suggesting that the contract is not efficient with respect to the information variables known during contracting. These information variables have a residual impact on project profit and we interpret these results accordingly.

Our analysis is subject to a few limitations and caveats. First, we do not have first-hand data from the individual clients and data on contract prices due to confidentiality reasons. We were not allowed to directly contact clients and elicit responses to our questionnaires. Second, some of the data is susceptible to recall bias and results must be interpreted accordingly. Third, as noted earlier, our research is limited to two contract choices. However, these two contracts may not be always optimal. Further research is required to understand other incentive-based contracts such as agreements with a fixed price and a reward or penalty for the vendor based on the project outcome in terms of project schedule and product quality.

Although the context here is offshore software outsourcing, some broad results can be applied to domestic outsourcing as well. Many of the task uncertainty and risk factors studied apply to domestic outsourcing as well and the efficiency of contracts needs to be analyzed in this context. Additionally, it is possible that reputations of vendors and clients are more easily verifiable and disputes more easily
resolved in domestic outsourcing, therefore leading to the occurrence of more hybrid contractual types. At present, there is a lack of empirical analysis of contracts in domestic outsourcing. This is an area for future research and it would also be beneficial to conduct a comparison of contract types between these types of outsourcing and their effects on project performance. Cost is often the primary reason to move offshore but it would be useful to analyze the determinants of this cost advantage and how they accrue over different contract types at the end of a project.

References

Accepted by Bala Balachandran, former department editor; received December 10, 2001. This paper was with the authors 3 months for 3 revisions.