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Offshore Outsourcing Contracts: Real Options Analysis Using Trinomial Option Pricing Model

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ABSTRACT

In this paper, we analyze offshore outsourcing contracts using the trinomial model, which is very useful in analyzing real options associated with offshoring projects. Earlier studies by Grenadier (1995) and Pashley, Krishnaswamy and Gilbert (1997) used the option pricing model to analyze lease contracts and debt contracts respectively. So far, however, no studies address offshore outsourcing contracts. Gopal, Mukhopadhyay, Krishnan, and Sivaramakrishnan (2003), Ethiraj, Kale, Krishnan, and Singh, (2004), Gopal and Koka (2010), and Gopal and Koka (2012) found through empirical studies a significant relationship between profits and type of contracts, and price and types of contracts respectively. But they do not provide a theoretical basis for their findings. In this paper we provide a theoretical basis for such a relationship employing the real options analysis using trinomial option pricing model.

Keywords: Real options, Trinomial model, Outsourcing, Fixed Price Contracts

I. Introduction

Offshore outsourcing or offshoring is defined as the practice of moving employees or certain business activities to foreign countries as a way to lower costs, avoid taxes, and essentially add to the bottom line of a company or organization. Because emerging market countries offer low labor costs, developed companies move their business processes including manufacturing and other supporting activities like accounting, taxation, payroll, customer service functions. These savings therefore create value for stockholders. The offshore outsourcing often includes

technology processes: software development, business and knowledge processes, and software development, information technology.

There has been a remarkable growth in offshoring over the last 30+ years. Although the recent recession of 2008 increased the backlash on offshoring and put a crimp on it, it has continued its growth spurt. One example of offshoring is software development: A given software is developed in the developer's countries and then transferred to the buyers' organizations located in other developed countries. Countries including India, Philippines, Ireland, Russia and Israel among others, have seen impressive growth rates in their software industries. Offshore outsourcing development poses important challenges as the lack of proximity affects a firm's ability to monitor its vendors and coordinate development activities. Therefore, contractual arrangements entered into between

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the offshoring parties at the beginning are very important in determining the viability and profitability of vendor (offshore)/client (offshore) relationships (Lacity & Willcocks, 1998, Gopal, Mukhopadhyay, Krishnan, & Sivaramakrishnan, 2003, Gopal & Koka, 2010, and Gopal & Koka, 2012).

Essentially, two types of offshoring contracts are used in information technology and other industries: fixed price and time and materials contracts. In a fixed price contract, a vendor and a buyer agree on the price the buyer will pay for a set of products that the vendor will produce and deliver per contractual terms. In a time and materials contracts, the buyer agrees to pay an hourly or daily rate for time spent by the vendor to complete and deliver a set of products. A fixed price project shifts risk management to the vendor. Time and materials projects are more likely to be well-defined and more successful than fixed price projects because in order to maximize the payoff, the buyer has an incentive to control both the scope and costs. There are time and materials projects, and there are projects that start as fixed price but have additional costs added to them as the project unfolds. These can be thought of as a hybrid form contracts.

Offshore outsourcing involves contracting between parties from different economies in differing political and cultural environments; therefore, it provides a unique opportunity for study. Gopal et al. (2003), Ethiraj, Krishnan, & Singh (2004), Gopal and Koka (2010), and Gopal and Koka (2012) through their empirical studies, show that a significant relationship between profitability and type of offshoring contracts and additionally between price and types of contracts. But they do not provide a theoretical basis for their findings. In this paper, we provide a theoretical basis for such a relationship using the real options analysis.

II. Literature Review

Theoretically speaking, 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 equivalent. However, in most real-world settings, incomplete information is the order of day, and hence contracts are also incomplete

(Gopal & Koka, 2010); offshore outsourcing context is no exception. Assuming that the contracting parties can foresee all future contingencies at the time of contracting and hence incorporate these into the contract is not very realistic. Everything being equal, a risk-averse agent would prefer a contract that shields an organization from risk ex-post to a contract that does not adequately compensate for risk ex-ante because of incomplete information.

A survey of contract choices in franchise decisions by Lafontaine and Slade (2001) shows that the contract theory of risk and incentives is not supported by empirical studies of contracts in various industries, and they stress the need for both theoretical models and empirical studies to better understand real-world contracts.

Gopal et al. (2003), Gopal and Koka (2010) and Gopal and Koka (2012) conduct an empirical investigation of the determinants of offshore contractual arrangements and the manner in which contract choices affects project performance. Gopal and Sivaramakrishnan (2008), Gopal et al. (2003), and Gopal and Koka (2012) study the adoption of the two common forms of contracting in the software industry—fixed price contracts and time-and-materials contracts. As already noted, in a fixed price contract, the vendor bears all or a major portion of the development risk while in a time-and-materials contract, the outsourcing firm bears a major portion of the development risk. While a risk-neutral vendor would be indifferent between these contractual forms, a risk-averse vendor would prefer a time-and-materials contract and vice-versa, all else being equal. Using a sample composition of 38 time-and-materials and 55 fixed-price contracts, the authors find a significant relationship between contract type and profits. Similarly, Ethiraj et al. (2004) through their empirical study find a significant relationship between price and contract type.

III. Fixed Price versus Time-and-materials Contracts

As stated previously, fixed price projects shift risk management to the vendor. Time-and-materials projects are more likely to be well-defined and more successful than fixed price projects because the buyer has an incentive to control scope and costs. From a financial perspective, most people would initially agree that fixed price contracts

Table 1. Comparison of Fixed Price versus Time-and-Material Contracts

Characteristics	Fixed Price Contract	Variable Price Contract (Time and Material)	Hybrid
Flexibility		X	
Price Protection	X		X
Upfront Certainty	X		
Least Risk for Client	X		X
Least Risk for Vendor		X	X
Suitable for Small Straightforward Projects	X		
Suitable for Large Complex Projects		X	X
Saves Money for the Client	X		
Profitable for the Vendor		X	X

Source: Krishnaswamy and Shetty (2007) and Gopal and Sivaramakrishnan (2008)

are safer for the buyer than time-and-materials contracts. No matter how long it takes the vendor to produce the end product, the buyer's costs are fixed. Table 1 provides a comparison of the features of the fixed price versus time-and-materials (variable price) contracts.

A. Fixed Price Contracts

If a fixed price project has a well-defined contract and the project is managed to the letter of the contract, the buyer will receive the best possible deal for the time, money, and effort expended. But most fixed price contracts are incomplete or make incorrect assumptions from their inception. When these omissions or errors are discovered during course of the project, changes must be made to the contract; and that has the potential to increase the final cost of the project. No contract, no matter how well written, can predict and define remedies for all of the potential risk events in a project. The efforts required to resolve risk events throughout the life of the project, like time and effort overruns and changes in scope, have the potential to drive costs above and beyond the original contracted price. All fixed price projects guarantee the buyer will pay a specific amount as long as there are no scope changes and no delays caused by unforeseen events. Of course, the probability of no delays and no functional changes on a project is extremely low or zero. Fixed price contracts increase the risk for the vendor in that the buyer will try to introduce new activities or deliverables into the project that were originally out of

scope. "It's just a minor change that will take no time to implement" attitude can result in conflicts of interest between the parties to the contract because of change in scope, and they must be resolved. This puts the onus on the vendor to control scope. During the life of a fixed price contract, the vendor and the buyer may spend an inordinate amount of time preparing, evaluating, and arguing over change requests to determine what is within the original project scope, what is legitimate change, and what is outside the scope of the original project (CMP Media LLC, 2004; Gopal & Sivaramakrishnan, 2008; Gopal & Koka, 2010; Gopal & Koka 2012).

Fixed price contracts, by contrast, may induce the vendor to cut corners in order to finish all the deliverables on time and on budget. Corner cutting is likely to occur especially when a project's tasks run past major deadlines. Also, the vague contract terms or the limits to the functional specifications of the product could be used by a vendor as most powerful tools. They may be used to generate change requests that drive up the price of the end product to recoup the losses the vendor is taking on the fixed price portion of the project (Gopal & Koka, 2012).

Fixed price contracts may also lead to poor client/vendor relationships. As the vendor tries to do the least amount of work to complete the assignment and the buyer tries to get the most functionality for the money invested, the relationship between the buyer and the vendor can sour. Over time, the relationship becomes strained, which explains why the duration of most vendor/buyer relationships is one to two years. This problem can be mitigated to some extent by resorting to service level agreements (SLA) by the firm (Gopal & Sivaramakrishnan,

2008; Gopal & Koka, 2010; Gopal & Koka, 2012).

B. Time-and-materials Contracts

No buyer is going to enter into a time-and-materials contract where the deliverables are not well defined and therefore the costs are unlimited. If contracts must be negotiated on a time-and-materials basis, both the vendor and the buyer are motivated to create smaller contracts with clearly defined and achievable deliverables.

Time-and-materials contracts motivate the buyer and the vendor to have the project finished on time in order to stay on budget. The buyer has an additional incentive to control scope to stay on budget. While the vendor is motivated to do a good job in a timely manner to secure follow-on business. If this is true, then, there must be more demand for time- and-material contracts; but that does not seem to be case.

Most organizations believe the myth that fixed price projects lessen the risk of cost overruns and that time-and-materials projects are more risky. But in a fixed price contract, as explained before, risk is not reduced or eliminated but is merely being shifted from the buyer to the vendor. This shift in the burden occurs when the buyer wishes to avoid risk by ensuring that as much risk as possible is assumed by the vendor. If the project fails, the vendor takes the blame. However, both the vendor and the buyer will eventually "feel the pain" if the risk is shifted but not eliminated.

A more appropriate approach to managing risk is due diligence on the part of the buyer. When purchasing professional services, the watch words are still *caveat emptor*. Trying to set a fixed time, fixed scope and fixed cost on a complex project does not work in the variable and dynamic business setting of information technology business. The contracting parties have to be prepared for changes and to eliminate or resolve (not shift) the risks associated with changes. The only way to do this is to draft solutions not for the big picture but to build these systems in small manageable and well-defined slices.

Quite a few projects fail in the information technology business, and one would think by now that vendors, buyers, and investors should have caught on to what causes the failures. The primary cause of project failure is fixing a price on a poorly defined product and then failing to meet price, functionality, or benefit expectations. If the

product is poorly defined or if a large amount of customization is required to the product being purchased, then a fixed price contract poses a huge risk for the buyer and the vendor.

If a firm desires to give up all responsibility for the project's success to a third party vendor and is prepared to spend much more than the initial budget, then a fixed price contract is a better choice. However, if a firm is thinking about going to tender with a project, it has to consider the benefits of time-and-materials projects over fixed price projects. If a firm understands its business and understands the requirements and is able to manage the project scope and risks, a time-and-materials contract might be a better choice (Kern, Willcocks, & van Heck, 2002).

All risk events can be better resolved by breaking projects down into smaller more manageable sub-projects and by making each a time-and-materials project. When the time schedules are tight for both the buyer and the vendor, everyone has an incentive to deliver the best product possible on time and on budget (CMP Media, LLC, 2004; Gopal & Sivaramakrishnan, 2008; Gopal & Koka, 2010; Gopal & Koka, 2012).

IV. An Introduction to Real Options

An option is a type of derivative security. It is classified as a derivative because its value can be derived from the value of some other asset or an underlying asset such as a common stock. There are two types of options; call options and put options. Call options give investors the right but not the obligation to purchase a given asset at some specified price (*the exercise price* or the *strike price*) over a specified time period. The call option that can be exercised at any time before expiration is referred to as an *American call option*. In contrast, European options can only be exercised on the date of expiration. In some cases, it is advantageous to exercise the option early. This means that American options are always at least as valuable as equivalent European options. Calls allow investors to benefit from part or all of the upside potential of the underlying asset price without tying up the funds required to purchase the underlying asset.

Put options give investors the right but not the obligation

to sell a given underlying asset at a specified strike price over a specified time frame. Put options can also be either American or European, but most traded options on financial assets, whether calls or puts, are American. The greater the variability of the stock and the time to expiration, the higher the value of the puts. In contrast to the call, there is an upper limit on the potential value of the put. It is sometimes preferable to exercise a put option early when the price of the underlying asset is very low, although it does not necessarily have to fall to zero, because the gain from investing the funds realized from exercising the put and selling the asset is greater than the potential gain from the price of the underlying asset falling even further. For this reason, the risk-free rate of interest has a negative correlation with the value of the put; higher rates increase the opportunity cost of waiting to realize the proceeds from exercising the put and selling the underlying asset. Since the dividends expected decrease the value of the underlying asset, they increase the value of put options (Copeland & Antikarov, 2001; Copeland, Weston, & Shastri, 2007).

A. Real Options

Myers (1984) first coined the term *real options* to describe corporate investment opportunities that are similar to options. He proposed that the value of a firm could be divided into the value of its assets in place and the value of these options that represent future growth. These growth options are also referred to as *expansion options*. Discounted cash flow techniques such as expected net present value (NPV) work well for valuing assets in place but not suitable for valuing growth options. The standard NPV analysis framework implicitly assumes that investment opportunities must be framed as now or never: decisions that require an all or nothing commitment. In real world situations, management often has considerable flexibility on when to enter or exit a project and on the scale of the initial and subsequent commitments to the project. The value of this flexibility is appropriately captured by real options analysis (ROA), the application of option pricing techniques to capital budgeting. Hence, traditional NPV analysis systematically undervalues most investment projects. ROA allows us to arrive at more accurate valuations of managerial flexibility, strategic value, that facilitate better investment decisions than

decisions arrived at using standard NPV analysis. Though ROA represents a significant improvement over standard NPV, it is not productive to think of real options analysis and NPV as competitors. Indeed, standard NPV calculations are usually included in a real options analysis. It is more constructive to think of real options analysis as a method of obtaining a more accurate estimate of NPV (Copeland & Antikarov, 2001; Copeland et al., 2007).

While growth options are analogous to financial call options, another important type of real option known as an *abandonment option* can be modeled as an American or European put. If the underlying asset can be traded in a market, then the firm may salvage some value from a failed project through liquidation. For instance, when a trucking firm is evaluating the decision to purchase an additional truck, the value of the project is enhanced by the option to sell the truck at the market price. If the value of the future cash flows that can be generated from operating the truck falls below the strike price, which is the liquidation value of the truck, then the trucking firm can gain by exercising the put option. Similarly, some projects may contain an option to scale down the investment without entirely abandoning it. Another important type of real option that is similar to a call option is the option to delay a project. Many projects may contain more than one type of real option. In many cases by starting a project, the firm is giving up the option to delay and purchase options to expand, to abandon, and to scale down. This implies that many investment opportunities should be valued as a combination of a currently available project using standard NPV and a portfolio of real options using option-pricing techniques (Copeland & Antikarov, 2001; Copeland et al., 2007).

For ROA to be useful, some degree of uncertainty, irreversibility, and flexibility is necessary in the underlying project. If there is no uncertainty that can potentially be resolved over time, then we might as well simply apply standard NPV to the project and make an immediate decision to accept or reject (Michelson & Weaver, 2003). Flexibility is quite important so that managers can respond to the resolution of uncertainty. For example, if a development firm purchases a tract of land in an urban area, there may be option value in waiting to see if rents on local apartment houses increase before building. However, this value would not be present if the land were purchased from the city with the stipulation that it be developed right away. The requirement that the investment

in the underlying asset be at least partially irreversible may seem to conflict with our assertion that ROA is best suited for valuing flexibility. The standard NPV analysis generally assumes that the investment is completely irreversible while ROA allows for the possibility of investment and disinvestment in stages. If the investment is completely reversible, management has almost complete flexibility in deciding whether to own the asset or not at a given point in time. In real world situations, most major investments in fixed assets or intangible assets are at least partially irreversible (Copeland & Antikarov, 2001; Michelson & Weaver, 2003; Krishnaswamy & Shetty, 2007; Copeland et al., 2007).

B. Valuing Real Options

Copeland and Antikarov (2001) recommend a four-step process for finding the value of an investment opportunity using real options analysis. The first step is to locate and define the opportunity and identify the embedded options and their parameters. Second, find the value of the parameters associated with the options. This step will usually involve finding the NPV of the underlying project. Third, use an option pricing model to value the options and then determine the total NPV of the project. The fourth step is to analyze the estimated value using qualitative tools and sensitivity analysis.

When attempting to value an asset, it is preferable to base the valuation on market prices. When it is not possible to identify explicitly a comparable project, it is possible to estimate the cash flows associated with the project and to discount them back to the present using a risk-adjusted discount rate that would reflect the return that the investors would require on the project if it were an actively traded asset. Managers approach the valuation in this manner because they realize that investors typically compare the value of cash flows from real projects with similar opportunities available in the financial markets. This is basically the standard NPV analysis and fulfills all of the theoretical conditions necessary to value real options on underlying projects whose values are not derived from traded assets or through explicitly identifying comparables. In summary, the value and volatility of an underlying asset should be based on market values if possible but should be able to be estimated without them if necessary.

The issue of estimating volatility is critically important in real options analysis, and so it needs additional discussion. First, it is important to know that because options allow the control of the potential upside of an asset while limiting exposure to the downside, higher volatility increases option prices. In cases where the volatility of the underlying asset must be estimated, it gets more complicated. If entities have undertaken similar projects many times in the past, then they may be able to use the standard deviation of the outcomes of these projects as our volatility estimate. Copeland and Antikarov (2001) recommend running a full simulation of NPV spreadsheet model using state of the art commercial software and calculating the standard deviation of the values of the underlying asset based on the simulation output; in many cases, a lot can be learned about a project from a well-run simulation. However, Michelson and Weaver (2003) point out some possible problems with simulation. First, if the probability distributions of the variables in the model and the correlations between them are unclear, simulation is difficult to implement with any degree of confidence. Second, the proper implementation of simulation requires a wide range of skills that can be costly to acquire.

To value an option, it is necessary to specify the process that governs changes in the value of the underlying asset. For stock options, it is usually assumed that the value of the underlying asset moves according to a "random walk" so that small percentage changes in the value of the underlying asset are normally distributed. This is also the most common assumption made when valuing real options and is the assumption to which we adhere (Copeland et al., 2007).

In this paper, we use the real options analysis in general and trinomial option pricing model in particular to analyze the fixed price contracts. For ease of understanding, we look at the fixed price contracts. Here we use the risk neutral approach to real option valuation. Under this approach, the discount rate used is the risk-free rate. Kamrad and Ritchkin (1991), Rubinstein (2000), Copeland et al. (2007), and Chan, Joshi, Tang, & Yang (2008) provide an excellent discussion of the real option valuation procedure using trinomial option pricing model. We follow the trinomial option pricing model for valuing fixed price offshore contracts.

C. One Period Fixed Price Contract

The trinomial option pricing model for one period is described below. The three expected outcomes of the three states for the underlying stock price movements depend on the values of u, d, and m. Values of u, d, and m are determined by the standard deviation of the stock returns (σ) as given by equations (1), (2), and (3) respectively. For convenience, m is fixed at 1, or the stock price remains the same for that state. The risk neutral probabilities associated with the three states P_u , P_d , and P_m are given by the equations (5), (6), and (7) respectively (Figure 1). λ is a parameter that has a value of 1.2274 (Chan et al., 2008).

$$u = e^{\lambda\sigma\sqrt{T/N}} \tag{1}$$

$$d = 1/u \tag{2}$$

$$m = 1 \tag{3}$$

$$\lambda = 1.22474 \tag{4}$$

$$P_u = [\{1/ (2\lambda^2)\} + \{(r - \sigma^2/2)\sqrt{T/N}\}/(2\lambda s)] \tag{5}$$

$$P_d = [\{1/ (2\lambda^2)\} - \{(r - \sigma^2/2)\sqrt{T/N}\}/(2\lambda s)] \tag{6}$$

$$P_m = 1 - P_u - P_d \tag{7}$$

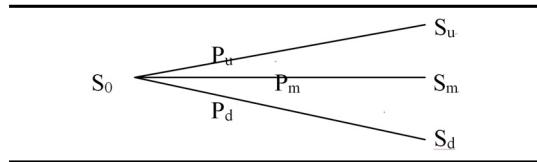


Figure 1. Trinomial Model

where

$$S_u = S_0 * u; S_d = S_0 * d \text{ and } S_m = S_0 * m = S_0$$

P_u , P_d , and P_m are probabilities associated with the outcomes.

Described below is the numerical example for option value using trinomial model:

$$S_0 = \$100; r \text{ (risk-free rate)} = 5\%; \sigma = 10\%;$$

$$X \text{ (exercise price for the option)} = \$100;$$

$$T \text{ (time to expiration)} = 1 \text{ year};$$

$$N \text{ (number of steps)} = 1$$

Using the above equations, we can calculate the following:

$$u = 1.1303; \quad d = 0.8847$$

$$P_u = 0.507; \quad P_d = 0.1597; \quad P_m = 0.3333$$

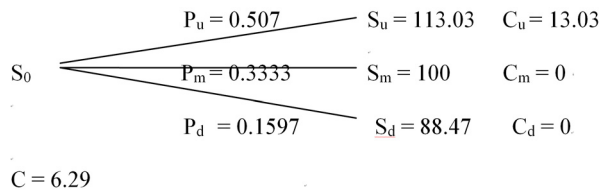


Figure 2. Call Option Price Estimation Using Trinomial Model

(X axis: Number of Steps; Y axis: Call option price)



The call option value of the one year fixed price contract at various standard deviation levels is presented below.

Figure 3. Convergence of Trinomial Model with Increase in the Number of Steps

The call option price is given by Figure 2:

$$C = (C_u * P_u + C_m * P_m + C_d * P_d) / (1+r) = \$ 6.29$$

Figure 3 shows the effect of increasing the number of steps (N) on the value of the option. As we increase the number of steps, the accuracy of the estimation increases, and the value of the option converges smoothly to a steady value. This is very important as it gives an idea about the use of number steps for the estimation. We use 150 steps for the calculations given in Table 2 and Table 3.

This idea can be directly applied to valuation of offshore outsourcing contracts. The exercise price is the fixed price paid to the vendor firm. The value associated with the contract to the outsourcing firm is difficult to measure and can be thought of as fluctuating just as the fluctuations in the underlying stock price. The call option price is the additional value realized by the outsourcing firm for its option to outsource the project using vendor contracts.

The call option value of the five year fixed price contract at various standard deviation levels is presented below.

The values in these tables show that the outsourcing firms gain substantially through offshore outsourcing from a financial point of view. The vendor firms are also better off because of the fixed price associated with the contract. The outsourcing firms should ensure that vendor firms maintain the quality of the delivery of products and services. This is done through Service Level Agreements (SLA) associated with these contracts.

Three key assumptions underlie the real options approach:

- (1) Market asset disclaimer (MAD): This assumes that we treat net present value of a project without flexibility as though it could be bought and sold in an active market,
- (2) Real options valuation obeys the principle of no arbitrage,
- (3) Properly anticipated prices fluctuate randomly: This means that the value of a risky project will follow a random walk even though the cash flows are predictable.

These assumptions are very important because the value received by the outsourcing firm from a project can fluctuate

Table 2. One Year Option and Contract Values for Various Standard Deviation Percentages

$\sigma(\%)$	C	Total Value of the Contract
10%	\$6.801	\$106.801
15%	\$8.587	\$108.587
20%	\$10.444	\$110.444
25%	\$12.238	\$112.238
30%	\$14.221	\$114.221
35%	\$16.117	\$116.117
40%	\$18.010	\$118.010

Table 3. Five Year Option and Contract Values for Various Standard Deviation Percentages

$\sigma(\%)$	C	Total Value of the Contract
10%	\$24.413	\$124.413
15%	\$25.991	\$125.991
20%	\$29.124	\$129.124
25%	\$32.486	\$132.486
30%	\$35.937	\$135.937
35%	\$39.406	\$139.406
40%	\$42.850	\$142.850

up or down even though the cash flows from the project are estimated for the NPV of the project (Copeland et al., 2007).

This analysis shows that the value of the contracts increases significantly when we include the value of the options associated with the contracts. We believe that this is an important reason behind the widespread practice of offshore outsourcing. The value of the contracts should include options associated with the contracts. A contract can have more than one option associated with it, and each of these can be evaluated separately through ROA using the trinomial option pricing model method.

V. Summary and Conclusions

In this paper, we show how offshore outsourcing contracts can be analyzed through real options analysis using the trinomial option pricing model methodology. We have provided valuable insights on valuing fixed price offshore outsourcing contracts. We have shown that the option values significantly modify the value of the contracts to the outsourcing firm as well as to the vendors. The analysis shows that the values associated with fixed price contracts are significantly higher for the outsourcing firm. Therefore, we conjecture that added option values might explain the predominance of fixed price contracts over time-and-materials contracts. Our approach also provides a basis and a methodology for analyzing more complex contracts.

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