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Monitoring process quality in off-shore outsourcing: A model and findings from multi-country survey

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Abstract

We investigate how recent advances in information technology and telecommunications have led to real-time monitoring of processes at the site of the provider by a buyer located across the globe. We construct a game-theoretic model of the dynamics of the buyer–supplier interaction in the presence of moral hazard and incomplete contracting. We derive the Minimum Quality Threshold (MQT) below which the provider's output will certainly be inspected. Our findings show that the buyer can pick a level of monitoring and thereby force the provider to exceed the quality level of the MQT in output quality and avoid costly and wasteful inspection. Finally, our model explains why the production of processes that are complex and more prone to errors are actually monitored less by the buyers. We furnish the results of a comprehensive, multi-year, multi-country survey of the efficacy of monitoring in off-shore outsourcing projects and demonstrate strong empirical support for the findings of the model.

Keywords: Global operations; Operations strategy; Technology management; Information technology; Service operations

1. Introduction

Advances made in information technology and telecommunications in the recent years have enabled firms to create real-time linkages between their information systems and share large data sets at relatively low costs. This trend has given rise to the phenomenon of firms outsourcing their entire back-offices to off-shore (and onshore)[1] third party service providers who execute these processes for them. Consulting firm Gartner estimates that cross-border Business Process Outsourcing (or BPO for short) will grow into a US$ 178.5 billion business by 2005 from US$ 123.6 billion in 2001 (Gartner, 2002). Other estimates suggest that the off-shore BPO industry will grow to over US$ 230 billion in 2015 (Forrester, 2001). The practice has gained considerable attention from the business media and from policy makers. Several legislations have been proposed to curtail the extent of outsourcing of processes to overseas labor markets. While lot of the media attention has centred on outsourcing of call centres, outsourcing now spans knowledge-intensive functions.

An associated issue is the requirement for effective monitoring of the outsourced functions, to prevent post-contractual opportunistic behavior. While the moral hazard problem in a principal-agent setting has been addressed extensively in the extant literature, this has largely dealt with managerial monitoring of employers in

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[1] The term outsourcing is not used to mean the relocation of processes to a branch of the firm in off-shore labor markets to take advantage of the global wage arbitrage. Firms often relocate processes to their captive centers off-shore which is not considered as "out-sourcing". While outsourcing has some overlap with practice of relocating processes off-shore there exist significant differences between the two practices.

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the same firm. In cross border BPO contracts, however, the monitoring problem is inter-firm, and the recent technological advances that have enabled the monitoring of supplier's agents in real-time by the buyer are a relatively new phenomenon. Unlike in the production of physical goods, the production of purely information goods involves just the flow of digitized information. Recent advances in technology and workflow software have made it possible to calibrate the digital flow of information (and therefore workflow) in order to achieve real-time monitoring. For example, Telecorp Products, Inc.'s CentrEE Solution Suite's Quality Monitoring Module allows for managers to observe and asses the quality of agents' interaction with customers, while Voice Print International Inc.'s Activ! IQ software (and several other similar products like HandMetric Inc.'s CCPM or Data Collection Resources Inc.'s CEMS) monitors a call center's performance and quality metrics. In addition to these, our survey revealed a wide variety of custom developed monitoring systems that were deployed by firms such as OfficeTiger, Wipro Technologies, HCL Ltd. (India), Beredium International (Mauritius), IT-One (Thailand). These systems are inter-organizational information systems that allow a client (buyer of services) to monitor the quality of the off-shore provider's finished processes. Thus, the confluence of traditional human intervention with the new real-time software monitoring mechanisms has made it possible to outsource even highly knowledge-intensive functions such as radiology, equity research, cash flow forecasting, third-party logistics and coordination, bioinformatics and tax accounting.

These developments have several implications for the client or the buyer firm, which would like to control costs but nevertheless maintain an optimal level of quality, while the provider firm would like to deliver the requisite quality at the lowest possible cost. An important problem that we choose to investigate in this paper is the impact of monitoring across the boundaries of the firm in real-time, even as the production of services takes place across the globe.

The remainder of the paper is arranged as follows. Section 2 summarizes some of the relevant literature in this area. Section 3 describes the research issues of the paper and Section 4 discusses a model for monitoring outsourced processes. Section 5 discusses the results. Section 6 considers their managerial implications and Section 7 concludes.

2. Literature review

With the rapid growth of outsourcing services, it is no wonder that Chopra et al. (2004) identify research issues in services, including business process outsourcing, as one of the drivers of future research in operations management. Apte and Mason (1995) analyzed the outsourcing of information-intensive services, and developed a framework for identifying criteria and guidelines for selecting services that can be globally "disaggregated", while Bozarth et al. (1998) studied the various stages of the global outsourcing strategy evolution for 55 different manufacturers. Cachon and Harker (2002) analyzed outsourcing under scale economies within a game-theoretic framework, and concluded that scale economies provided a strong incentive for outsourcing even without cost advantages, and Gunasekaran and Ngai (2005) looked at the build-to-order supply chain management strategy that has improved the competitiveness of many organizations by leveraging the advantages of outsourcing and information technology (IT).

The extant literature in economics has analyzed the problem of governance mechanisms associated with a make-versus-buy decision, and what governance mechanism would optimally define a supply contract. It was Coase (1937) who first challenged the prevailing notion that the natural boundaries of the firm were determined by technology, technological non-separabilities and economies of scale. Coase held that the firm and the market were alternatives for organizing the very same set of transactions. The firm-as-production-function approach and applied price theory combined with technological determinism do not entirely explain all the transactions that take place within the firm (Williamson and Winter, 1993). Klein et al. (1978) extended Coase (1937) by addressing the issue of moral hazard involved in post-contractual opportunistic behavior. Transaction cost economics (TCE) was developed to justify the firm as economizing on transaction cost, i.e., to identify the most economically efficient governance structure (Williamson, 1979). Central to TCE is the role played by transaction frequency, investment idiosyncrasy and uncertainty. These are the critical dimensions of contractual relations that result in transaction costs and thus lead to different governance structures. Furthermore, TCE emphasizes the role of investment idiosyncrasy as the key reason for vertical integration (or long-term contractual relationships) when the transactions are recurrent and are executed under uncertain outcomes. Another research paradigm that explains the boundaries of the firm is incomplete contracts and property rights theory pioneered by Grossman and Hart (Grossman, 1986) and Hart and Moore (Hart and Moore, 1990) (collectively referred to as GHM). Although based on the same investment idiosyncrasy assumption, GHM mainly focus on ex-ante incentive distortions and see the firm as a set of property rights. In their framework, vertical integration occurs when there is need to give one party disproportionately higher incentives to optimize the return on assets. A different explanation of existence of the firm comes from Holmstrom and Milgrom (Holmstrom, 1994) who also hold an incentive perspective. They proposed that the measured performance, asset ownership and design of the job are complementary instruments that the firm can use to obtain optimal output from agents (workers).

Empirical studies of TCE and the theories of incomplete contracts have long lagged behind theoretical work until recently. The earlier empirical works mainly focus on testing the relationship between investment specificity and contract duration (Joskow, 1987; Masten, 1986; Palay, 1984) or vertical integration (Crocker and Masten, 1988; Malone et al., 1987). Almost all of them find that there exist positive correlation between the increased use of long-term relational contracting devices (or vertical integration) and the existence of highly idiosyncratic investments by the parties. Anderson and Schmittlein (1984) test the conditions under which firms would find it optimal to use in-house salespersons versus independent sales agents. They find that the most important variables that drive the choice are the difficulty of evaluating performance and the importance of non-selling activities.

There has been some research to explore the relationships between contracting and product quality. Reyniers et al. (Reyniers, 1992; Reyniers and Tapiero, 1995a,b) modelled the effects of contract parameters on the choice of quality provided by a supplier, the inspection policy of the buyer and the resulting end product quality. They derived explicit formulas for the probability that the supplier will adopt a high quality technology and the probability that the buyer will decide to inspect the output of the technology. These papers either exogenously fixed the buyer–supplier contract or studied settings in which non-cooperative solution is first best. In contrast, Baiman et al. (2000) developed a model in which under reasonable contractibility assumptions, the first-best is not achievable.

Focusing mainly on investment incentives, some papers (Che and Hausch, 1999; Edlin and Reichelstein, 1996; Noldeke and Schmidt, 1995) have looked at the outcome of buyer–supplier interactions. They assume that the buyer and supplier can observe each other's actions but are unable to contract on it. All contracting arrangements could be later renegotiated. However, Baiman et al. (2000) make no distinction between observability and contractibility. They also allow renegotiations.

In the field of information systems, TCE has been used to explain the impact of information technology (IT) on the boundaries of the firm. Malone et al. (1987) argue that IT influences the optimal governance structure by reducing the costs of communication and coordination and by alleviating the asset-specificity and complexity of product description. The resulting impact is to increase the proportion of transactions that are coordinated by the price mechanism (market). While other authors also draw on agency theory and point out that IT not only reduces external coordination costs, but reduces the internal coordination costs that consists of agency costs and operation costs as well. Therefore, the overall effect of IT on the vertical integration is ambiguous and must be analyzed by combining with other factors such as industry characteristics and market condition (Gurbaxani and Whang, 1991). Brynjolfsson (1994) incorporated the idea of an "information asset" into the GHM framework and explained the relationship between information technology and firm size. The main finding of Brynjolfsson et al. (1994) is that if the information is an asset that is owned by the agent, it makes the agent indispensable to the firm and it follows (from the GHM hypothesis) that the increased contractibility (alienability) of the information asset will facilitate decentralization of managerial control and decision making, especially since appropriate incentives can be offered via a contracting mechanism to induce optimal effort on the part of the agent.

There is considerable empirical evidence in support of the theoretical hypothesis offered by researchers (Clemons and Kleindorfer, 1992; Clemons and Row, 1992). Evidences of IT and firm size are also consistent with the theory's basic prediction (Brynjolfsson et al., 1994), i.e., IT investments do lead to a "smaller firm". However, their metrics of firm size cannot distinguish between the firm's horizontal diversification and vertical integration. Hitt (1999) uses panel data and different diversification and vertical integration metrics and finds that IT is strongly associated with reduction in vertical integration and weakly with increases in diversification.

While prior research is almost entirely focused on macroeconomic impacts, only of late has research focused on the impact of IT at the microeconomic level. Recently, several authors have begun to employ game-theoretic models to analyze the governance structure within and between firms (Baker et al., 2002). These models characterize the nature of contracting relationships within and between firms in addition to traditional relationships, but still under extreme cases of integration and non-integration. They investigate such firm-level decisions as the formation of joint ventures, alliances and inter-firm networks.

Gopal et al. (2004) carried out an empirical study with an Indian software vendor and identified several vendor-, client- and project-specific factors that determines project profit. However, there are very few theoretical or empirical studies of the phenomenon of IT-enabled process outsourcing. This phenomenon is fairly recent—and this governance structure is beginning to be deployed in the last 2 years. To the best of our knowledge, little research has been done to study how the strength of one form of governance (viz., monitoring) can be grafted to a very different form of governance, namely markets.

In this paper, we propose to investigate the phenomenon and the issues surrounding this unique IT-enabled tool of governance – real-time monitoring – through a model which we will then validate using survey data.

3. Off-shore outsourcing: The State of Praxis

The advances made in telecommunication that have made bandwidth both cheap and ubiquitously available have enabled firms in the US and UK to link themselves reliably to firms in countries such as China, India, Mauritius, the Philippines and Singapore. As a result, it is now possible to transfer large data sets between firms located in different time zones or geographical regions. Advances made in software platforms and connectivity have also made it possible for firms to monitor projects, people and the execution of processes across the globe in real-time and in fine-grained detail. For instance, Dell Computers uses a third-party service provider to monitor the working of their call centers and query resolution operations in several countries. The same firm monitors calls, tracks quality across different centers, providers and process types and highlights issues that require managerial attention and intervention from Dell. Another example of deep linkages between firms can be found in the case of AllSec Tech Ltd., a Chennai-based firm that has placed its process execution specialists inside the Ford Trusted Zone, across the city on it client's premises. Allsec Tech's agents resolve supply chain coordination problems, by tracking invoice clearance, payment and accounts receivables and payables, and through expert intervention where it is called for. The agents of the provider work under the direct supervision of the provider's mangers and the buyer's (client's) managers. The buyer's managers monitor the decisions made by the provider's agents. An added layer of complexity is that the buyer's (i.e., Ford Motor Company's) managers in USA also may intervene in the process execution cycle and direct the employees of Allsec Tech to perform specific tasks in specific ways and/or give them volume targets for process execution.

Such arrangements are not uncommon in the financial services industry either. Lehman Brothers has set up such arrangements with its service providers in India, where agents of the provider work closely with the managers of the buyer under joint monitoring and supervision. Two large British banks have set up similar arrangements with their off-shore service providers in India that enable the buyer to monitor the working of the employees of the provider in real-time or with minimal latency. A Singapore-based accounting firm that we studied has account management teams that are monitored by their British clients in such tasks as preparing asset schedules and working capital reports, accounting support and transaction status verification.

These developments led us to examine the emergence of managerial compliance tracking mechanisms where the buyer not only specifies what it wants done for a pre-specified price, but also monitors how the tasks are executed. The resulting governance structure has features of both a hierarchy and a market. While price coordinates economic activity, managerial monitoring mechanisms, a feature of hierarchy, are employed to mitigate moral hazard problems that appear in the execution of the contract.

The feasibility of real-time monitoring mechanisms gave firms the ability to 'look into' the operations of their service providers who may often located on the other side of the globe. Wipro InfoTech, a large India-based outsourcing firm offered many of its buyers additional layers of control using a technology driven mechanism called 'The Cocoon'. This platform enables buyers to monitor the status of various projects and get an estimate of the eventual output quality level. Other firms such as HCL Ltd. (based in India) permitted their buyers to use real-time monitoring mechanisms to track how specific functions were being executed. Tata Consulting Services Ltd. (TCS) developed in-house management information systems that would enable the buyer of its BPO services, a large UK financial services firm, to monitor the working of project teams as work progressed. The managers of the UK-based firm would log on to the system and get an idea of what processes were being executed and in some cases by which workers (within a team). Further, the system allowed them in some cases to specify what members of the project team could handle specific tasks. These trends were given further impetus by recent BPO contracts whereby buyers would monitor their suppliers. Managers at Lehman Brothers work closely with their outsourcing providers in India and often specify in fine-grained detail procedures for training, sampling of output prior to delivery, error reduction techniques and the configuration of software and hardware platforms. They also transplant managerial best practices and monitor the implementation of these practices at their providers' locations. OfficeTiger, a large financial services BPO firm based in Chennai, India took this practice further by creating a mechanism that they call "Program Office" which allows the managers from the buyers firms to collaborate, and monitor the provider (in this case OfficeTiger) to minimize errors in process output and ensure compliance with process execution standards. Thus, we see that monitoring can improve quality of process execution, lower cost of process production and give buyers more control over the agents of the provider. In the sections that follow, we will also present quantitative evidence from our field research which provides insights into the magnitude of improvement that monitoring can bring. We now build a model of off-shore outsourcing that seeks to explain how monitoring by the buyer impacts outcomes such as process quality, cost of production, provider's profits and the buyer's surplus. All the parameters of the model are all grounded in the surveys of BPO contracts – as we demonstrate – that we have conducted over the past 4 years.

4. A model of monitoring information-intensive processes

We begin our discussion with a description of our model, which features the traditional divide between the firm (a hierarchy) and the market where economic activity is coordinated through the price mechanism. This is a canonical outsourcing model with moral hazard problems confounding the make-or-buy choice leaving the buyer (a service firm) facing a trade-off between attractive labor arbitrage and misaligned incentives between buyer and seller.

4.1. The model: outsourcing processes of varying complexity

The focus of our paper is an off-shore outsourcing contract between a buyer of services and a provider of services. The typical buyer is a service sector firm such as a retail or corporate bank, an insurance firm or an HMO while the supplier is a BPO services provider (firm). Each buyer procures the services from a provider (BPO firm), which it then builds into its own final service to its buyers[2] after value addition.[3] The production of processes is characterized by a quality parameter q, which is the likelihood that a unit of production is free of errors. In the foregoing discussion, we will analyze the cost, the demand and the price of a unit of service, which we call a 'Process Cycle'. To deliver a unit of service to the market it is necessary to execute a set of tasks, which we measure as a Process Cycle[4]—thus one process cycle results in a unit of service delivered to the buyer by the provider. This has the advantage in that it renders the results of this model independent of the volume of work executed. Since our focus is not the impact of volume of services produced, scale economies, etc., as much as the role of monitoring and quality of output in off-shore outsourcing contracts, we find this unit of analysis particularly effective and elegant.[5] The buyer of these services could produce these processes in-house or contract them to an off-shore services providing firm which would execute these services for a fee. We model the cost of production of the processes and the demand as a function of the quality as follows. The value to the buyer of a single unit of this service net of all costs of value addition[6] at a level of quality q is given by: $V(q) = Vq$. The cost of production[7] of the process at a level of quality q by the buyer and the provider are given by $c_i q$ and $c_o q$, respectively.[8] Thus

$$V(q) = Vq; C_i(q) = c_i q \text{ and } C_o(q) = c_o q$$

[2] In our survey of off-shore outsourcing, buyers of these services were firms that were generally in the retail sector. However, a significant proportion of firms in our survey (such as Investment Banks, Corporate Banks and Law firms) were in institutional markets.

[3] An example would be a retail bank that buys transaction processing services from an off-shore provider (of these services) and then bundles this with other services to offer to a market.

[4] This scheme of measurement, based on number of process cycles executed is most often used by BPO firms themselves. Our survey revealed that BPO firms measure the number of units of processes executed in process cycles.

[5] It can be seen from the model development that results are invariant for n process cycles.

[6] If the buyer incurs costs of value addition given by c_v, we normalize this to 0 since our interest is not in the buyer's own end market but in the off-shoring of services by the buyer to a provider.

[7] Appendix of empirical results, which will be made available on request, has the details of how these structures were estimated from survey data.

[8] The subscripted variables with "i" and "o"—stand for 'in-house' and 'outsource', respectively.

There are two important observations that we make in this context; the above functional forms have been used widely in extant research as they are considered to be an ideal abstraction of the problem domain; more importantly, we estimated these through econometric techniques from the data that we gathered on off-shore outsourcing practices across several countries and firms. We find that there is strong empirical support for the use of these functional forms.[9]

Remark 1. It is obvious from inspection that:

(1) When the buyer (firm) produces the service in-house it will set quality $q = 1;\ \forall\ V - c_i > 0$.
(2) For off-shore outsourcing to occur the constraint $c_i \geq c_o$ binds.
(3) The cost of production of the service increases in quality since greater process quality is associated with greater effort on the part of the firm (whether done in-house or outsourced). The higher the quality level q, lower is the likelihood of an error in the finished process.

For the Individual Rationality constraint[10] to hold the price paid by the buyer must be at least equal to the vendor's total cost of production at the highest quality level. At a lower price, the vendor will never provide the highest quality level as this makes him infra-marginal.[11] In consonance with all moral hazard models, the buyer imposes a penalty on the vendor when the vendor's output is not perfect. When the buyer firm detects an error in the service (which is the provider's output), the provider is obliged to correct the error and forfeits the fee for that portion of output.[12] For instance, if the provider of transaction processing service is paid US$ 1.00 per account managed, if an error is noted in the transactions posted to the account, the provider forfeits the fee for that account and must correct the transaction for free. Our survey of BPO firms in India, Singapore and the Mauritius showed that of the 23 contracts surveyed 21 of these had this penalty structure built in (see Appendix B in Appendix of Empirical Results for details). The provider incurs a cost in correcting the process when an error is detected. The total cost of correction to the provider is the original production cost plus the cost of correcting the error and ensuring an error-free output of the process, which effectively equals the cost of delivering the full quality solution. This is given by[13]: c_o.

4.1.1. Information asymmetry and moral hazard

The provider's effort level and therefore the quality of the process delivered is private information (known only to the provider). The provider's costs are increasing in quality and the output quality is not visible to the buyer ex-ante. The buyer's valuation of the finished process is increasing in quality and he cannot determine the quality without inspection (which has cost implications). If the buyer does not inspect he will get sub-optimal quality and if he does he will incur costs, which act as a dead weight loss.[14] This sets up the classic moral hazard problem. When faced with this problem several firms in our survey chose an option that is possible largely because of the nature of the work outsourced—work that involves no transformation of physical goods but only the transformation of information results allows fine-grained, real-time monitoring of work from a remote location (Aron and Singh, 2005). The buyer can invest in IT-enabled monitoring which allows him to monitor the work of the provider and get an estimate of the provider's quality level. In our survey of BPO contracts, we found several instances of IT-enabled monitoring mechanisms. Where they differed was in the accuracy, the extent of managerial involvement that was required on the part of the buyer's firm and the cost of monitoring. Office-Tiger Inc., a firm based in Chennai in India has such a system which generates MIS reports, tracks the productivity different groups working for the same client, the error rates of different agents that work for a client and maintains historical data that allows a buyer to construct and analyze trends in the provider's (in this case Office Tiger's) quality of process execution. Office Tiger's clients can track the work done on each individual process cycle, the status of completion, the agents working on a particular process, the quality control checks that have been performed on a particular

[9] We furnish these results in Appendix of Empirical Results, which will be made available on request.

[10] For a discussion of the Individual Rationality constraint and its applications, the reader is referred to pp. 192–193 (Luce and Raiffa, 1957).

[11] This price does not guarantee the optimal quality—the contract is prone to moral hazard problems. However, below this price the provider will certainly not make the optimum effort.

[12] This is also in consonance with dominant industry practice. For more details, the reader is referred to the Gartner Survey 2004.

[13] This is the cost of executing a process the highest quality level. Note that this should not be less than the cost of producing error free output—otherwise providers will always choose this option. The full derivation of this structure is furnished in Appendix of Mathematical Proofs and Derivations—and will be made available by the authors on request.

[14] Detract from the total welfare.

process. This can be done across a variety of clients (buyers) and processes as diverse as account management and analysis for US financial firms, equity research, contract research for I-Banking and accounting and financial reconciliation and process support for "Fund of Funds"[15] based in the US. Beredium International, a Mauritius-based firm, provides the same service to its clients—it allows its European clients to track the productivity, quality and levels of exception handling of the agents that work in Mauritius on the client's processes. In all these systems, the greater the extent of managerial involvement in the monitoring of processes more accurate is the buyer's estimation of process quality. The cost of monitoring, as it is to be expected, increases with the extent and granularity of monitoring by the buyer. We now discuss the monitoring mechanism and model it as per our discussion.

4.1.2. The monitoring mechanism

The buyer can choose to monitor at a level of precision that represents the optimal trade-off between cost of monitoring and the accuracy of the signal (or provider's quality). The monitoring mechanism provides an estimate of the provider's true quality q:$q \in [0, 1]$, via a signal $\hat{q}$ where:

$$|q - \hat{q}| \leq \theta \Rightarrow \hat{q}\, U[q - \theta, q + \theta]$$

For example, if the provider's true quality level is 0.8 and the value θ is 0.1, then the signal $\hat{q}$ will fall in the interval $\hat{q} \in [0.7, 0.9]$. It is obvious that θ *inversely proportional precision or the level of precision decreases in* θ. Obviously, as the precision increases the value of the signal becomes a better estimator of the true quality.

For the provider, the above set up means that for a given θ, if he picks a quality level given by q then the buyer will receive a signal $\hat{q}$ given by:

$$\hat{q} : \hat{q} \in [q - \theta, q + \theta] \Rightarrow \hat{q} : U[q - \theta, q + \theta]$$

Remark 2. As $\theta \to 0$ the precision of the signal approaches unity or $|q - \hat{q}| \to 0$. In other words, the *greater the level of precision that the buyer chooses*, *the smaller the* θ.

Greater precision is achieved only with greater managerial effort on the buyer's part and therefore, there are costs associated with monitoring. Since precision is decreasing in θ we model the costs of monitoring, $M(\theta)$ by the very general characteristics: $M(\theta)$:$M'(\theta) < 0$. This implies that as θ increases the cost of monitoring decreases. A second aspect of monitoring and one that it intuitive is *that monitoring is less expensive than actually executing the task in-house*. In all our surveys, we found that monitoring by the buyer's managers to have far lower costs associated with it than the actual execution of processes in-house. Note that in the case of *monitoring it only calls for assessing the quality of work and not doing the actual work*. It is therefore, to be expected that monitoring work is less costly than the actual execution of work. We captured in our survey the average number of buyer's agents (employees) that monitor a given volume of work that takes place in an off-shore BPO contract. As we would expect this number varies with the type of work, the maturity of the off-shore business initiative and the industry to which the firm that has off-shored its processes belongs. From this data, we compute the ratio of buyer's managers monitoring work to the number of provider's agents that were involved in executing processes. The number ranged from 1:65 to 1:215. In general, there was strong empirical evidence in support of the claim that monitoring was cheaper than execution.[16] We capture this insight from our survey in the model. The costs of executing a process in-house and achieving a gain in quality is less than the cost of monitoring another firm's agents and achieving the same quality gain. In a parsimonious construction of the model, we do not assume that the total cost of monitoring plus the cost paid to a provider is less than the cost of executing the processes in-house. Rather, we make a more parsimonious inference—the cost of improving the quality of output by any quantum is less than improving the cost of monitoring by that same quantum. In other words, the cost of executing processes and making a quality gain of Δ in output is more than making a corresponding gain[17] of Δ in monitoring and precision.

$$C_{\mathrm{i}}(\theta + \Delta) - C_{\mathrm{i}}(\theta) \geq M(\theta - \Delta) - M(\theta)$$

We will not assign a specific functional form for monitoring costs. With the above parsimonious set of features, we will capture the principal insights of our

[15] A fund of funds is a mutual fund or hedge fund that invests in other funds and takes minority equity position in other funds.

[16] This is consistent with what we know about corporations in the US and UK. A middle manager's salary is far less than the sum of salaries of all the employees that report to her.

[17] Since θ is inversely related to precision, making a gain of Δ involves going from $M(\theta)$ to $M(\theta - \Delta)$.

field research and model them as theoretically explainable results.

- When the buyer receives a finished process cycle from a provider, he gets a signal of the provider's true quality and based on the signal and its accuracy he can inspect the output of the provider and incur a cost in doing so or bundle the process from the provider into his end offering and release it to his end market. This leads us to two important optimization problems faced by the buyer.
- What is the optimal level of precision that the buyer should choose?
- Under what conditions should the buyer inspect the provider's output and when should he absorb it without inspection?

To address these issues, we begin by deriving the optimal inspection policy. Given a cost of inspection (per process cycle) I, the buyer faces the following trade-off. If he inspects the process and detects an error he will get the process for free from the provider but if there is no error he will bear both the cost of inspection and will have to pay the provider the fee for the service. If he does not inspect he runs the risk that the provider's quality level, q, is less than unity and his opportunity cost (of sub-optimal quality) is therefore, $V(1-q)$.

The buyer, however, has only a signal of the provider's true quality and estimates from this the expected value of the provider's true quality. Based on this signal of quality, the buyer estimates the threshold value for the signal such that if the signal value falls below this threshold, the buyer will inspect the provider's quality. We term this as the *Minimum Signal Threshold* and proceed to derive it analytically.

If the buyer were to pick a level of precision (and therefore a resulting θ), the *Minimum Quality Threshold* (MQT from hereon) is the *minimum value of the quality signal* for which the buyer will choose the non-inspection outcome (for that level of θ). We denote this by $\hat{q}$ which is an implicit function of θ. When the buyer receives a signal $\hat{q}$ (of the seller's true quality q), we seek to determine the minimum value of $\hat{q}$ at which the buyer is certain that the true quality is high enough for him to not to inspect the output. Alternatively, for what values of $\hat{q}$ (or higher) will the buyer know for certain that the non-inspection strategy dominates the inspection strategy? This question leads us to our next result.

Lemma 1. *For a given θ, when the buyer receives a quality signal $\hat{q}$ the buyer will not inspect the seller's output if*:

$$\bar{q} \geq 1 - \frac{I}{V + c_o}$$

The value of the quality signal $\hat{q}$ at which the buyer is certain that the true quality exceeds the inspection threshold is given by:

$$\hat{q} \geq (1+\theta) - \frac{I}{V + c_o}$$

Proof. The proof of this result is presented in Appendix 5 of Mathematical Proofs and Derivations.

Note. While we refer to the lower of the two values – i.e. $\bar{q}$ – as the *MQT* the larger value – the certainty limit – is referred to as the *Absolute Signal Threshold* and is given by:

$$\hat{q} = 1 - \frac{I}{V + c_o}.$$

Corollary 1. *When the buyer adopts the Absolute Signal Threshold strategy, for θ: $\theta > I/V + c_o$ inspection will always result no matter what the provider's true quality is. For this reason, the buyer rarely if ever, adopts the Absolute Signal Threshold strategy as this is a needless stringent inspection strategy and one that involves sub-optimal costs.*

Remark 3. As intuition would suggest the Absolute Signal Threshold increases with the level of uncertainty θ and decreases in the cost of inspection I.

To solve the buyer's problem of determining the optimal precision level (given by $1-\theta$), we must investigate the provider's incentives.

4.1.3. The provider's decision problem

The provider faces the problem of making the choice of optimal quality. He faces two outcomes—either the buyer will inspect his output of finished processes or he will not. We will derive the provider's payoff under each of the two outcomes. Fig. 1 models the provider's trade off.

Case A. Buyer inspects the process. With probability q the process is error-free and with $1-q$ it is not. The profit function for this case is given by:

$$\pi(q|I) = qc_o(1-q) + (1-q)(-c_o) = -c_o(1-q)^2$$

Case B. Buyer does not inspect the process. In this case, the profit function is given by:

$$\pi(q|\bar{I}) = c_o(1-q)$$

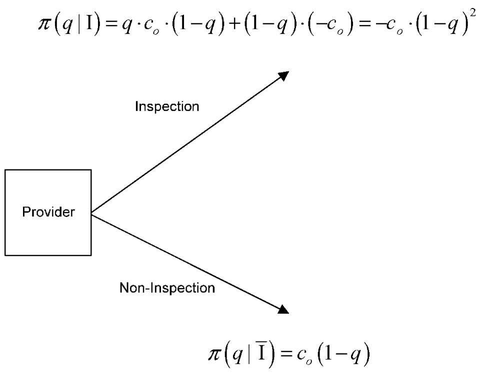

Fig. 1. Provider's tradeoff.

This leads us to our first proposition.

Proposition 1. *At any quality level less than unity the provider prefers the non-inspection outcome and at q = 1 he is indifferent between the two outcomes.*

We are now ready to solve the buyer's problem of choice of optimal level of precision. To do so we note that: (i) the buyer's choice of optimal level of monitoring – i.e. θ^* – will result in the provider's response—i.e. choice of level of quality q^* and (ii) this in turn will result in the buyer having to decide whether or not to inspect the provider's output. It thus becomes clear that the solution will involve solving the resulting game between the buyer and provider.

4.2. Dynamics of the buyer-service provider game

We model the decision problems of the buyer and the service provider as a game. The sequence of players' moves results in the following game: the buyer sets up monitoring mechanisms that result in a level of monitoring precision, the provider chooses the quality of output q and executes the process(es), the buyer receives a signal of quality, $\hat{q}$ and determines whether or not to inspect. Note that while buyer would ideally like to "force" the provider to set the quality level high enough to generate a signal that meets the Absolute Signal Threshold, it will not be possible for him to do so since he cannot *credibly threaten* to monitor if the quality signal were less than the Absolute Signal Threshold. If $\hat{q}$ is greater than the MQT of $\bar{q}$, the buyer does not inspect the final output. If on the other hand, $\hat{q} < \bar{q}$, the buyer inspects the output to determine if it is error free. This sequence of moves is what happens most often in off-shore outsourcing contracts. The buyer either estimates the quality of the provider and then decides on the level of managerial control effort or gets an idea of the provider's quality in the initial few months of the contract and then invests in a level of managerial control. More formally, this game is structured as follows:

Stage 1: Buyer chooses $\theta \rightarrow$ Stage 2: Provider chooses $q \rightarrow$ Stage 3: Buyer gets a signal $\hat{q}$ and chooses to either inspect or not inspect the output depending on its estimated quality. The extensive form of this game is shown in Fig. 2.

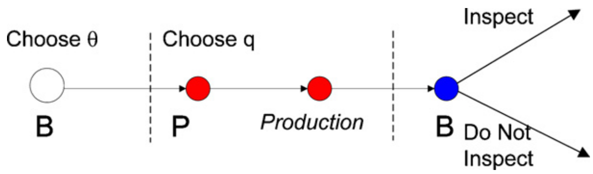

Fig. 2. Structure of the game.

If the buyer picks a precision level given by θ the provider will pick a level of quality that maximizes his expected profit. If the provider picks too low a quality he will risk inspection and expected loss (recall Proposition 1). If he picks too high a quality his profits will diminish. His optimal response is to trade-off the probability of inspection against the cost of quality and choose the optimal level of quality given a θ. The buyer in turn is aware of the provider's incentives and will pick the θ that maximizes his total expected profits given by:

$$B^*(V, \theta^*, M) = Vq^*(\theta^*) - M(\theta^*) - c_0$$

The above reaction function of the Buyer's profit (surplus) indicates the nature of the solution technique—the buyer will solve the three stage game starting with the final stage through *Backward Induction* to arrive at a *Subgame Perfect Equilibrium* solution.

To do this, the buyer will first have to determine the optimal quality q^* as function of θ. Note that for any choice of $\{\theta_i, q_i\}$ by the buyer and provider (respectively) sets up three possibilities given by:

$$\theta_i + q_i \leq \bar{q}$$
$$\bar{q} \leq \theta_i + q_i \leq 1$$
$$\theta_i + q_i > 1$$

This observation leads us to the provider's optimization problem.

4.2.1. Provider's optimization problem

When faced with a value of θ the provider has three choices—(1) pick a level of quality $q : \theta + q \leq \bar{q}$, (2) pick a level of quality $q : \bar{q} \leq \theta + q \leq 1$ or (3) pick a

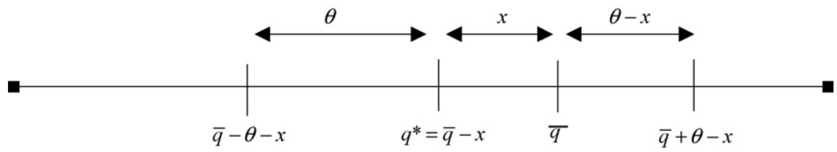

Fig. 3. Provider chooses $q^* = \bar{q} - x$.

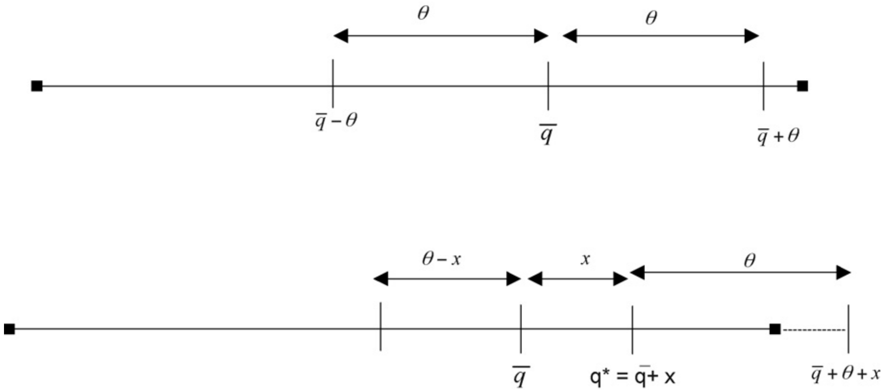

Fig. 4. Provider chooses $q^* = \bar{q}$ and $q^* = \bar{q} + x$, respectively.

level of quality q: $\theta + q > 1$. The three choices are schematically represented in Figs. 3 and 4.

Lemma 2. *The provider will not choose a quality such that $\theta + q \leq \bar{q}$ for any θ.*

Proof. The claim can be verified quite easily. If the provider picks a quality $q : q + \theta < \bar{q}$ then the signal $\hat{q} < \bar{q}$ and this will invite inspection with certainty. However, from Proposition 1, we know that the provider will never choose a quality level so low as to invite inspection.

This leaves only two possible sets of values for $\{\theta_i, q_i\}$. These are:

$$\bar{q} \leq \theta_i + q_i \leq 1$$
$$\theta_i + q_i > 1$$

This observation leads us to our next result.

Lemma 3. *When the buyer picks $0 \leq \theta \leq 1 - \bar{q}$, the provider's optimal response is to pick a quality that is strictly greater than the Minimum Quality Threshold.*

Remark 4. This means that the provider's quality is given by *given by*: $q = (\bar{q} + x)$, where $x > 0$ and $\pi^*(\bar{q} + x) > \pi^*(\bar{q}) > \pi^*(\bar{q} - x)$.

We know that when the buyer picks θ such that $0 \leq \theta \leq 1 - \bar{q}$ the provider will always pick a level of quality greater than $\bar{q}$. However, picking a small θ means higher monitoring costs are incurred by the buyer (recall that smaller than θ greater the precision in monitoring). The buyer must determine the provider's response to different choices of θ and must then estimate his expected profits for each of those choices and estimate therefore, the optimal level of monitoring. This brings us to our next result, which specifies the provider's best response choice of quality to each of the different values of the buyer's choice of θ.

Proposition 2. The buyer's choice of θ and the provider's best response are as specified below:

Buyer's choice of θ	$q + \theta \leq 1$	$q + \theta > 1$
Provider's best response (q)	$q > \bar{q}$	$q \leq \bar{q}$

Corollary 2. *The choice of θ that maximizes the provider's output quality is given by*: $\theta < 1 - \bar{q}$.

4.2.2. The Precision-Quality Frontier

For various values of θ picked by the buyer the provider picks different values of quality as his best response. We call this set of paired values of $\{\theta_i, q_i\}$ the *Precision-Quality Frontier.* In order to determine the benefit from picking the right value of θ, the buyer determines the trade-off between the benefits of increased precision in monitoring and the additional cost of precision. By inspecting the Precision-Quality Frontier θ and q it is clear that to induce the highest quality the buyer will have to pick a value of θ such that it falls in $[0, 1-\bar{q}]$. However, since monitoring is not without costs, the buyer will first have to determine whether or not picking a value of θ in the highest quality interval is optimal. This trade-off can be represented as follows:

$$\Delta\pi = \pi(0 \leq \theta < 1-\bar{q}) - \pi(\theta = 1-\bar{q})$$

To capture this trade-off faced by the buyer we formulate his gains and costs from choosing a higher level of precision.

It can be seen from Proposition 2, that when the buyer picks a $\theta : 0 \leq \theta < 1-\bar{q}$, he forces the provider to provide a level of quality higher than $\bar{q}$. To determine the gains to the buyer from picking a smaller θ, we first specify the exact precision-quality pair picked by the provider for different values of $\theta : 0 \leq \theta < 1-\bar{q}$. This leads us to our next result.

Proposition 3. When the buyer picks $\theta : 0 \leq \theta < 1-\bar{q}$, the provider's best response quality choice is as specified below:

Possible values of $\{\theta, q\}$	$q+\theta \leq 1$
	$0 \leq \theta \leq (2-t-\sqrt{1-t+t^2})$
Buyer's choice of θ^*	$\theta^* = (2-t-\sqrt{1-t+t^2})$
Provider's best response quality (q^*).	$\frac{1}{3}\left(3+\theta^*-t-\sqrt{3t+(t-\theta)^2}\right)$

where $t = (I/V + c_o)$ has been employed for notational brevity.

Remark 5. Within the interval specified above, the provider's best response quality increases in θ. However, when θ exceeds $(2-t-\sqrt{1-t+t^2})$, the provider's best response quality falls thus setting up a maximum at $\theta^* = (2-t-\sqrt{1-t+t^2})$. From the above, it is possible to estimate the maximum quality that the buyer can hope to induce by choosing an appropriate θ. This leads us to the next result.

Proposition 4. The choice of θ^* by the buyer that leads to the maximum quality q^* and the provider's best response quality are given by:

$$\theta^* = (2-t-\sqrt{1-t+t^2})$$

$$q^* = \frac{1}{3}\left(\begin{array}{l} 5-2t-\sqrt{1+t^2-t} \\ \quad -\sqrt{5-6t+5t^2+4(t-1)\sqrt{1+t^2-t}} \end{array}\right)$$

Corollary 3. *The buyer's gain when he picks an optimal θ^* is the difference in quality between $\theta_{\max}$ and θ^* and is given by:*

$$\Delta = Vq^* - V\bar{q} = V(q^* - \bar{q})$$

$$\Rightarrow \Delta = \frac{V}{3}\left(\begin{array}{l} 2+t-\sqrt{1+t^2-t} \\ \quad -\sqrt{5-6t+5t^2+4(t-1)\sqrt{1+t^2-t}} \end{array}\right)$$

What are the costs incurred by the buyer in moving from $\theta_{\max}$ to θ^*? The only additional costs are the costs of monitoring incurred by the buyer for moving to a higher level of precision. Recall, that the costs of monitoring are dominated by the actual costs of executing the process.

If the buyer were to actually achieve this quality gain by executing these processes in-house, costs of producing the processes (as opposed to monitoring them) would be given by:

$$c_i q^* - c_i \bar{q} = c_i(q^* - \bar{q}) = c_i(\sqrt{1-t+t^2} - 1)$$

The marginal increase in the costs of monitoring is: $M(\theta^*) - M(1-\bar{q})$ and it is always lower than the corresponding costs of executing these processes in-house. Therefore, the buyer will choose to move to the optimal extent of monitoring if and only if the gains in the incremental quality are greater than the additional cost of monitoring incurred. This leads us to our next result.

Proposition 5. The buyer will always choose the optimal value of θ^* given by:

$$\theta^* = (2-t-\sqrt{1-t+t^2})$$

Remark 6. It can be seen from Propositions 3–5 that this game has a solution where the buyer and the provider's strategies given, respectively, by $\{\theta^*, q^*\}$ are best responses of each other.

This observation leads us to our final result.

Proposition 6. The precision-quality schedule of (θ^*, q^*) below represents the unique Subgame Perfect Nash Equilibrium solution to the game.

$$\theta^* = (2-t-\sqrt{1-t+t^2})$$

$$q^* = \frac{1}{3}\left(\begin{array}{l} 5-2t-\sqrt{1+t^2-t} \\ \quad -\sqrt{5-6t+5t^2+4(t-1)\sqrt{1+t^2-t}} \end{array}\right)$$

Corollary 4. *The provider will always pick a quality level higher than the MQT—and therefore his ex-ante expectation is that there will be no inspection.*

5. Discussion of results

The findings that emerge from the previous section are strongly supported by the empirical evidence that we gathered from field research. We proceed to delineate the findings of the model and comment on the extent of congruence between these results and the findings of our field research.

5.1. The Minimum Quality Threshold

The model predicts that the MQT value would decrease as cost of inspection increases and would increase with the process value (to the buyer). As the cost of inspection goes up the buyer would find the inspection option more costly and this would result in a decrease in his willingness to inspect the output. Similarly, as the process value increases, the buyer would be more inclined to inspect the process since the loss from sub-optimal quality increases. In Fig. 5, we plot the MQT as a function of the relative cost of inspection. We capture the variance for three value regimes—processes that are of high value, moderate value and low value. It is clear that as the inspection cost increases the MQT decreases and as process value increases the MQT increases.

The results of the field survey too clearly support the above conclusion. In our field survey, we collected data from six different BPO practices[18] across India and Singapore that specifically sought to explore the impact of monitoring on provider quality. We captured the joint variation of monitoring precision and the threshold above which the buyer inspected the output for errors. To capture the precision rate we looked at the historical data from the vendor's log files where the client had submitted the estimated quality, actual quality and whether or not there was error-check done (i.e. inspection). The absolute value of the difference in the estimated and actual quality scaled by the actual quality value[19] gave us the monitoring precision. To make this data comparable against the model we normalized the values of I and c_o as fractions[20] of V.

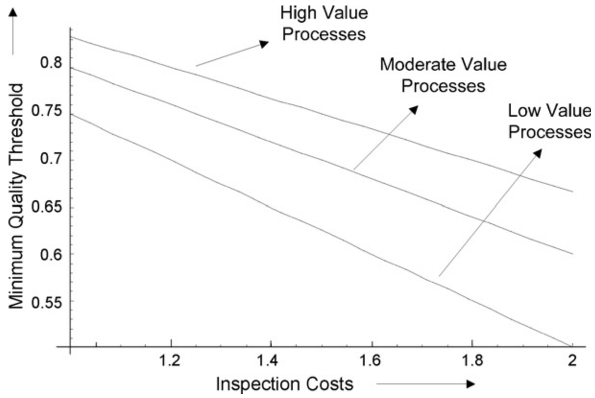

Fig. 5. Minimum Quality Threshold: cost of inspection and process value.

Finally, of the six firms that studied, we had to discard data from three firms—for comparability and heterogeneity reasons. We furnish below the data from the three firms[21] that we could analyze and the predictions of the model. From Fig. 6 and Table 1, it is clear that the model's predictions are strongly supported by the evidence from the field research.

Since the trends discussed above may possibly result from the factors idiosyncratic to a buyer–provider relationship, we collected data across multiple contracts and process types. We collected data on 26 Business Processes Offshoring contracts involving 19 clients and 6 BPO firms. We furnish below the details of the multiple BPO processes with corresponding values of inspection and production cost ratios and the quality of output. Table 2 presents the data.

In column (1) of the table, we captured the ratio of unit cost of inspection to process value and in column (2) we capture the ratio of unit cost of inspection to process value.[22] Columns (3) through (5) above are the predicted (model) threshold level and the quality of output and the actual quality of output. Fig. 6 shows the predicted and actual quality (for different values of the inspection threshold). Note that the predicted the quality tracks the actual quality quite closely.

In Table 3, we regress the values of the actual quality against the inspection cost and production cost ratios. The regression summary is shown below.

[18] We have been submitted to the strictest non-disclosure constraints and are not allowed to disclose the firm's identities or any other information that may lead to the identification of the firms or their clients.

[19] Scaling the deviation of the signal from a true value by the true value's magnitude is a commonly used econometric technique for problems in this domain.

[20] We used the same fractional weights as the weighted average of those parameter values for the firms in our survey.

[21] The data have been weighted by volume of processes. Firms 2 and 3 had error-check done twice a month by their clients, while Firm 1 had it done roughly once a week. We normalized for time by calculating the average over the LCM time period and stacking the periods sequentially.

[22] These ratios are I/V and c_o/V, respectively. These are average values for four quarters.

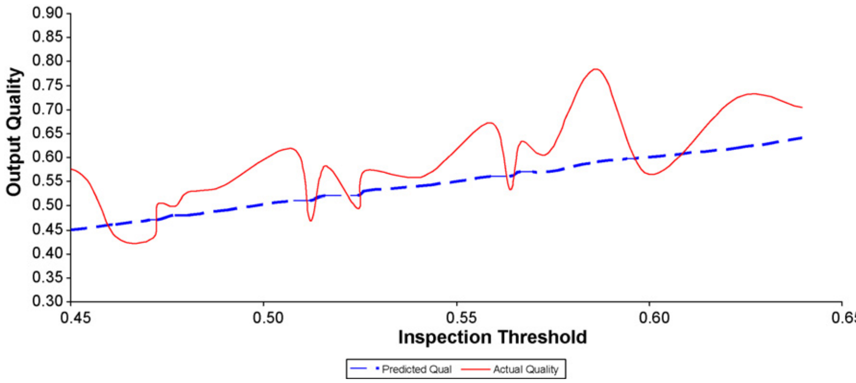

Fig. 6. Inspection threshold and output quality.

The regression coefficients enables the comparison between model's predicted values of output quality and the actual output quality that we captured from our survey for different values for inspection and production cost ratios as can be seen in Figs. 7 and 8.

The analysis shows that the model's predictions are borne out quite strongly in practice. The model explains adequately the quality outcomes in off-shore contracts.

5.2. The Precision-Quality Frontier

From Proposition 4, we know the optimal choice of precision in monitoring and the buyer's response choice of quality of output. What is of interest is the behavior of two key variables—the cost of inspection I and the cost of executing processes off-shore, c_o. If we substitute back the expanded form of $t = (I/c_o + V)$ in the expression in Proposition 4, we arrive the values θ^* and q^* as functions of I and c_o, which allows us to investigate how these two variables impact on the Precision-Quality Frontier.

5.3. Cost of inspection and optimal quality

The optimal output quality is decreasing in the buyer's cost of inspection. There are two effects at play here. Recall that optimal quality level picked by the provider is $q^* = \bar{q} + x^*$, where x^* is the *Safety Premium* that the provider pays (in terms of higher quality) to minimize chances of inspection. As inspection becomes more costly, we would expect that the buyer would be less willing to inspect – as a result, cetirus paribus the buyer will tolerate a lower expected quality before he inspects the provider's output – which in turn means the provider picks a lower value of x^*. Secondly, it turns out that Minimum Quality Threshold, $\bar{q}$ is also declining in the

Table 1
Monitoring precision vs. threshold of inspection

Monitoring precision	Threshold of inspection				
	Model	Firm 1	Firm 2	Firm 3	Weighted average empirical
81%	82.6%	77.3%	81.8%	83.6%	82.4%
82%	81.6%	76.3%	80.8%	82.6%	81.5%
83%	80.6%	75.3%	79.8%	81.6%	80.5%
84%	79.6%	74.3%	83.6%	77.6%	81.3%
85%	78.6%	73.3%	82.6%	76.6%	80.3%
86%	77.6%	72.3%	81.5%	81.6%	81.0%
87%	76.6%	63.0%	77.4%	80.6%	78.2%
88%	75.6%	62.0%	76.4%	73.6%	75.5%
89%	74.6%	61.0%	71.7%	72.6%	72.4%
90%	73.6%	60.0%	70.7%	71.6%	71.4%
91%	72.6%	63.5%	69.7%	78.6%	72.7%
92%	71.6%	62.5%	65.9%	77.6%	70.1%
93%	70.6%	61.5%	65.0%	74.1%	68.4%
94%	69.6%	60.5%	68.2%	73.1%	69.8%
95%	68.6%	66.4%	68.0%	69.6%	68.5%

Table 2
Inspection and production cost ratios and quality of output

I/V ratio (1)	c_o/V-ratio (2)	Predicted Minimum Quality Threshold (3)	Predicted quality of output-(model) (4)	Actual quality of output (5)
0.4	0.11	0.64	0.64	0.704
0.43	0.14	0.62	0.62	0.7254
0.46	0.15	0.60	0.60	0.564
0.49	0.15	0.57	0.57	0.6099
0.52	0.2	0.57	0.57	0.6327
0.55	0.2	0.54	0.54	0.5616
0.58	0.22	0.52	0.52	0.494
0.6	0.23	0.51	0.51	0.4692
0.61	0.26	0.52	0.52	0.5824
0.67	0.27	0.47	0.47	0.5029
0.66	0.27	0.48	0.48	0.528
0.64	0.3	0.51	0.51	0.6171
0.7	0.3	0.46	0.46	0.437
0.68	0.3	0.48	0.48	0.4992
0.63	0.33	0.53	0.53	0.5724
0.69	0.35	0.49	0.49	0.539
0.58	0.33	0.56	0.56	0.532
0.6	0.36	0.56	0.56	0.672
0.55	0.33	0.59	0.59	0.7847
0.8	0.38	0.42	0.42	0.4452
0.74	0.4	0.47	0.47	0.4324
0.88	0.41	0.38	0.38	0.418
0.81	0.4	0.42	0.42	0.4872
0.77	0.4	0.45	0.45	0.576
0.91	0.36	0.33	0.33	0.3399
0.8	0.35	0.41	0.41	0.5371

Table 3
Regression output: inspection cost and production cost ratios and actual quality

Regression coefficients

Model	Unstandardized coefficients		Standardized coefficients	t	Sig.
	B	S.E.	Beta		
1					
Constant	0.973	0.064		15.102	0.000
Inspection cost ratio	−1.004	0.179	−1.322	−5.597	0.000
Production cost ratio	0.772	0.267	0.683	2.893	0.008

Model summary

Model	R	R^2	Adjusted R^2	Std. error of the estimate
1	0.814(a)	0.663	0.634	0.06129

ANOVA[a]

Model	Sum of squares	d.f.	Mean square	F	Sig.
1					
Regression	0.170	2	0.085	22.646	0.000[b]
Residual	0.086	23	0.004		
Total	0.257	25			

[a] Dependent variable: actual quality.
[b] Predictors: (constant), C_o, I.

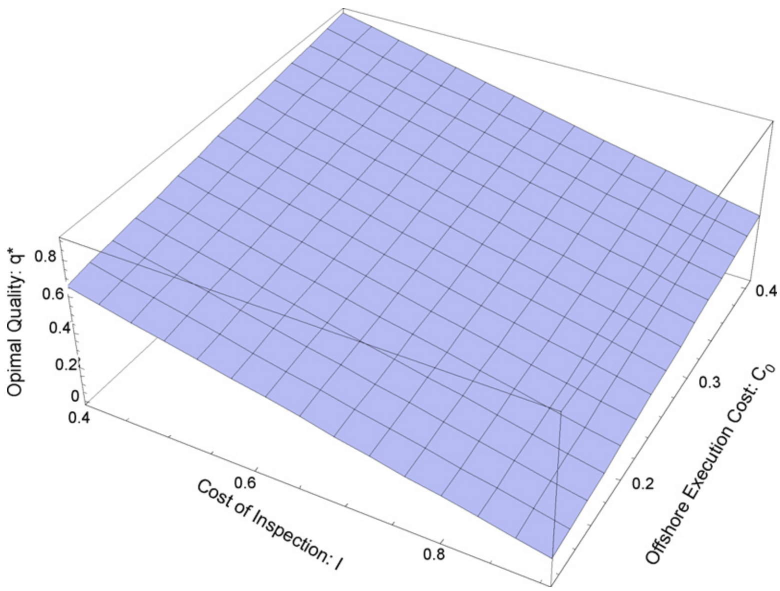

Fig. 7. Predicted quality for different levels of inspection and production cost ratios.

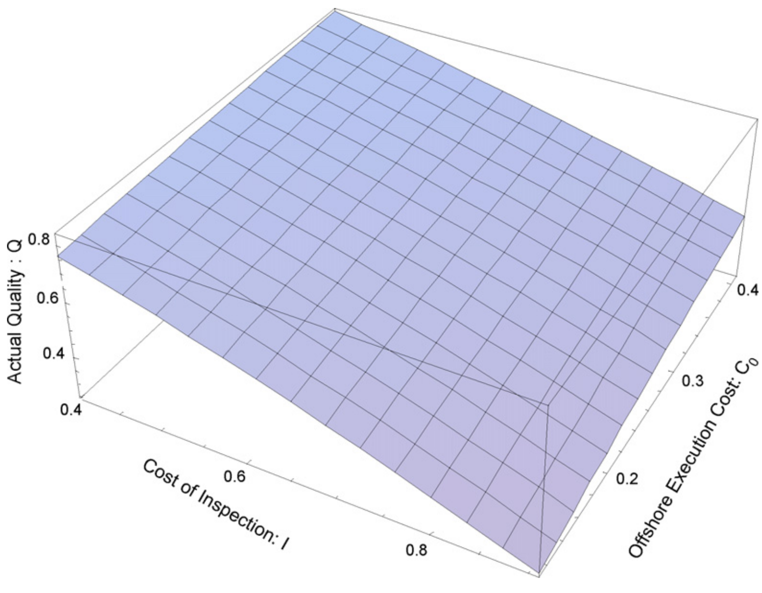

Fig. 8. Actual quality for different levels of inspection and production cost ratios.

buyer's cost of inspection—*I*. Thus, as the cost of inspection rises, the provider is able to 'get away' by providing a lower quality than he would otherwise.

5.4. Cost of executing processes off-shore (c_o) and the Precision-Quality Frontier

This parameter represents the value that is created by going off-shore to a lower wage regime. The provider's optimal quality declines as the cost of off-shore process execution. Increase in off-shore costs of production (given by c_o) make provision of higher quality less attractive to the provider even as the expected[23] loss from inspection go up as c_o increases. The loss of profit from paying a higher safety premium – i.e. choosing a

[23] The process may well be error free. Therefore, we analyze the expected loss from inspection—i.e. if there is an inspection and there is a error in the finished process.

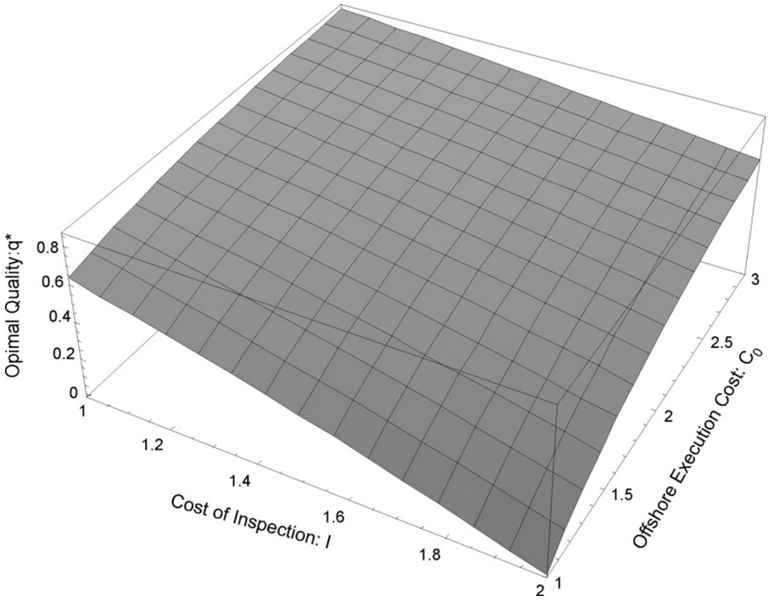

Fig. 9. Optimal choice of decision variables for the buyer and the provider. *Note*: To plot the figure above, we first made the substitutions: $c_o = f_1 V$ and $I = f_2 V$. Obviously, neither c_o nor I will ever take the values of V. These extreme values would ensure that the firm would not remain in business, leave alone attempt to take processes off-shore. We provided these values only for completion and to show that the decline in homogenous in the domain of the function.

higher q^* – becomes less attractive. Fig. 9 shows how the optimal quality declines in both I and c_o.

As we shall see in the section that follows, these observations have significant managerial implications for off-shore outsourcing.

6. Managerial implications

A key observation that was made by the head of an overseas firm a few years ago – which triggered this study – is how monitoring impacts off-shore outsourcing. The executive said that he found it surprising that the greater the complexity of the process that he executed for a client, the less likely that the client would inspect the output. He went on to add that for the more complex processes the effort level involved in inspection was obviously higher, but precisely for that reason he would have expected the opposite outcome. Indeed, this observation lies at the center of our research. When process complexity increases, the cost of inspection typically increases (Aron and Clemons, 2004). Yet there is often no attendant increase in the value—i.e. the price that the market would pay for the finished process. For instance, if a retail bank in the US or UK were to off-shore two processes, say, Transaction Processing and Account Management to a BPO service provider in China or Singapore, the value of the processes to the buyer – in this case the retail bank – is the same. This is the price that the retail bank charges by way of fees and/or commissions to its customers. However, the cost of inspecting the output of transaction processing (largely through automated means) is far lower than the cost of inspecting the quality of account management services. Yet, as our survey shows, firms are far more likely to inspect routine and less complex processes than the more complex ones with higher costs of inspection. As a result, we find that providers pick higher levels of quality for processes with lower inspection costs than they do for processes with higher inspection cost. In general, we find in our survey that if the complexity of a process increases without attendant increase in its value, the provider will pick a lower level of quality knowing that it is unlikely to invite inspection. We measured this effect across four firms (in addition to the 26 processes discussed earlier) and were able to get complete and accurate data from three of these.[24] The buyers were located in US and UK and the providers were in India and Mauritius. We collected 12 observations over a period of a year from each of the three firms and we found strong empirical support in favor of this proposition. Fig. 10 and Table 4 below illustrates our findings.

[24] After releasing some initial data, the fourth firm refused to provide any further data for policy reasons.

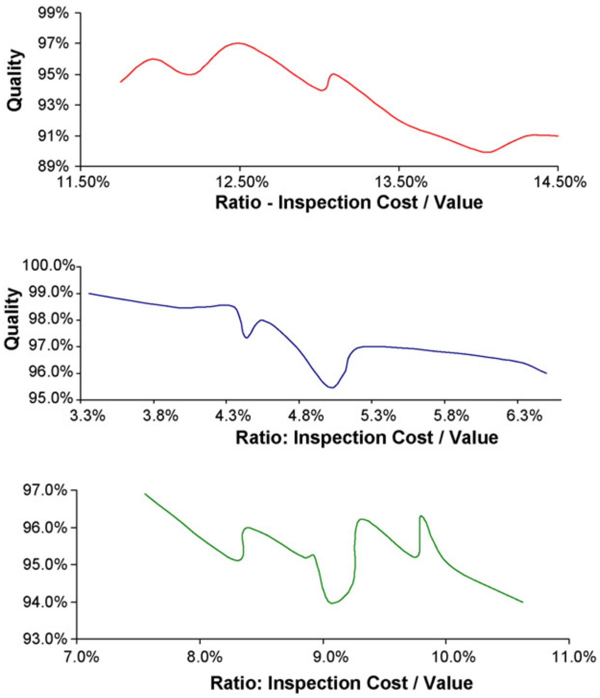

Fig. 10. Cost of inspection and provider's optimal quality: evidence from field research.

The results of the statistical and econometric tests[25] are furnished in Appendix 4 of Appendix of Empirical Results. The analysis as well as the model shows that when buyers outsource relatively more complex processes to off-shore providers, they should expect lower quality of output. Indeed, based on our findings a manager may consider outsourcing processes to *off-shore Captive Centers*, whose incentives are aligned with the buyers or *set up off-shore captive units with the mandate of inspecting these processes*. Several firms including Bank of America, General Electric, Citicorp and JP Morgan Chase bank are examining these options.

6.1. Monitoring greatly expands the scope of off-shore outsourcing

For a variety of processes, off-shore outsourcing was hitherto not possible either because of acute moral hazard problems or because the traditional division of in-house and outsourced options were not rich enough to span all the contingencies that could arise from outsourcing complex processes. However, with the advent of real-time, monitoring mechanisms it has become possible to add an additional layer of safe-guards – i.e. monitoring as a preventive measure that minimizes the need for inspection and penalties – to the conventional tools of governance.

[25] OLS with Huber-white standard errors.

Table 4
Cost of inspection vs. provider's optimal quality

Firm 1		Firm 2		Firm 3	
I/*V*-ratio	Quality	*I*/*V*-ratio	Quality	*I*/*V*-ratio	Quality
11.8%	94.5%	3.4%	99.0%	7.6%	96.9%
12.0%	96.0%	3.9%	98.5%	8.3%	95.1%
12.2%	95.0%	4.1%	98.5%	8.4%	96.0%
12.5%	97.0%	4.4%	98.5%	8.8%	95.2%
13.0%	94.0%	4.4%	97.4%	8.9%	95.3%
13.1%	95.0%	4.5%	98.0%	9.1%	94.0%
13.5%	92.0%	4.8%	97.0%	9.2%	94.5%
13.8%	91.0%	5.0%	95.5%	9.3%	96.2%
14.0%	90.0%	5.1%	96.0%	9.8%	95.2%
14.1%	90.0%	5.2%	97.0%	9.8%	96.3%
14.3%	91.0%	6.3%	96.5%	10.0%	95.0%
14.5%	91.0%	6.5%	96.0%	10.6%	94.0%

6.2. The impact of technology on the off-shore model

Technology, and information technology in particular, will influence the off-shoring model in the following ways. First, it lowers the cost of monitoring making many more processes suitable for off-shoring. In other words, technological developments allow firms to move over time to a higher level of precision at the same cost or lower cost than before. Thus, we find several 'high value-add' processes such as equity research, bond pricing, direct and indirect procurement, third-party logistics, etc., are being off-shored. A second and perhaps even more important impact the technology has is that *it can lower the costs of inspection of a complex process over a period of time*. Firms such as Wipro Technolgies Ltd., and OfficeTiger Inc. are developing technologies that would allow them to identify patterns and do '*intelligent inspection*' where verification of process quality is increasingly automated, thereby diminishing the need for costly managerial intervention. These technologies are being actively used by their buyers to minimize the cost of inspecting complex processes. Finally, technology helps buyers to coordinate and monitor the work of multiple vendors and move process volumes in real-time between vendors. AllsecTech, an India-based firm, monitors the work of several firms that provide call center support to US clients. AllsechTech Ltd.'s analysis has sometime been used within the same day to redirect call volumes to high performing vendors. Our research has addressed an important aspect of off-shore outsourcing, namely the impact of IT-enabled, real-time monitoring and its different facets on quality of output. We believe that there are a number of critical questions that are yet to be explored in this domain and we outline some possible extensions to this stream of research in the next section.

7. Conclusion and extensions

In this paper, we built a theoretical model to explain the findings of our field research consisting of several surveys of off-shore outsourcing practices. These surveys looked at various issues like cost structures, operational and strategic risks and technology-enabled emerging governance forms. The surveys further indicated the rise of a new hybrid governance mechanism, the extended organizational form, which combines the best features of the market (i.e., cost efficiency) and the firm (managerial control). Thanks to advances in information and communication technologies, buyer firms can exert managerial control (not just monitoring but actual control) over outsourced processes even as they take advantage of wage arbitrage. We are currently working on investigating how this hybrid organizational structure – wherein the agents (managers) of the client manage the employees of the providers – will impact the scope, efficiency and the pricing of off-shore outsourcing initiatives.

Our surveys have also indicated several other issues of interest; we would like to investigate the relative benefits of alternate governance mechanisms like JVs, BOTs[26] and Captive Centers. Another interesting issue that has emerged is how the boundaries of the firm are being changed by the emergence of new technologies that allow multiple firms to be linked through the same set of processes. We are investigating how an information architecture that can span multiple firms can be forged and what its impact will be on the nature and future of work in the modern corporation.

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[26] Build operate and transfer.

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