Quality, Incentives and Inspection Regimes in Offshore Service Supply Chains: Theoretical Predictions and Behavioral Outcomes

We investigate how the behavior of managers of offshore service supply chains results in outcomes that deviate from theoretically derived equilibria. We surveyed 81 service processes outsourced to offshore providers. We captured the key behavioral parameters of buyers and sellers in a principal-agent setting - these include the extent of inspection by the buyer, the supplier's investment in quality and the supplier's response to penalties and incentives. We develop a theoretical model that fully specifies the strategic behaviors of suppliers and buyers in a service supply chain and contrast this with actual behavioral outcomes captured in the survey. Our game theoretic model predicts that inspection is always more effective under pre-emptive commitment to inspection levels by the buyer. However, we found that, in practice, this is true only for agents with higher educational attainment; for agents with lower education and skill levels, the reverse is true -uncertainty around inspection levels leads to higher service quality. Further, while the model predicts that penalties for defects obviate the need for incentives for higher quality, we find that incentives do result in superior quality levels and their effectiveness depends on the agents' educational levels. Finally, in practice, inspection levels well below those predicted by theory are sufficient to ensure high quality. Possible explanations include reputation effects and risk-averse agents.

1. Overview

The term "offshore outsourcing" (or "offshoring" for short) is widely bandied about these days, particularly in the context of a debate on the tradeoff between efficiency gains leading to producer and consumer surplus versus labor losses. The term refers to the phenomenon of firms outsourcing their entire back-office operations to off-shore third party service providers who execute these processes for them. Expert estimates suggest that the off-shore BPO industry will grow from $123.6 billion in 2001 to over $230 billion in 2015 [Forrester (2001), Gartner (2002)]. The growth of off-shore outsourcing in recent times has been extraordinary not just in scale (as evidenced by the dollar volume of business) but also in scope: Currently, offshoring includes diverse services requiring a wide range of expertise such as equity research, financial analysis, transaction processing, insurance claims management and underwriting, supply chain coordination and tax accounting. With the rapid growth of outsourcing services, it is no wonder that, in their review of 50 years of research in *Management Science*, Chopra *et al* (2004) identify research issues in services, including business process outsourcing, as one of the drivers of future research in Operations Management.

Most recent studies are in agreement that there are significant differences in quality and efficiency outcomes between the best-managed offshore outsourcing initiatives and others. However, much of this discussion has been atheoretical, anecdotal and phenomenological in nature. The Operations literature has much to say on the subject of tradeoffs among different drivers of supply chain excellence, such as cost, quality, timeliness, reliability and variety. The tradeoff between *cost* and *quality* is central to the debate on the wisdom of offshore outsourcing of operations in service supply chains. Critics have argued that outsourcing key supply chain processes leads to a precipitous drop in service quality, not justified by short-term cost savings. However, very little by way of rigorous study (by which is meant mathematical modeling and/or empirical studies) has been done on this subject. This paper is an attempt to bridge this gap, specifically in the context of a widely perceived quality-cost tradeoff in outsourcing.

Two issues are critical in determining the quality of service of offshore providers: *Monitoring* (supervision to measure adherence to prescribed quality standards and performance metrics, and enforce these standards) and *Incentives* (to ensure that service providers make the right investments and tradeoffs in meeting customer requirements). In a service supply chain, unlike in the production of physical goods, the production and distribution of purely information goods involves just the flow of digitized information. This leads to some unique features (discussed below) in the governance of an offshore service supply chain, in relation to both monitoring and incentives. In the Sections that follow, we survey the state of praxis as well as the relevant academic theory.

2. Offshore Service Supply Chains: A survey of Praxis

Our study of the domain of offshoring services was two-pronged: First, we studied the processes of several companies recognized as leading providers world-wide, through personal interviews with their employees throughout their organizations and direct observation of their operations. This helped us gain an understanding of their practices, the challenges they face, and creative uses of IT to resolve issues peculiar (and critical) to the domain of offshore outsourcing of services. Second, in order to more rigorously capture these insights, and study the fundamental drivers of these businesses on a more scientific basis, our approach was to employ detailed survey instruments across the providers' hierarchy. In this Section, we survey some of the more interesting and idiosyncratic practices of some leading companies we studied, to motivate our theoretical model and empirical analysis.

One of the unusual features of the offshoring environment is the wide variance in the allocation of monitoring responsibility, which can be assigned solely to the supplier (as in more classical supply chains) or *jointly* (to varying degrees) to both the supplier and the buyer or, at the other end of the spectrum, almost entirely to the buyer. Particularly in the last case, the buyer make extensive use of recent advances in Information Technology (IT) and workflow software to calibrate the digital flow of information (and therefore work-flow) in order to achieve real-time monitoring. Incentives in the contract between supplier and buyer similarly take complex forms, since the lines of reponsibility can be blurred. For example, Telecorp Products, Inc.'s CentrEE Solution Suite's Quality Monitoring Module allows for managers to observe and asses the quality of agents' interactions 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 deployed by firms such as OfficeTiger, Wipro Technologies, HCL Ltd. (India), Beredium International (Mauritius) and 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. For example, OfficeTiger's Information Systems allow its clients to do quality control, real-time sampling for errors and random procedural checks, and to communicate with the supplier's project teams at the level of individual agents. These features are made available to clients across a wide range of services including financial analysis, desktop printing & document design, equity research and legal services. 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.

One example of the creative use of IT to forge deep supply chain links between supplier and buyer is 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 its client's premises. Allsec Tech's agents resolve supply chain coordination problems by tracking invoice clearance, payment and accounts receivables and payables (by querying data repositories that are located in Detroit and Chennai), and provide expert intervention where it is called for. *The agents of the provider work under the direct supervision of the provider's managers and virtual supervision of the buyer's (client's) managers.* It is important to note that this arrangement is offered for such of those processes where the cost of inspecting the provider's (AllsecTech Ltd.) quality of output directly is expensive. For several routine processes where the quality of output is easy to inspect, this form of governance is not featured in the outsourcing contract.

OfficeTiger's (OT) operations in India provider further evidence of the phenomenon that we investigate. The firm is in the business of providing expert judgment and analysis to its clients. OfficeTiger has established a mechanism - called 'The Program Office' - consisting of both the client's and OT's managers. Senior managers of the client and those of OT jointly review and manage the strategic, long term goals as well as day-to-day operational details. Further, OfficeTiger has developed real-time performance tracking and quality control systems which allows its clients to track the productivity and quality levels of teams of agents and where required, even the output of individual agents (employees of OT). It is possible for OT's clients -some of the leading Investment Banks in the US and UK - to use these systems to monitor their projects in fine grained detail and ask for modifications to operational procedure, agent assignment, QC mechanisms and project prioritization. About 40% of the firm's deadlines are under an hour long and often include work that involves research support, real-time scenario analysis or model-building with very little margin for error and little time to correct errors post-execution. The firm and its clients work off the same files, spreadsheets and data feeds; where necessary, they work iteratively. *Again, our survey of OT showed that such fine-grained joint monitoring and control mechanisms are created only for such of those processes and tasks where the provider's quality of output is not transparent or where inspection is costly (i.e., involving costly delay in the delivery of service to the client's customers). For more routine tasks, the governance of the contract resembles the traditional outsourcing contract with pre-specified price and post-inspection penalties* [Wharton (2004)].

Wipro has developed an in-house system called Veloci-Q to track the key success parameters of each team (cost, quality, productivity), down to each employee. Wipro's clients are given access to this tracking system via extranets which allow them to drill deep into Wipro and monitor the progress of their projects. Similarly, BPO service providers such as HCL Ltd. (based in India), I-OneSource (India), Beredium International (based in Mauritius) and

ITOne (based in Bangkok, Thailand) permit their offshore clients in Europe, US and Asia to use real-time monitoring mechanisms to track the execution of specific functions and key performance indicators in fine-grained detail, and jointly monitor these with their clients.

3. Offshore Service Supply Chains: Theory

Since offshoring of service supply chains is a fairly new phenomenon (at least, in any meaningful scale and scope), the academic literature that is directly relevant is relatively sparse. In this Section, we survey some of the related academic literature that touches upon various aspects of our problem domain.

Gopal et al. [20] carried out an empirical study with an Indian software vendor and identified several vendor-, client- and project-specific factors that determine the profits of software projects. Others (*cf* Bozarth et. al (1998), Cachon and Harker (2004), Gunasekaran and Ngai [22]) have studied outsourcing in a supply chain, albeit manufacturing, context. Bozarth et. al (1998) studied the various stages of the global outsourcing strategy evolution for 55 different manufacturers. Cachon and Harker (2004) analyze outsourcing under scale economies within a game-theoretic framework, and conclude that scale economies provide a strong incentive for outsourcing even without cost advantages. Gunasekaran and Ngai (2005) look at the build-to-order supply chain management strategy that has improved the competitiveness of many organizations by leveraging the advantages of outsourcing and IT. Our focus, unlike these studies, is in the context of *service* supply chains, which features many fundamental differences. In this context, our paper focuses on the role of contracting to ensure service quality. There are fundamental differences in the way contracts play out in manufacturing versus service supply chains. For instance, inventories play a key role in buyer-supplier contracts in a manufacturing context (*cf* Anand *et al* (2005)), whereas it is a truism that one cannot 'inventory' services, and so, service processes are invariably time-critical. For a survey of the academic literature and an elegant classification of different kinds of contracts for supply chain coordination, Cachon (2003) is the definitive reference.

There has been some previous research exploring the relationships between contracting and product quality. Reyniers *et al* (1992, 1995a and 1995b) model 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 derive 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 supplier's output. These papers either exogenously fix the buyer-supplier contract or study settings in which the non-cooperative solution is first-best (i.e., maximizes overall supply chain profits). In contrast, Baiman et al. (2000) develop a model in which under reasonable contracting assumptions, the first-best solution is not achievable. However, in their model, they make no distinction between observability and contractibility.

Our objectives are two-fold. Firstly, based on a wide-ranging study of around 80 processes across three offshore supplier firms, we develop a theoretical model of the contractual structures observed in practice between a buyer/customer and an offshore supplier.[1] We observe three key control variables used in practice (and implemented as part of the terms of contract) by service firms outsourcing upstream operational processes, to monitor quality and implement performance controls. These are: *(i) Monitoring or inspection at the transaction (process) level,* to measure quality; *(ii) Performance-based incentives* for meeting quality targets; and *(iii) Penalties* for losses due to upstream errors. Associated with the inspection is a *sampling probability*, which measures the percentage of transactions scrutinized by the buyer or a trusted third party. Sampling is almost always randomized to maximize compliance with quality standards; however, the inspection probability is often preannounced (in the terms of trade) and equally often at the sole discretion of the buyer. The advantages of preemptive commitment to a sampling probability are obvious. In the context of a 'game' between supplier and buyer, such a commitment makes the threat of sampling credible, and further, gives the buyer an 'early-mover' advantage *á l$\hat{a}$* Stackeberg. Thus the buyer can influence the quality levels (and measures) put in place by the supplier for his processes. On the other hand, when inspection is costly, the buyer may be able to shave inspection costs by not pre-commiting to a sampling probability; also, he retains a further element of surprise by varying the actual sampling probability. Our game-theoretic model (in Section 4) captures the roles of incentives, penalties and sampling probabilities in a contract between a buyer and a supplier. Further, we develop two models that differ only in respect to their *compliance regimes*, reflecting the two popular implementations of inspection discussed above. In the *preemptive compliance regime*, the sampling probability is specified *a priori* by the buyer, in the terms of the contract. In the *reactive compliance regime*, the buyer arbitrarily sets a sampling probability after the supplier delivers a certain volume of transactions. We derive

[1]Our study in fact encompassed 107 processes across three supplier firms. For 26 of these processes, the data were either incomplete or unreliable, or we felt that the constraints on data confidentiality placed by the client through the supplier firm were too stringent to serve our objectives. Therefore we pruned the data to 81 processes for which the data was usable.

the values of the bonuses, sampling probabilities and supplier quality levels in closed form, in the equilibria arising in each compliance regime. We compare their values, and study the drivers of these parameters. We also derive and compare the supplier's and buyer's expected profits under each regime.

Building on these results, in Section 5 we investigate how the behavior of managers of offshore service supply chains results in outcomes that *deviate* from theoretically derived equilibria. We surveyed 81 service processes outsourced to offshore providers. We captured the key behavioral parameters of buyers and sellers in a principal-agent setting - these include the extent of inspection by the buyer, the supplier's investment in quality and the supplier's response to penalties and incentives. Our game-theoretic model predicts that inspection is always more effective under pre-emptive commitment to inspection levels by the buyer. However, we found that, in practice, this is true only for agents with higher educational attainment; for agents with lower education and skill levels, the reverse is true– uncertainty around inspection levels leads to higher service quality. Further, while the model predicts that penalties for defects obviate the need for incentives for higher quality, we find that incentives do result in superior quality levels and their effectiveness depends on the agents' educational levels. Finally, in practice, inspection levels well below those predicted by theory are sufficient to ensure high quality. Possible explanations include reputation effects and risk-averse agents.

4. Models

We develop two models that differ only in respect to their *compliance regimes*. In the *preemptive compliance regime*, the sampling probability is specified *a priori* by the buyer, in the terms of the contract. In the *reactive compliance regime*, the buyer can choose a sampling probability after the supplier delivers a certain volume of transactions.

A supplier (provider) and a buyer (client) constitute the supply chain for a service. The value received by the buyer from his end customers by delivering a unit of service of adequate quality is V. He pays the supplier the value P $(< V)$ for each unit of service delivered. P is specified exogenously, e.g. based on competitive forces or relative bargaining power. The supplier can set his quality/effort level $\theta \in [0, 1]$, which is observable by both parties but not contractible, for reasons discussed in Section 2. θ can be interpreted as the *average* quality level of a process performed or service delivered to an end-customer; however, the actual quality is binary: the service provided meets the quality threshold with probability θ, and fails to do so with probability $(1-\theta)$. Thus, the buyer will obtain an expected revenue of $V \cdot \theta$, by sourcing a unit of service of quality θ from the supplier. The supplier's cost of producing a unit of the product is convex in the quality parameter θ, and is given by $c \cdot \theta^2$. It is well-known [*cf* Forrester (2003c)] that in this industry, $V \gg c$ (which is after all the primary motive for outsourcing most processes), and so it is reasonable to assume that $V > 2c$.

The buyer has a choice of inspecting each unit of the supplied good or not, to determine the exact quality, at a unit cost $I \approx c$ (hence, $V > 2I$).[2] Let f be the sampling probability ($0 \leq f \leq 1$), set by the buyer. Then, f is both the fraction of units inspected and the probability of inspection of an arbitrary unit of service unit. If a unit of service is inspected and found to be error-free, an incentive payment of λ is made by the buyer to the supplier. However, if the service or process is found to be defective, the supplier compensates the buyer to the tune of his lost gross margins, viz., $(V-P)$. The preceding is common to both compliance regimes. We discuss the differences between the two regimes and derive the equilibria in each, below.

4.1 Compliance Regime 1:Preemptive Commitment to an Inspection Level

The preemptive commitment regime has the following timeline. First, the buyer specifies λ and f in the terms of contract. Then, the supplier responds by setting his quality/effort level θ ($\in [0,1]$). Finally, the buyer can choose to inspect each unit of the supplied good at the unit inspection cost I. If the product is defective, the buyer is compensated by the supplier for lost revenues (given by $(V-P)$). If the product is found to be error-free, the supplier is paid the additional bonus λ, in addition to P.

4.1.1 Supplier's problem

Under Inspection (I), the supplier makes $(P+\lambda- c\cdot\theta^2)$ with probability θ (under no error) and $(-(V-P)- c\cdot\theta^2)$ with probability $(1-\theta)$ (when the product is discovered to be defective). Thus, the supplier's expected payoff under inspection is[3] $\pi_S(\theta|I) = (P+\lambda-c\cdot$

[2] Typically, $I \in (0,c]$ in a wide range of industries in which outsourcing is common. Most often, inspection of a transaction involves replicating the entire process of that transaction, more or less, and so $I \approx c$. [Also see Forrester (2003c)]

[3] We use the subscripts S and B to denote the supplier and buyer respectively.

$\theta^2) \cdot \theta + (-(V-P) - c \cdot \theta^2) \cdot (1-\theta)$, which simplifies to $\theta \cdot (P + \lambda - c \cdot \theta) - (V-P)$. Under Non-Inspection (NI), the supplier's profit is simply $\pi_S(\theta|NI) = P - c \cdot \theta^2$. Given that f is the fraction inspected by the buyer (or equivalently, the probability that any given unit is inspected, the supplier optimizes over θ to maximize his expected profits, given by

$$\begin{aligned} \pi_S(\theta) &= f \cdot \pi_S(\theta|I) + (1-f) \cdot \pi_S(\theta|NI) \\ &= f \cdot \theta \cdot (V+\lambda) - f \cdot V + P - c \cdot \theta^2. \end{aligned} \tag{1}$$

The profit $\pi_S(\theta)$ is concave in θ, and the optimal value of θ is given by

$$\theta^* = \min\left\{\frac{f \cdot (V+\lambda)}{2c}, 1\right\} = \begin{cases} \frac{f \cdot (V+\lambda)}{2c}, & \text{if } f \cdot (V+\lambda) > 2c; \\ 1, & \text{otherwise.} \end{cases} \tag{2}$$

4.1.2 Buyer's problem

If the buyer inspects a unit, and it is defective (which is with probability $(1-\theta)$), his net profit is $(V-P-I)$; if it is not defective (which is with probability θ), his net profit is $(V-P-\lambda-I)$, since λ is the compensation bonus paid to the supplier under inspection when the item is not defective. Thus, $\pi_B|I = V - P - I - \lambda \cdot \theta$. Expected profits under Non-Inspection is $\pi_B|NI = V \cdot \theta - P$. Suppose f is the fraction of units inspected (and hence, the probability that any one random unit is inspected). The buyer's expected profits from buying and selling that unit are:

$$\begin{aligned} \pi_B(\lambda, f \mid \theta) &= f \cdot (V - P - I - \lambda \cdot \theta) + (1-f) \cdot (V \cdot \theta - P) \\ &= f \cdot V \cdot (1-\theta) - f \cdot (I + \lambda \cdot \theta) + V \cdot \theta - P, \end{aligned} \tag{3}$$

where θ is specified in (2). Thus, constrained by the supplier's reaction function $\theta = \min\left\{\frac{f \cdot (V+\lambda)}{2c}, 1\right\}$, the buyer chooses λ (≥ 0) and $f \in [0,1]$ to maximize his own profits. Theorem 1 derives the unique subgame perfect equilibrium for the entire game.

Theorem 1 *Consider the following game, wherein the buyer first picks* λ (≥ 0) *and* f $\in [0.1]$, *and the supplier then sets his process quality* θ, *also* $\in [0.1]$.

1. *The* unique subgame-perfect equilibrium *for the entire game is given by:*

$$\begin{cases} f^* = \frac{2c}{V}, \lambda^* = 0 \textit{ and } \theta^* = 1, & \textit{when } \frac{V}{2c} > 1 + \frac{I}{V}; \\ f^* = \frac{1}{2} + \frac{c}{V} - \frac{c \cdot I}{V^2}, \lambda^* = 0 \textit{ and } \theta^* = \frac{1}{2} + \frac{V}{4c} - \frac{I}{2V}, & \textit{otherwise.} \end{cases}$$

2. The buyer's profits in equilibrium are:

$$\pi_B = \begin{cases} V - \frac{2cI}{V} - P, & \text{when } \frac{V}{2c} > 1 + \frac{I}{V}; \\ \frac{V^2}{8c} + \frac{V-I}{2} + \frac{c}{2} \cdot \left(1 - \frac{I}{V}\right)^2 - P, & \text{otherwise.} \end{cases}$$

The supplier's profits in equilibrium are:

$$\pi_S = \begin{cases} P - c, & \text{when } \frac{V}{2c} > 1 + \frac{I}{V}; \\ P - c \cdot \left(\frac{1}{2} + \frac{V}{4c} - \frac{I}{2V}\right) \cdot \left(\frac{3}{2} - \frac{V}{4c} + \frac{I}{2V}\right), & \text{otherwise.} \end{cases}$$

Proof: The buyer solves two maximization subproblems (corresponding to each possible value of θ from the supplier's reaction function, given by $\theta = \min\left\{\frac{f\cdot(V+\lambda)}{2c}, 1\right\}$), and picks the values of λ (≥ 0) and $f \in [0,1]$ that maximize his own profits. The two subproblems are:

$$(1)\ \max_{\lambda,f} \pi_B (\lambda, f \mid \theta = 1) \text{ such that } \frac{f\cdot(V+\lambda)}{2c} \geq 1; \text{ and} \tag{4}$$

$$(2)\ \max_{\lambda,f} \pi_B \left(\lambda, f \mid \theta = \frac{f\cdot(V+\lambda)}{2c}\right) \text{ such that } \frac{f\cdot(V+\lambda)}{2c} < 1. \tag{5}$$

We solve each separately below. The complete specification of subproblem (1) is obtained by setting $\theta = 1$ in (4). $\pi_B(\lambda, f \mid \theta = 1) = V - f\cdot(I+\lambda) - P$ is decreasing in f for every feasible λ, and so the minimum f that satisfies the constraint $\frac{f\cdot(V+\lambda)}{2c} \geq 1$ is $f = \frac{2c}{V+\lambda}$. Plugging this value back into the profit expression gives $\pi_B(\lambda, f \mid \theta = 1) = V - 2c \cdot \left(\frac{I+\lambda}{V+\lambda}\right) - P$, which is decreasing in λ in the range $\lambda \geq 0$. Thus the optimal solution for subproblem (1), wherein $\theta^* = 1$, is $f^* = \frac{2c}{V}$ and $\lambda^* = 0$. The buyer's profits are $\pi_B(\lambda^*, f^* \mid \theta = 1) = V - \frac{2cI}{V} - P$.

Subproblem (2) is more complex and requires optimization using the Lagrangian and the Kuhn-Tucker conditions. This problem is (using expression (3)

$$\max_{\lambda,f} \pi_B \left(\lambda, f \mid \theta = \frac{f\cdot(V+\lambda)}{2c}\right) = f\cdot(V-I) + \frac{f\cdot(V+\lambda)}{2c} \cdot ((1-f)V - f\cdot\lambda) - P,$$

where

$$f\cdot(V+\lambda) < 2c \tag{6}$$

and

$$\lambda \geq 0. \tag{7}$$

(Rather than explicitly enforcing the additional constraint $f \in [0,1]$, we will check that the solution(s) to this problem satisfy the constraints on the range of f.) The Lagrangian is given by

$$\mathcal{L}(\lambda, f, \mu, \beta) = f\cdot(V-I) + \frac{f\cdot(V+\lambda)}{2c} \cdot ((1-f)V - f\cdot\lambda) - P + \mu\cdot[2c - f\cdot(V+\lambda)] + \beta\cdot\lambda,$$

where $\mu, \beta \geq 0$. The Kuhn-Tucker first order necessary conditions are:

$$\frac{\partial \pounds}{\partial f} = (V - I) + \frac{(V+\lambda)}{2c} \cdot [(1-2f)V - 2f \cdot \lambda] - \mu \cdot (V+\lambda) = 0, \tag{8}$$

$$\frac{\partial \pounds}{\partial \lambda} = \frac{f}{2c} \cdot [-f \cdot (V+\lambda) + (1-f) \cdot V - f \cdot \lambda] - \mu \cdot f + \beta = 0, \tag{9}$$

and the complementary slackness conditions:

$$\mu \cdot [2c - f \cdot (V+\lambda)] = 0, \text{ where } \mu \geq 0, \tag{10}$$

and

$$\beta \cdot \lambda = 0, \text{ where } \beta \geq 0. \tag{11}$$

Solving the simultaneous equations (8)-(11) gives the following candidate solutions:

1. $\beta = \mu = f = 0; \lambda = \frac{2c(I-V)-V^2}{V}$,which fails because this requires that $\lambda < 0$.

2. $\mu = \lambda = 0; f = \frac{V^2+2c(V-I)}{2V^2} = \frac{1}{2} + \frac{c}{V} - \frac{c \cdot I}{V^2}; \beta = \frac{(V-I)\cdot\left[V^2+2c(V-I)\right]}{2V^3}$. The conditions $\beta \geq 0$ and $0 \leq f \leq 1$ are always satisfied. However, $\theta = \frac{f\cdot(V+\lambda)}{2c} = \frac{1}{2} + \frac{V}{4c} - \frac{I}{2V}$. The condition applicable for subproblem (2) is that $\theta < 1$, which means that $\frac{V}{2c} < 1 + \frac{I}{V}$. So this solution is feasible whenever $\frac{V}{2c} < 1 + \frac{I}{V}$. Substituting into expression (3) , we get that the buyer's profits are $\pi_B = V - \frac{2cI}{V} - P$.

3. $\lambda = 0; f = \frac{2c}{V}; \beta = \frac{2c(V-I)}{V^2}; \mu = \frac{V}{2c} - \frac{I}{V} - 1$. Again, the conditions $\beta \geq 0$ and $0 \leq f \leq 1$ are always satisfied. However, $\mu \geq 0 \iff \frac{V}{2c} \geq 1 + \frac{I}{V}$. Also, $\theta^* = 1$. Again, plugging these values into expression (3) and simplifying, $\pi_B = \frac{V^2}{8c} + \frac{V-I}{2} + \frac{c}{2} \cdot \left(1 - \frac{I}{V}\right)^2 - P$. At the point $\frac{V}{2c} = 1 + \frac{I}{V}$, note that the solutions (2) and (3) are identical.

Combining the above results, the solution to subproblem (2) is

$$\begin{cases} f^* = \frac{2c}{V}.\lambda^* = 0 \text{ and } \theta^* = 1, & \text{when } \frac{V}{2c} \geq 1 + \frac{I}{V}; \\ f^* = \frac{1}{2} + \frac{c}{V} - \frac{c \cdot I}{V^2}, \lambda^* = 0 \text{ and } \theta^* = \frac{1}{2} + \frac{V}{4c} - \frac{I}{2V}, & \text{otherwise.} \end{cases}$$

The buyer's profits are, correspondingly,

$$\pi_B = \begin{cases} V - \frac{2cI}{V} - P, & \text{when } \frac{V}{2c} \geq 1 + \frac{I}{V}; \\ \frac{V^2}{8c} + \frac{V-I}{2} + \frac{c}{2} \cdot \left(1 - \frac{I}{V}\right)^2 - P, & \text{otherwise.} \end{cases}$$

It is easily checked that the second-order Kuhn-Tucker conditions hold– the objective function and constraints are smooth and regular in the parameter domains. When $\frac{V}{2c} \geq 1 + \frac{I}{V}$, note that the solutions to subproblem (1) and subproblem (2) are identical. When

$\frac{V}{2c} < 1 + \frac{I}{V}$, the buyer chooses between the equilibria of the two subproblems (by setting λ and f appropriately) to maximizes his profits. The difference in buyer profits in this case, between the solutions of subproblem (1) and subproblem (2), is given by

$$\begin{aligned} \Delta\pi_B &= \left[\frac{V^2}{8c} + \frac{V-I}{2} + \frac{c}{2}\cdot\left(1-\frac{I}{V}\right)^2 - P\right] - \overset{\Box}{} V - \frac{2cI}{V} - P\Big] \\ &= \frac{\left(V^2 - 2c(V+I)\right)^2}{8cV^2} > 0. \end{aligned}$$

(by setting λ and f appropriately)

Hence, when $\frac{V}{2c} < 1 + \frac{I}{V}$, the buyer will prefer to play equilibrium of subproblem (2), by setting λ and f as above. This completes the proof of part (1) of the Theorem. Buyer profits of part (2) of the Theorem are obtained by plugging in the parameter values from part (1) into the expression (3) for buyer profits. The supplier's profits of part (2) of the Theorem are obtained by plugging in the parameter values from part (1) into (1). ♣

4.2 Compliance Regime 2: Reactive Inspection Level

The problem structure is identical to the Preemptive Compliance regime, but the timeline differs in one crucial aspect. The buyer specifies λ early, as before, but not f,the probability of inspection. Thus the supplier sets his quality/effort level θ in response to λ, *anticipating* f. Then the buyer, having observed θ, tailors his choice of inspection level f to maximize his own profits. The solution to this game is by backward induction.

4.2.1 Buyer's optimal inspection level

Expected profits for the buyer when he chooses to inspect an unit are: $\pi_B|I = V - P - I - \lambda\cdot\theta$ (derived as before). Under No Inspection (NI), his profits are $\pi_B|NI = V\cdot\theta - P$. The buyer's expected profits from an inspection level f for given values of λ and θ are:

$$\begin{aligned} \pi_B(f \quad | \quad \lambda,\theta) &= f\cdot(\pi_B|I) + (1-f)\cdot(\pi_B|NI) \\ &= f\cdot V\cdot(1-\theta) - f\cdot(I+\lambda\cdot\theta) + V\cdot\theta - P, \end{aligned} \tag{12}$$

which is the same as equation (3). It is easy to check that the optimal f *is given by:

$$f^* = \begin{cases} 0, & \text{when } \theta \geq \frac{V-I}{V+\lambda}; \\ 1, & \text{otherwise.} \end{cases} \tag{13}$$

Thus, already we see one advantage of the Reactive Compliance regime: Inspection is costly to the buyer in two ways– through the Inspection cost I and the Performance Incentive

λ paid to the supplier to reward high quality. Inspection is beneficial in dollar terms through the penalty $(V-P)$ levied for shoddy service from the buyer, which avoids paying for a bad quality service that the market won't bear (Recall that the revenue from a unit of service is precisely $V \cdot \theta$). Since the buyer observes θ, he prefers inspection only if θ is small, leading to a large percentage of defects. The result is that the buyer inspects *all* or *none* of the units supplied. Of course, the supplier will factor this in setting θ, particularly if he wishes to minimize buyer-driven inspection.

4.2.2 Supplier's response

For any θ, under inspection, the supplier's payoff is $\left(P+\lambda-c\cdot\theta^2\right)$ if the inspected unit is not defective (which is with probability θ), and $\left(-(V-P)-c\cdot\theta^2\right)$ if the inspected unit is defective (which occurs with probability $(1-\theta)$. Thus, the supplier's profit under inspection is $\pi_S|I=\theta\cdot\left(P+\lambda-c\cdot\theta^2\right)+(1-\theta)\cdot\left(-(V-P)-c\cdot\theta^2\right)=P+\theta\cdot\lambda-(1-\theta)\cdot V-c\cdot\theta^2$. Under Non-Inspection, the supplier's profit is simply $\pi_S|NI=P-c\cdot\theta^2$. Thus the supplier prefers inspection if and only if $\theta\cdot\lambda-(1-\theta)\cdot V\geq 0$; i.e., $\theta\geq\frac{V}{V+\lambda}$. However, recall from the equation (13) that the buyer will inspect the product iff $\theta<\frac{V-I}{V+\lambda}$. This leads to the following result.

Lemma 1 *The unique equilibrium for the Reactive Regime subgame for any* $\lambda\geq 0$ *is* $f^*=0$ *and* $\theta^*=\frac{V-I}{V+\lambda}$*; i.e., Non-Inspection is the unique equilibrium for all* λ.

Proof: At the point $\left(f^*=0;\theta^*=\frac{V-I}{V+\lambda}\right)$, the supplier's profits are $\pi_S\left(\frac{V-I}{V+\lambda}\right)=P-c\cdot\left(\frac{V-I}{V+\lambda}\right)^2$. We will show that this is the unique equilibrium by a process of elimination, by examining the different possible values of θ and showing that these choices are dominated for the supplier by $\theta^*=\frac{V-I}{V+\lambda}$.

Case 1: $\theta\in\left[0,\frac{V-I}{V+\lambda}\right)$. In this range, $f^*=1$ by equation (13). So the supplier will make $\pi_S\left(\theta|\theta\in\left[0,\frac{V-I}{V+\lambda}\right)\right)=\pi_S\left(\theta|I\right)=P+\theta\cdot\lambda-(1-\theta)\cdot V-c\cdot\theta^2$ (since inspection is guaranteed).

$$\frac{\partial\pi_S\left(\theta|\theta\in\left[0,\frac{V-I}{V+\lambda}\right)\right)}{\partial\theta}=(V+\lambda)-2c\cdot\theta>0,\forall\theta\in[0,1)\,.$$

Hence,

$$\begin{aligned}\pi_S\left(\theta|\theta\in\left[0,\frac{V-I}{V+\lambda}\right)\right) &\leq \pi_S\left(\frac{V-I}{V+\lambda}\right)\\ &= P-c\cdot\left(\frac{V-I}{V+\lambda}\right)^2+\left(\frac{V-I}{V+\lambda}\right)\cdot\lambda-\left(1-\left(\frac{V-I}{V+\lambda}\right)\right)\cdot V\end{aligned}$$

$$
\begin{aligned}
&= \pi_S\left(\frac{V-I}{V+\lambda}\right)+\frac{(V-I)\cdot\lambda - V\cdot(\lambda+I)}{V+\lambda} \\
&< \pi_S\left(\frac{V-I}{V+\lambda}\right).
\end{aligned}
$$

Case 2: $\theta \in \left[\frac{V-I}{V+\lambda}, 1\right]$. In this range, $f^* = 0$ by equation (13). So the supplier will make $\pi_S\left(\theta | \theta \in \left[\frac{V-I}{V+\lambda}, 1\right]\right) = \pi_S(\theta | NI) = P - c \cdot \theta^2$, which is strictly decreasing in θ. Hence, $\pi_S\left(\frac{V-I}{V+\lambda}\right) > \pi_S(\theta), \forall \theta > \left(\frac{V-I}{V+\lambda}\right)$.

Combining the results of cases (1) and (2), we get: $\pi_S\left(\frac{V-I}{V+\lambda}\right) > \pi_S(\theta), \forall \theta \in [0,1]$. Hence $\theta^* = \frac{V-I}{V+\lambda}$ (and correspondingly, $f^* = 0$) is the unique equilbrium for the Reactive Regime subgame, $\forall \lambda \geq 0$. ♣

4.2.3 Equilibrium for the Reactive Compliance regime

Lemma (1) proved above makes it easier for us to derive the equilibrium for the entire Reactive Compliance regime, in which the buyer chooses λ (≥ 0), followed by the supplier's choice of θ and subsequent decision of inspection/non-inspection by the buyer. Theorem 2 derives the unique subgame perfect equilibrium for the entire Reactive Compliance game.

Theorem 2 *Consider the following game, wherein the buyer first picks λ (≥ 0), the supplier then sets his process quality $\theta \in [0.1]$, and finally, the buyer sets his inspection probability f , also $\in [0.1]$.*

1. *The* unique subgame-perfect equilibrium *for the entire game is: $\lambda^* = f^* = 0$, and $\theta^* = 1 - \frac{I}{V}$.*
2. *Correspondingly, the buyer's profits are $\pi_B = V - P - I$ and the supplier's profits are $\pi_S = P - c \cdot \left(1 - \frac{I}{V}\right)^2$.*

Proof: Plugging the results proved in Claim (**??**), i.e., $f^* = 0$ and $\theta^* = \frac{V-I}{V+\lambda}$, in the buyer's profit expression (12), we get:

$$\pi_B(\lambda) = V \cdot \left(\frac{V-I}{V+\lambda}\right) - P; \text{ for } \lambda \geq 0.$$

This is decreasing in λ, and hence maximized at $\lambda^* = 0$. Thus, the buyer's profits are $\pi_B = V - P - I$, and $\theta^* = 1 - \frac{I}{V}$. Since $f^* = 0$,the equilibrium results in no inspection, under which the supplier's profit is simply $\pi_S = P - c \cdot \theta^2 = P - c \cdot \left(1 - \frac{I}{V}\right)^2$. ♣

4.3 Comparisons of Compliance Regimes: Theoretical

In this Section, we theoretically compare the equilibria and profits under the two compliance regimes. The Propositions below are derived from the key Theorems 1 and 2. Subsequently, in Section 5, we will compare these results to observed behavior (based on field data).

Proposition 1 *The Preemptive compliance regime always leads to strictly superior service quality than the Reactive compliance regime.*

Proof: From Theorems 1 and 2, $\theta^*_P = 1$ when $\frac{V}{2c} > 1 + \frac{I}{V}$, and $\frac{1}{2} + \frac{V}{4c} - \frac{I}{2V}$ otherwise; $\theta^*_R = 1 - \frac{I}{V}$.[4] The result follows straight-forwardly when $\frac{V}{2c} > 1 + \frac{I}{V}$, since $\theta^*_P = 1 > \theta^*_R$. When $\frac{V}{2c} \leq 1 + \frac{I}{V}$, $\theta^*_P - \theta^*_R = \left(\frac{1}{2}\right) \cdot \left(\frac{V}{2c} - 1 + \frac{I}{V}\right) > 0$. ♣

Proposition 2 *In both the Preemptive and the Reactive compliance regimes, the optimal quality- inducing incentives are always zero.*

Proof: This follows from Theorems 1 and 2, which show that $\lambda^* = 0$ in both regimes. ♣

What Proposition 2 shows is that the combination of *inspection* and a *moderate penalty structure* consisting of exact compensation for the buyer's losses due to defects ensures optimal quality. The buyer does not need to resort to the added payout of quality-rewarding incentives.

Proposition 3, next, is consistent with our intuition stemming from Proposition 1: The superior service quality provided by the supplier under the pre-emptive compliance regime is driven by the buyer's choice of a higher sampling probability under that regime.

Proposition 3 *The sampling fraction depends on the compliance regime. It is higher under Preemptive compliance than under Reactive compliance.*

Proof: This is straight-forward from Theorems 1 and 2. ♣

The final Proposition in this Section compares the expected buyer and supplier profits under the two regimes.

[4] We will use the subscript P to refer to the pre-emptive compliance regime and R for the Reactive compliance regime.

Proposition 4 *The buyer is strictly better off, and hence prefers, the Preemptive compliance regime to the Reactive compliance regime. However, the supplier strictly prefers the Reactive compliance regime.*

Proof: The results are derived from the profit expressions for the buyer and the supplier of Theorems 1 and 2. The algebra is omitted. ♣

Proposition 4 shows that early commitment to the sampling probability on the part of the buyer is beneficial to him– leading to higher supplier service quality and ultimately higher buyer profits. On the other hand, the supplier gets away with lower quality (and higher profits) when the buyer's sampling probability is set reactively rather than preemptively. In other words, under the Reactive compliance regime, the buyer cannot commit to a higher sampling probability than the one that arises in the equilibrium of Theorem 2 ($f_R^* = 0$) – in the presence of inspection costs, such a commitment is simply not credible unless it is preemptively set as part of the terms of contract. Thus, neither regime leads to a Pareto-dominant equilibrium. Given the opposing preferences of the buyer and the supplier, we would expect that the choice of regime would depend on the *relative bargaining power* of the two firms (in addition to process specifics such as cost of quality and inspection, and customer valuations and prices). In practice, we observe that both types of compliance regimes are widely deployed. The next Section reports on our empirical analysis of behavioral outcomes across nearly eighty service supply chain processes.

5. Behavioral Outcomes: Empirical Analysis

The analysis of the model in the previous Section produced three important results: *(i)* the preemptive regime always leads to better quality (Proposition 1); *(ii)* the optimal quality-inducing incentives are always zero; i.e., the buyer need not offer any incentives, and the combination of inspection with penalties will induce the optimal quality of output (Proposition 2) and *(iii)* the actual sample size depends on the nature of the regime (Preemptive or Reactive) (Proposition 3). When we investigate the actual behavior of managers, we find that there are some significant deviations from theoretical predictions. These deviations have to do with *(a)* how incentives affect output quality, *(b)* how the nature of the inspection-incentive regime affects agent behavior, and finally, *(c)* how the differences in agents' educational backgrounds drives quality outcomes. We begin the analysis of these behavioral deviations by addressing how incentives and penalties play a role in determining process quality, in practice.

5.1 Incentives And Penalties

We analyze panel data for 78 processes from three supplier firms for which the compliance regime was unchanged for the period of study.[5] Our objective was to study how the variables of the model actually influence managerial behavior. Towards this end, we captured quarterly data over a year that spanned the following elements: *(i)* the supplier's final output quality, *(ii)* the Penalty for sub-optimal quality that buyer and supplier agreed on for each contract execution period[6], *(iii)* incentives for optimal output quality, *(iv)* nature of the compliance regime under which processes were executed, *(v)* the average unit cost of execution of the process at the realized quality level, *(vi)* the average price paid by the buyer per unit of process, and *(vii)* the actual fraction of output that was inspected by the buyer (the sampling fraction). (For detailed descriptive statistics of the data captured, see Tables 1, (A)–(D) of the Appendix.) In addition to the above, we also captured information about the agents that executed the processes. It turned out that this information was key to explaining several aspects of managerial behavior and process outcomes.

Insert Table 1 of Appendix About Here

5.1.1 Agent Background and Behavior

Processes that we surveyed ranged from the traditional customer-service call center processes to semi-technical processes such as tech-support and hardware troubleshooting to processes that require professional training to execute, such as tax accounting, financial forecasting, equity research and asset pricing analysis, and legal research for patent filing and litigation. Agents that execute these processes (especially in India, China, the Philippines and Mauritius) have specific professional qualifications in domains such as accounting (CPAs), finance (CFAs and MBAs), market research (Master's degrees in Statistics) or R&D (Engineering

[5] In fact, we have complete data for 81 processes. For three of these processes, the compliance regime changed midway through our longitudinal study. We discarded these three processes since consistency of compliance regime is critical in our comparisons, and proceeded with the analysis of panel data of 78 processes.

[6] For most processes in our survey, this coincided with a quarter; for some processes this worked out to a year. Under this scheme, for each payment period (quarter / year), the supplier and buyer agree on a set of penalties for sub-optimal process delivery and incentives for optimal process quality.

and OR), or are workers with bachelor's degrees only and not deemed as professionals in these societies. Thus, processes are executed mostly by either *generalists* without professional degrees or *specialists* with professional degrees. To make this distinction sharper, we looked through the RFPs and skill specifications that clients (buyers) and BPO firms (suppliers) jointly signed. These documents specify the educational qualifications and skill levels of agents assigned to specific processes. Indeed, in the countries in which these processes are executed, there is considerable difference in workers with a professional or Master's degree in the sciences and graduates in generalist disciplines such as the humanities[7]. Processes that require mostly professionals to execute them - such as financial forecasting, investment banking research support, Bioinformatics, underwriting and claims management in insurance, and risk analysis in corporate banking - allow greater discretionary flexibility to managers and agents in using their expertise to interpret and determine the optimal course of action when they encounter exceptions. On the other hand, processes that are executed by generalists - such as call-center operators, customer service representatives, collection center workers, transcription and typing service providers - offer less discretionary flexibility [Forrester (2003b), Forrester (2006)]. The former tend to work as independent, autonomous specialists, while the latter are generalists who are expected to follow procedural guidelines by rote. We discovered that this distinction between autonomous experts and generalists had a highly significant impact on how the two compliance regimes fared in practice (through the impact of inspection and incentives on agent behavior). Based on the RFP and skill requirements specified in the contracts we divided the processes that we surveyed into two categories - processes executed by High-skill Specialists and Low-skill Generalists[8]. If the proportion of Low-Skill Generalist (or High-Skill Specialist) agents that executed the processes exceeded 80%, then we termed the process as a 'Low-Skill Generalist' (or 'High-Skill Specialist') process. As can be seen from Table 2, processes fall unambiguously into low skill or high skill categories based on this metric.

[7]There have been numerous reports in the business and trade press about the quality of workers in India and China. For a more detailed discussion of the nature of educational qualifications needed in the BPO industry, we refer the interested reader to recent research reports by the research firm Forrester Inc. [Forrester (2003b), Forrester (2006)].

[8]The dichotomy seen here between "High-skill Specialists" and "Low-skill Generalists" is widely recognized and acknowledged in the industry. The so called "Low-Skill" processes are often referred to as back-office work while the "High-skill" processes are referred to as "Knowledge Processes". So much so, that there have been a spate of articles in the business press about "Knowledge Process Outsourcing" over the past few years.

Insert Table 2 of Appendix About Here

We now examine how incentives, penalties and inspection fractions interact with agent types and drive behavioral outcomes in these offshore contracts.

5.1.2 Incentives For Quality

Recall that our model predicted that the buyer should provide no incentives for optimal quality ($\lambda^* = 0$) in either regime (Proposition), and further, that the combination of penalties and inspection would dominate the use of incentives. However, we found that in practice not only did incentives induce higher quality but also they had a greater effect size; i.e. had a greater impact on output quality than penalties. In practice, the use of incentives for inducing optimal quality from the supplier is widespread. In fact, of the 81 processes on which we have complete data, we found that there were no incentives for superior quality of output during the entire survey period only in the case of eight processes.

Why do buyers and suppliers behave in a manner different from the predictions of the model? To investigate this we first model the impact of the three factors– penalties, incentives and inspection proportion– on output quality under each compliance regime and for the two kinds of agents.

Preemptive Regime: Quality Outcomes The dependent variable in our model is output quality and the independent variables are incentives, penalties and the fraction of output inspected. We discuss each of these variables below.

Quality: This is the dependent variable in the model and it is captured as the fraction of processes that are error-free. The data was captured from the SLA delivery logs[9] based on which the supplier is paid. We captured this number for each process once every quarter (to coincide with the payment and settlement period). Thus the quality of the i^{th} process in the t^{th} quarter is given by Q_{it}.

Incentives: This is the amount that the buyer pays the supplier for a tranche of processes delivered that are error-free. This amount is the quality premium paid to the supplier's agents by the buyer and is measured as a fraction of the average wage. There are two reasons that we have chosen to normalize the quantum of incentive by the wage structure of the supplier.

[9] SLA here stands for 'Service Level Agreement'. The buyer and supplier maintain the output quality log jointly.

Firstly, buyers and suppliers are in different countries and therefore in currency regimes. An incentive amount of \$100 may seem a small sum in the US and Western Europe, but it amplifies to 4600 *Rupees* in India, which can represent as much as forty percent of an agent's monthly salary. Thus the amount paid was converted at the prevailing exchange rate to the local currency and measured as a percentage of the mean salary of agents. Secondly, even within the supplier collective, a quality premium of \$100 represents very different fractions of the wage rate of a call center worker in Mauritius or a molecular biologist or equity research analyst in India. Thus, to capture the relative magnitude of impact of the incentive amount on each agent, we model this as a fraction of his wage. While a financial analyst might experience a lower level of motivation when given a quality bonus of \$100 than say, a call center operator, it is reasonable to expect that they value 10% of their respective wages equally. This variable is operationalized as follows: if the total bonus paid for the i^{th} process in the t^{th} quarter is B_{it}, the number of agents who worked on the process is n_{it} and the mean wage rate is w_{it}, then the incentive quantum is given by $\lambda_{it} = \frac{B_{it}}{n_{it} \cdot w_{it}}$.

Penalties: This is the amount that the supplier pays when he falls below his contractually specified level of quality. This variable is captured as a ratio of the penalty amount paid to the price paid by the buyer. This too is normalized by the price of the process, for reasons similar to those for normalization of incentives, discussed above. As before the penalty amount has very different levels of impact when currency-effects are captured. Secondly, a penalty of $\$1,000$ per defective tranche of processes is not the same for a call-center customer contact process for which the buyer pays \$3 per call minute as opposed to an investment banking process for which the buyer pays as much as $\$25,000$ per agent deployed. Thus we divide the penalty amount by the price of the project. We captured the actual penalty paid (per unit volume) from the quarterly payment logs. This variable is operationalized as follows: if the total penalty paid for the i^{th} process at the t^{th} instant is given by Γ_{it} and the price of the process by p_{it} then the penalty quantum is given by $\gamma_{it} = \frac{\Gamma_{it}}{p_{it}}$.

Inspection: This variable denotes the proportion of output from the supplier that is inspected by the buyer. The buyer's QC agents and the suppliers jointly monitor the inspection process and record the results on which payments are based. We collected the mean inspection fractions of processes. The fraction of output inspected by the buyer for the i^{th} process in the t^{th} quarter is gven by f_{it}.

The model of quality is thus given by:

$$Q_i = f(\lambda_i, \gamma_i, f_i)$$

More specifically[10],

$$Q_i = \beta_1 + \beta_2\lambda_i + \beta_3\gamma_i + \beta_4 f_i + \varepsilon_i$$

Rather than run a pooled OLS across agent types, we separated the data by agent type and ran OLS estimates. The results of the regression analysis are shown in Tables 3 and 4 below:

Insert Tables 3 and 4 About Here

Before discussing the differences in behaviors of High and Low Skilled agents we first discuss the similarities. Recall that our model predicts that incentives are unnecessary and are dominated by penalties as a means of inducing higher quality. It is clear from Tables 3 and 4 that in practice incentives are an effective means of inducing superior output quality from the supplier. How do incentives compare with penalties as a means of inducing higher output quality? To answer this we need to estimate the marginal impacts of penalties and incentives. For the Low-Skill generalists (in the Preemptive compliance regime) the *marginal* value of penalties and incentives are, respectively:

$$\frac{\partial Q}{\partial \lambda} = 1.16; \ \frac{\partial Q}{\partial \gamma} = 0.024$$

That is, each additional percentage increase in the incentive amount paid produces 1.16 percent gain in quality while an additional percentage increase of the penalty amount results only in 0.024 units of gain in quality. We can translate these into dollar terms for the buyer. Recall that Quality features in the buyer's revenues through the term $V \cdot \theta$. Thus an additional 1% increase in the incentive amount translates to a revenue gain of 1.16% of $V = \frac{1.16 \cdot V}{100}$(since θ goes up by 1.16%). Further, recall that the incentive amount was expressed as a fraction of the supplier agents' average wage (c in our model), for reasons discussed above. Hence the cost of hiking the incentive amount by a percentage point is 1% of $c = \frac{c}{100}$. Thus, each additional percentage of incentives produces a net gain to the buyer given by: $G_{L\lambda} = \frac{1.16V - C}{100}$. We analyze the effectiveness of penalties similarly. For reasons detailed above, penalties were normalized by taking the ratio of the absolute penalty amount paid to the price paid by the buyer (the *latter* corresponding to P in our model). A hike of 1% in penalties leads to a revenue gain of 0.024% of $V = \frac{0.024 \cdot V}{100}$ directly through improved quality. Further, the penalty hike of 1% of P is also captured by the buyer (unlike incentives, which

[10]The Box-Cox parameter $\lambda \to 1$ suggests that the linear form is appropriate.

are *paid out* by the buyer). Thus the gains to the buyer from penalties are: $G_{L\gamma} = \frac{0.024V+P}{100}$. Since $V > 2P > 2C$ for almost all processes in our data set[11], it is clear from inspection that $G_{L\lambda} \gg G_{L\gamma}$. In other words, *dollar for dollar, incentives actually dominate penalties in inducing higher output quality from the supplier.*

Similar analysis done for the High-Skill regime yields:

$$\frac{\partial Q}{\partial \lambda} = 0.566; \ \frac{\partial Q}{\partial \gamma} = 0.090.$$

A comparison of the two contracting instruments yields: $G_{H\lambda} = \frac{0.566V-C}{100}$ and $G_{H\gamma} = \frac{0.09V+P}{100}$. Again for *most* values of V, P and C,[12] it turns out that $G_{H\lambda} > G_{H\gamma}$.While the above is generally true, it binds less stringently than in the case of Low-Skilled agents. An explanation for this observation is *Income effects.* In general, High-Skill Specialists earn more than Low-Skilled Generalists. As a result it is necessary for the buyer to pay out a higher amount by way of incentive to induce the same increase in effort as compared to payments made to Low-Skill agents. Hence the effect is slightly weaker in the case of High-Skill agents.

It is clear that the first significant behavioral deviation from the model, viz., incentives are a profitable way of inducing higher quality and they dominate penalties, holds in the case of the Preemptive regime. We now investigate if these results hold under the Reactive regime also.

Reactive Regime: Quality Outcomes As before, we investigate how the three factors – incentives, penalties and inspection – induce quality outcomes under this regime. We measure incentives and penalties in exactly the same fashion as before. However, when it comes to measuring the impact of inspection on quality we run into a problem. Recall that in the Reactive regime, the buyer announces the sampling fraction *post*-production. This means that the supplier when setting quality levels for a period does not know what proportion of the finished output would be sampled. What the suppliers agents do know is the fraction sampled in previous periods - indeed in *all* previous periods - and hence the cumulative weighted average sampling rate upto but excluding the current period. In our interviews with the quality control managers on the suppliers' site, we came across managers that used the cumulative inspection rate as a "benchmark rate" for the sampling fraction

[11]Recall that V is the market value of the service in an advanced economy such as the US, P is the price paid to a supplier in China or India, and C the cost of the process to the supplier.

[12]The exact binding condition is that $0.47 \cdot V > (P + C)$.

for the current period, while others, in Markovian fashion, used just the previous quarter's inspection rate as an indicator of the current quarter's sampling fraction. It is interesting to note that both systems of heuristics commonly adopted by the suppliers' managers are in fact sub-optimal when compared to the predictions of the model.

We decided to investigate the **anchoring behavior** of managers. How did the agents' anchoring of the current period's inspection rate to either the weighted average inspection rate-to-date or to just the preceding quarter's inspection rate affect the quality of their output? In addition to the variables mentioned earlier, we captured the inspection effort in terms of two variables: the weighted average inspection rate up to (but excluding) the current period and the previous period's inspection rate. The weighted average inspection rate was measured as follows: for the i^{th} process in the t^{th} period if the fraction of output that is inspected is given by f_{it},then the weighted average cumulative inspection rate for that process is given by[13]: $f_{cit} = \left(\sum_{j=1}^{t-1} f_{ij}\right) / (t-1)$, while the last period's inspection rate is a straightforward measure given by $f_{Lit} = f_{i,t-1}$.

As before, we set up the econometric model of quality as follows:

$$Q_i = f\left(\lambda_i, \gamma_i, f_{ci}, f_{Li}\right)$$

More specifically[14],

$$Q_i = \beta_1 + \beta_2\lambda_i + \beta_3\gamma_i + \beta_4 f_{ci} + \beta_5 f_{Li} + \varepsilon_i.$$

The results of the regression are shown in Tables 5 and 6 below.

Insert Tables 5 & 6 About Here

For both sets of agents - High-Skill specialists and Low-Skill Generalists - incentives result in significantly higher quality. As before we notice that the marginal impact of incentives on quality is greater than the marginal impact of penalties on quality for both types of agents. Finally, in terms of cost effectiveness, again it becomes clear that as long as $0.62V > P + C$ holds,[15] incentives are indeed more cost-effective than penalties in inducing superior quality.

[13]The subscripts "c" and "L" stand for 'cumulative' and 'last period' respectively.

[14]The Box-Cox parameter $\lambda \to 1$ suggests that the linear form is appropriate.

[15]This condition is derived in identical fashion to the condition for the Preemptive compliance regime, for which the derivations were provided above in detail.

As mentioned earlier, for most processes in our survey the market value of the service was well in excess of the minimum value that satisfies the above condition.

Therefore, it is clear that in a major behavioral deviation from the equilibrium reported in our model, incentives dominate penalties in inducing higher output quality. There are several reasons for this phenomenon. Firstly, penalties are less effective in firms where agents can easily switch jobs rather than pay penalties (even when their contracts are terminated under adverse conditions by an employer). Indeed there have been numerous reports in the business and trade press that point to the shortage of skilled labor in China and India and the rapid increases in wage levels in those countries.

Secondly, while penalties directly erode a firm's profits, they do not have any other adverse impact since clients do not make the details of adverse service public. This is because of the great political sensitivity that surrounds offshore outsourcing of service processes. However, when firms or their agents are awarded quality bonuses, there are direct and immediate reputational effects [Forrester (2003a)]. Firms are quick to make public the details of their quality achievements and client satisfaction metrics including bonuses won for superior quality. Thirdly, and equally importantly, there is high turnover in this industry, and agents who move from firm to firm create and sustain firm-level reputations for quality [Forrester (2003a)].

When we look at Tables 3, 4, 5 and 6, it becomes evident that agents' behavior varies considerably between the two regimes and in fact this behavioral variation explains much of the difference in outcomes between predictions of the model and actual practice. This observation leads us to the discussion of the second major behavioral effect uncovered by our survey.

5.2 Agent Behavior and Quality Outcomes

As we mentioned earlier, the behavior of agents varies greatly depending on their educational background and the kind of work that they do. In particular, agents' type produces significant reactions to the kind of regime under which they work. In particular, the high-skill specialists are used to executing processes with considerable degree of autonomy and these specialists react adversely to contractual impositions which are seen as a threat to their status as experts within their domain area. This observation sets up a crucial difference that is evident in the behavior of the agents.

Table 7 shows that Low-Skill Generalists actually produce higher quality when confronted with a regime where the Inspection rate will be determined after the production of processes.

Insert Table 7 About Here

The buyer's managers determine the inspection rate after the production of processes is completed.[16] By leaving open the option of inspecting a relatively high proportion of processes the buyers wield inspection as a strategic threat, thus inducing the supplier's agents to deliver higher levels of quality. For reasons such as inspection costs, discussed in the modeling section, this will not result in higher output quality when the agents adopt a rational and strategic response. However, we find that agents' behavioral predilections manifest themselves in seemingly contradictory quality outcomes - for one set of agents the Reactive regime results in a higher quality, while for the other it results in lower quality.

5.2.1 Impact of Regime on Low-Skill Generalists

Tables 3(C) and 5 (C) offer a comparison of how Low-Skill Generalists behave under the two regimes. The regression analysis disaggregates the components of output quality under the two regimes making clear the relative importance of factors that drive outcomes in the two cases.

As compared to the Preemptive regime, under the Reactive regime penalties become nearly four times. The marginal impact of penalties on quality is 0.02 under the preemptive regime while it is 0.08 under the Reactive regime. This is unusual for three reasons: *(1)* In both the Reactive and Preemptive regimes the role of inspection is to induce higher quality by combining the threat of penalties with incentives to induce quality. There is no reason to think that under either regime inspection is not a threat. *(2)* The extent of sampling under each regime is not very different. The buyer's mean Inspection rate under the Reactive regime is 13.68% (standard deviation, $\sigma = 5.31\%$) while under the Preemptive regime, the buyer's mean Inspection rate is 14.23% ($\sigma = 6.29$ %). Thus, there is no real difference in the actual Inspection rates of the two regimes. *(3)* Finally, the mean penalty levels under the two regimes too are quite similar. Under the Reactive regime the mean penalty ratio is 5.08 ($\sigma = 1.6$) while under the Preemptive Regime the mean penalty ratio is 5.84 ($\sigma = 3.39$).

[16] After these managers make periodic estimates of the effort levels, QC procedures and compliance measures, they manage their inspection through automated means, third-party inspection firms and their managers on site.

Thus there is no rational reason for the fourfold increase in the importance of the penalty ratio as we move from the Preemptive to the Reactive regime.

The only real difference between the two regimes is the uncertainty associated with the Inspection rate. Under the Reactive regime the supplier does not know the Inspection rate *ex-ante*. This *uncertainty in the Inspection rate amplifies the sense of threat* experienced by the supplier's agents, thus inducing risk-averse behavior. This in turn induces the Low-Skill Generalists to exert greater effort. The quality gain in moving to the Reactive regime is nearly 6%. It is clear that the Low-Skill Generalists produce higher quality under the Reactive regime.

The difference in quality outcomes between the two regimes for these agents is clearly seen in Figures 1 and 2. The figures show the difference in quality levels – between the actual quality realized and the predictions of the model.

Insert Figures 1 and 2 About Here

It is clear that under the Reactive regime the quality output of the Low-Skill Generalists exceeds that of the model predictions by a greater magnitude as compared to the same metric under the Preemptive Regime. We now investigate how the regime impacts the output of the High-Skill Specialists.

5.2.2 Impact of Regime on High-Skill Specialists

In the case of these workers too the inspection regime has a significant impact on the quality of outcome. However, it happens in a manner that once again confounds rational expectations.

From Table 8, it can be seen that High-Skill Specialists produce a significantly higher quality of output under the Preemptive regime ($\mu_R = 86.91\%;\ \sigma_R = 8.95\%;\ \mu_P = 80.06\%;\ \sigma_P = 7.89\%$).

Insert Table 8 About Here

The question is, what explains this difference in quality. As before, it can be seen (from Tables 4(c) and 6(c)) that there are no significant differences in the Inspection rates between the two regimes.

What is intriguing is that there is a significant difference in the mean penalty levels under the two regimes. Under the Reactive regime, the mean Penalty Ratio is 6.89 ($\sigma = 3.43\%$) while under the Preemptive regime, the mean Penalty Ratio is 2.59 ($\sigma = 1.29\%$). This leads to a contradiction: *The level of penalties is higher under the Reactive regime and yet the mean output quality under the Reactive regime is lower.*

In order to explain this anomaly we must look at the nature of work of these agents. Recall that the High-Skill Specialists enjoy considerable autonomy in their work based on their expertise. These agents see the delayed announcement of Inspection rates - i.e., ex-post production as a thinly veiled threat. Although there is no real difference in the intent behind inspection between the two regimes, it turns out that in the minds of the high-skill agents this is not seen as such. They see the buyer's attempt to set up uncertainty surrounding the Inspection rate as an attempt to undermine their own 'expert authority' and wield a coercive influence on their effort levels. This in turn weakens their motivation and produces lower quality outcomes under the Reactive regime.[17] Numerous interviews with managers of High-Skill Specialist workers confirmed that there was indeed an erosion in job satisfaction levels leading to lower quality levels under the Reactive regime.

The difference in quality outcomes between the two regimes for these agents is clearly seen in Figures 3 and 4. The figures show the difference in quality levels – between the actual quality realized and the predictions of the model.

Insert Figures 3 and 4 About Here

It is clear that under the Reactive regime the quality output of the Low-Skill Generalists exceeds that of the model predictions by a greater magnitude as compared to the same metric under the Preemptive Regime.

In sum, the supplier clearly cannot be treated as a composite whole with a single strategic response to incentives and inspection. Indeed the quality outcomes vary by the nature of work and the beliefs and preferences of the worker (agent). This leads us to ask the question– while the supplier's agents may differ in their behavior in *response* to incentives and penalties, do they process the *inputs* of factor levels strategically? In other words do they estimate the Inspection rates correctly and factor in the penalties and incentive levels as they are expected to? This question leads us to another behavioral bias of managers.

[17]Our follow-up survey of job satisfaction rates confirmed our hypothesis. The job satisfaction levels of High-Skill Specialists were lower by a standard deviation under the Reactive regime, while the job satisfaction levels of Low-Skill Generalists remained nearly the same across the two regimes. For expositional brevity we omit the details of this survey here.

5.2.3 Agents' Anchoring Bias in Estimating Inspection Rates

Under the Reactive regime, agents process inspection rates in ways that are counter-intuitive. Tables 5(C) and 6(C) show that agents interpret Inspection rates very differently based on their skill levels.

For Low-Skilled Generalists the inspection rate of the last quarter is significantly important and contributes substantially to effect size. For these agents, a unit percentage increase in the last quarter's inspection rate results in an increase of 0.64% in the quality of output, while the cumulative Inspection rate until the current period is completely insignificant. Thus the Inspection rate of the previous quarter has considerable explanatory power while the long run Inspection rate has no significance whatsoever. This demonstrates a strong *Myopic Anchoring Bias* in the case of Low Skill Generalists.

In the case of the High-Skill Specialists the situation is reversed. It can be seen that for these agents the long run Inspection rate (weighted average cumulative Inspection rate) has far greater explanatory power. A one-percent increase in the weighted average cumulative rate results in an increase of 1.22% in output quality, while the previous quarter's sampling rate is statistically insignificant in their case. This behavior points to the existence of a *Trend Anchoring Bias* in these agents. They seem to believe that a long run mean Inspection rate is the best predictor of the current period's Inspection rate and don't accord any special significance to the previous quarter's inspection rates. This is explained in part by the fact that High-Skill Specialists are used to cognitive complexity and therefore, are more capable of using trends and long run averages as opposed to myopically relying on the most recent data as the best predictor of future events. Low-Skill Generalists on the other hand, are neither used to cognitive complexity nor used to sophisticated analyses based on trends and long run data. Further, they have never enjoyed great autonomy in their work and therefore, have not been called upon to make decisions that call for deep analysis. Their *Myopic Anchoring Bias* is also the result of another factor– Low-Skill Generalists are usually involved in work that is transactional in nature where a unit of work is well defined (a call, a financial transaction, an invoice to be data entered etc.) and therefore, have tighter, more frequent deadlines. They often may not be able to factor in long run average values of behavior-inducing parameters and may have to rely on cognitive shortcuts that are not time-consuming to use.

The next Section contrasts the principal findings of our behavioral study with the predictions of our theoretical model and concludes.

6. Concluding Remarks and Future Directions

This research is at the intersection of a number of substantive areas and methodological disciplines. Operations researchers have historically focused on and developed a rich vein of theoretical research in Supply Chains with an emphasis on manufacturing and inventory management. More recently, researchers have thrown the spotlight on some of the unique challenges within *Service* Operations. Nevertheless, with the tremendous growth in the 'services' economy over the past few years, there is an urgent need for research to better understand and optimize the management of services. As Chopra *et al* (2004) point out, services will be one of the drivers of future research in Operations Management.

Within the area of Service Operations, Business Process Outsourcing (BPO) is a rapidly growing hot-button issue. Our research squarely addresses some of the key questions facing managers– on the viability of offshoring services to 'low-cost' overseas providers, and the management of such offshoring through optimal monitoring and contracting.

On the methodological front, we combined both theoretical and empirical approaches to study the key questions and issues facing both firms seeking to offshore elements of their service supply chains and the offshore providers. Firstly, we built a Game-Theoretic model incorporating the quality-cost tradeoff to capture the conflicting objectives (and incentives) of the offshore provider (supplier) and the client (buyer). Our model enabled us to develop a number of testable hypotheses. Next, using cost, revenue, quality and compliance data on nearly eighty offshored processes, we were able to test our theoretical predictions.

While some of the theoretical predictions are borne out by the data, others find tepid support, and still others are strongly contradicted by our data. Behavioral effects not captured by our theoretical model of rational agents playing out a game-theoretic equilibrium, perhaps amplified by cultural factors, drive these differences.

One important finding of our empirical study was that *incentives* are powerful drivers of service quality, and in fact dominate *penalties* both in inducing quality and in dollar for dollar effectiveness. Our theory had predicted the opposite– that across all compliance regimes, incentives would not be used in equilibrium, and further that their use would be obviated by judicious inspection and penalties.

We also found that process and agent characteristics are critical in determining which compliance regime will produce higher quality service for the client. For low-skilled agents (and processes), the Reactive Compliance Regime leads to higher quality, whereas for high-skilled/specialist agents and processes, the Preemptive Compliance Regime delivers superior quality. This again diverged from the developed theory, which had predicted that when dealing with rational econmic agents, the Preemptive Compliance Regime would *always* delivers superior quality. Furthermore, our data shows unambiguously that all types of agents show *anchoring* behavior with respect to their expectations of inspection probability– leading to suboptimal outcomes in contrast to rational predictions. Moreover, we find that the nature of the anchoring varies with the skill-levels of the agents. Low-skilled or generalist agents tend particularly towards a *Myopic Anchoring Bias*, and heavily weight the previous inspection event (e.g. the previous quarter's inspection ratio), while high-skilled or specialist agents are anchored more to the cumulative history, revealing a *Trend Anchoring Bias*. (The inspection ratio predicted by our rational model ignores any presumption of 'norms' and is notably ahistorical.)

Finally, we find that, in practice, inspection/sampling levels lower than those mandated by theory are effective in producing high levels of quality. Two possible explanations are agents' risk aversion and reputation effects in the BPO business [*cf* Gartner (2003a)].

More research grounded both in theory and the empirical tradition is needed to further understand the drivers of these results.

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Appendix: Tables and Figures

Table 1: Descriptive Statistics

1(A) Preemptive Compliance Regime; Low-Skilled Generalists

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
OUTPUT QUALITY	80	.46	1.00	.8055	.14903
Incentive Ratio	80	.00	.15	.0504	.04593
Penalty Ratio	80	1.31	12.63	5.8355	3.38544
Inspection Rate	80	.05	.33	.1426	.06282
Valid N (listwise)	80				

1(B) Preemptive Compliance Regime; High-Skilled Specialists

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
OUTPUT QUALITY	80	.600	1.000	.86913	.089638
Incentive Ratio	80	.000	.150	.04612	.041077
Penalty Ratio	80	.777	5.291	2.58817	1.285168
Inspection Rate	80	.050	.330	.14875	.061918
Valid N (listwise)	80				

1(C) Reactive Compliance Regime; Low-Skilled Generalists

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
OUTPUT QUALITY	76	.49	1.00	.8647	.16378
Incentive Ratio	76	.00	.12	.0493	.03458
Penalty Ratio	76	1.83	7.26	5.0795	1.60134
Inspection Rate - Last Qtr	76	.0	.3	.137	.0531
Cumulative Inspection Rate	76	.1	.2	.141	.0216
Valid N (listwise)	76				

1(D) Reactive Compliance Regime; High-Skilled Specialists

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
OUTPUT QUALITY	76	.62	.94	.8007	.07895
Incentive Ratio	76	.00	.15	.0439	.03541
Penalty Ratio	76	2.30826706478	16.19467198088	6.8869053645989	3.42734272416255
Inspection Rate - Last Qtr	76	.05	.30	.1403	.04996
Cumulative Inspection Rate	76	.05	.20	.1303	.02803
Valid N (listwise)	19				

<u>Table 2: Agent Skill Levels and Processes:</u> Observe that processes fall unambiguously into *"Low-Skill Generalist"* or *"High-Skill Specialist"* categories based on the simple metric of percentage of *low-skilled* (or equivalently, *high-skilled*) workers employed.

Low-Skilled Generalist Processes		
	Preemptive Compliance Regime	**Reactive Compliance Regime**
Number of Processes Surveyed	**20**	**19**
Mean proportion of Low-Skilled Agents	94%	94%
Median proportion of Low-Skilled Agents	96%	94%
Maximum proportion of Low-Skilled Agents	100%	100%
Minimum proportion of Low-Skilled Agents	89%	88%
High-Skilled Specialist Processes		
	Preemptive Compliance Regime	**Reactive Compliance Regime**
Number of Processes Surveyed	**20**	**19**
Mean proportion of High-Skilled Agents	96%	96%
Median proportion of High-Skilled Agents	95%	97%
Maximum proportion of High-Skilled Agents	100%	100%
Minimum proportion of High-Skilled Agents	90%	91%

Table 3: Results of Regression Analysis of Low-Skilled Processes under the Preemptive regime.

(3A) Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.879(a)	.772	.763	.07255

a Predictors: (Constant), FRACTION, INCENTIV, PENALTY

(3B) ANOVA(b)

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1.355	3	.452	85.770	.000(a)
	Residual	.400	76	.005		
	Total	1.755	79			

a Predictors: (Constant), FRACTION, INCENTIV, PENALTY
b Dependent Variable: QUALITY

(3C) Coefficients(a)

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.555	.028		19.709	.000
	INCENTIV	1.160	.385	.357	3.013	.004
	PENALTY	.024	.005	.555	4.641	.000
	FRACTION	.349	.132	.147	2.639	.010

a Dependent Variable: QUALITY

Table 4: Results of Regression Analysis of High-Skilled Processes under the Preemptive regime.

(4A) Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.718(a)	.515	.496	.063622

a Predictors: (Constant), Inspection Fraction, Incentive, PENALTY

(4B) ANOVA(b)

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.327	3	.109	26.939	.000(a)
	Residual	.308	76	.004		
	Total	.635	79			

a Predictors: (Constant), Inspection Fraction, Incentive, PENALTY
b Dependent Variable: QUALITY

(4C) Coefficients(a)

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.354	.058		6.076	.000
	INCENTIV	.566	.178	.259	3.184	.002
	PENALTY	.090	.010	1.283	8.740	.000
	FRACTION	1.728	.212	1.194	8.138	.000

a Dependent Variable: QUALITY

Table 5: Results of Regression Analysis of Low-Skilled Processes under the Reactive regime.

(5A) Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.816(a)	.666	.647	.097303

a Predictors: (Constant), Inspect_C, PENALTY, Inspect_L, Incentive (L) Proportion

(5B) ANOVA(b)

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1.340	4	.335	35.374	.000(a)
	Residual	.672	71	.009		
	Total	2.012	75			

a Predictors: (Constant), Inspect_Cumul, PENALTY, Inspect_Last, Incentive (L) Proportion
b Dependent Variable: QUALITY

(5C) Coefficients(a)

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.278	.088		3.162	.002
	Incentive (L) Proportion	.755	.351	.159	2.150	.035
	PENALTY	.081	.007	.795	11.288	.000
	Inspect_Last	.639	.226	.207	2.826	.006
	Inspect_Cumulative	.349	.544	.046	.641	.524

a Dependent Variable: QUALITY

Table 6: Results of Regression Analysis of High-Skilled Processes under the Reactive regime.

(6A) Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.714(a)	.510	.482	.05681

a Predictors: (Constant), Sample Fraction Cumulative, Penalty Fraction, Sample Fraction - Last Q, Incentive (L) Proportion

(6B) ANOVA(b)

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.238	4	.060	18.459	.000(a)
	Residual	.229	71	.003		
	Total	.467	75			

a Predictors: (Constant), Inspect_Cumul, PENALTY, Inspect_Last, Incentive (L) Proportion
b Dependent Variable: Output Quality

(6C) Coefficients(a)

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.559	.051		10.987	.000
	Incentive (L) Proportion	.628	.234	.282	2.685	.009
	Penalty Fraction	.007	.002	.315	3.146	.002
	Inspect_last	.036	.148	.023	.246	.807
	Inspect_Cumulative	1.224	.283	.434	4.328	.000

a Dependent Variable: Output Quality

Table 7: Quality of Output of Low-Skill Generalists

	Output Quality		Output Quality
Pre-Emptive		**Reactive**	
Average	80.6%	Average	86.5%
Std Dev	15%	Std Dev	16.4%
Max	100%	Max	100.0%
Min	46%	Min	49.0%

Table 8 – Quality of Output of High-Skill Specialists

	Output Quality		Output Quality
Pre-Emptive		**Reactive**	
Average	86.91%	Average	80.07%
Std Dev	9.0%	Std Dev	7.9%
Max	100.0%	Max	94.0%
Min	60.0%	Min	62.0%

Figure 1: Preemptive Compliance Regime; Low-Skilled Generalists

Quality Difference: Actual Quality – Predicted Quality for each process arranged by quarter

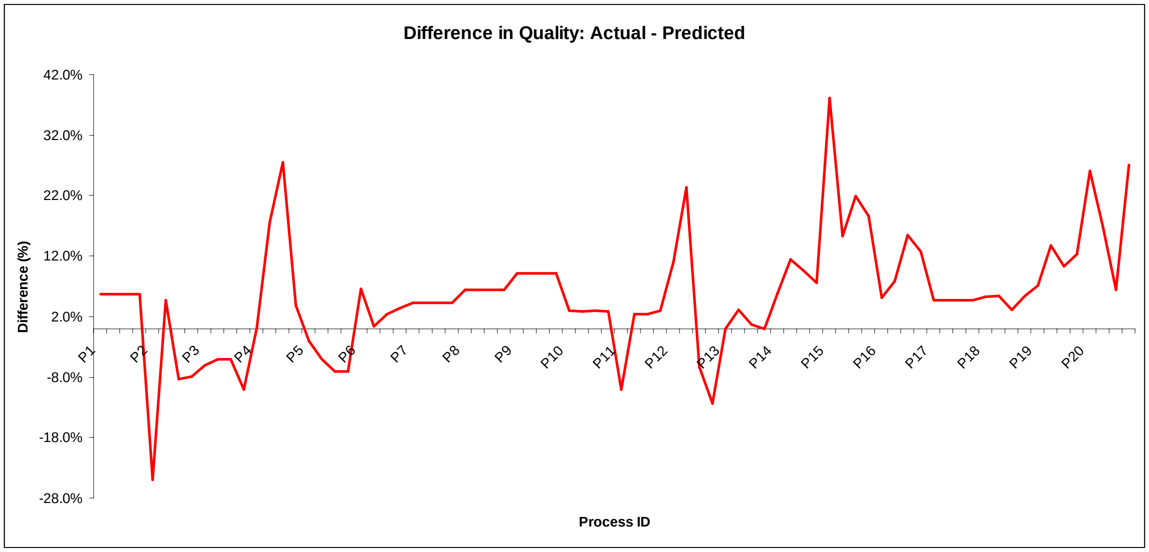

Figure 2: Preemptive Compliance Regime; High-Skilled Specialists

Quality Difference: Actual Quality – Predicted Quality for each process arranged by quarter

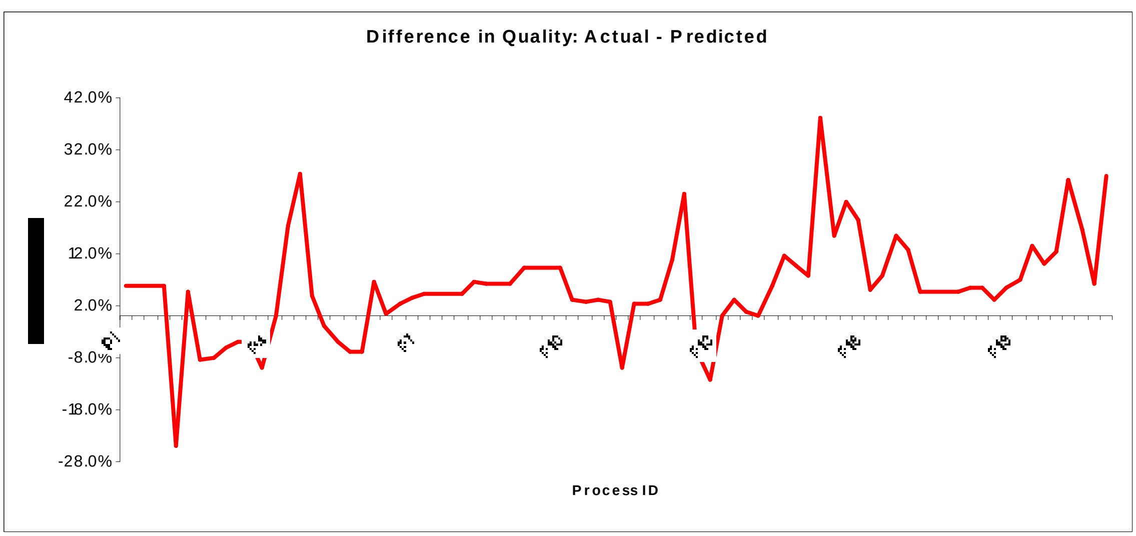

Figure 3: Reactive Compliance Regime; Low-Skilled Generalists

Quality Difference: Actual Quality – Predicted Quality for each process arranged by quarter

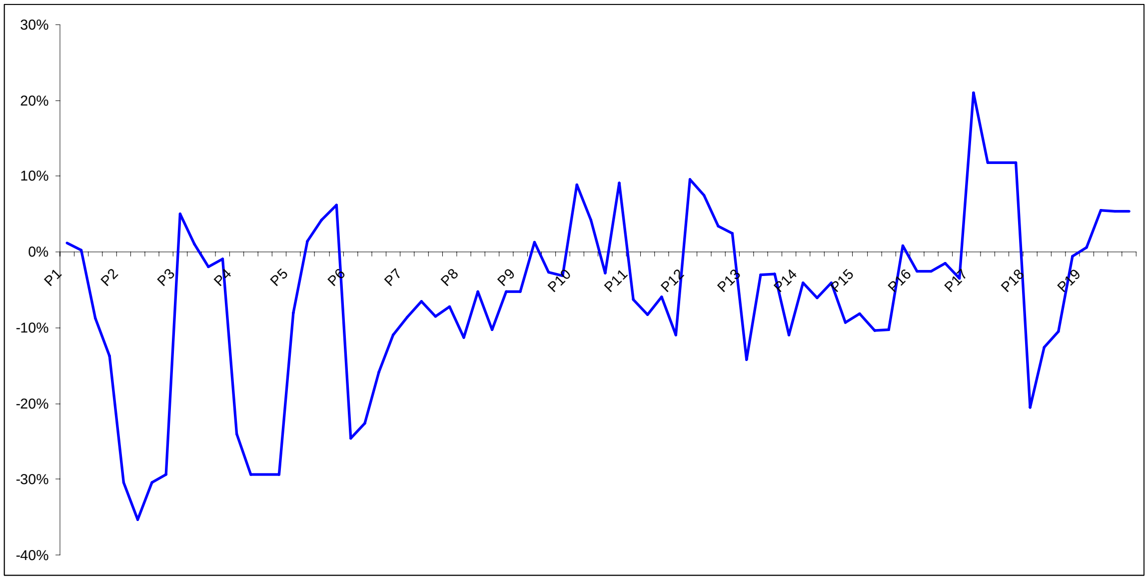

Figure 4: Reactive Compliance Regime; High-Skilled Specialists

Quality Difference: Actual Quality – Predicted Quality for each process arranged by quarter