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Naughty or Nice?

Punishment and the Interaction of Formal and Informal Incentives in Long-Term Contractual Relationships

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ABSTRACT

The paper develops a model of repeated interaction between a buyer and a seller, which is then tested via laboratory experiments. The model allows for both formal and informal incentives in the contractual relationship between the parties. Formal incentives are explicit, performance-conditioned obligations enforced by third parties, such as a binding bonus paid for meeting an objectively measurable criterion. Informal incentives are non-binding promises to reward good performance. Although they are not enforced by external institutions, parties engaged in long-term interactions have incentives to “keep their words” about these promises and such payments can provide motivation for desirable performance.

The current literature posits that these two types of incentives can function either as complements, so that joint use leads to better outcomes than either alone, or as substitutes, so that the availability of formal incentives may actually undermine the effectiveness of informal incentives. This study uses laboratory experiments to provide a rigorous test of hypotheses about the interaction of these incentives. The observed results suggest that the complementarity effect occurs in certain situations, but that the substitution effect does not occur as predicted, possibly because people do not punish transgressions in the manner that the theoretical model assumes.

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Introduction

In many agricultural sectors, producers and buyers (integrators) interact repeatedly over many seasons, and these relationships are increasingly framed by the use of production contracts rather than reliance on spot markets (MacDonald et al, 2004). In a repeated interaction, the parties can use both formal and informal incentives to motivate behavior, and understanding how these two types of incentives interact is critical to analyzing how the entire relationship works.

This paper investigates how formal and informal incentives work in combination, using laboratory experiments to test predictions from a theoretical model. The current literature posits that these two types of incentives can function either as complements, so that joint use leads to better outcomes than either alone, or as substitutes, so that the availability of formal incentives may actually undermine the effectiveness of informal incentives. The observations suggest that the complementarity effect does occur in certain institutional environments, as predicted. However, the substitution effect is not apparent, even under conditions predicted to favor it.

Formal incentives refer to explicit, performance-conditioned obligations that are enforced by third parties, such as written contract terms enforced by the legal system. Once a party commits to a formal incentive to induce desirable performance by another party, he or she has no discretion to change the terms of the obligation. In tobacco contracts, for example, the buyers often condition contract prices on narrowly defined quality grades (Dmitri, 2003).

Informal incentives refer to discretionary powers of the parties to reward and punish each other for good or bad performance. The use of informal incentives may arise when formal terms are impractical, due to the costs of monitoring performance or the difficulty of specifying performance in objective terms that can be verified by an enforcement institution. Informal incentives range from rewarding satisfactory performance with repeat business (i.e. the repeat-purchase mechanism of Klein and Leffler, 1981) to providing "perks" to favored customers to end-of-year bonuses based on employee performance[1].

When an interaction is modeled as a single-shot game, neither player should (in theory) respond to informal incentives for performance. The player with the last move would be expected to maximize his payoff by his choice at that decision node, regardless of the prior choices of other players. The penultimate mover would anticipate this response and make his choice at that node in an attempt to maximize his payoff, and the game would "unravel" accordingly. Thus, promises to pay discretionary rewards for

[1] This example refers to bonuses that are at the employer's discretion and may be adjusted or withheld without legal consequences. Bonuses based on quantified criteria and part of a legally enforceable agreement, such as commission-based compensation for sales personnel, would be classified as formal incentives.

desirable performance are non-credible in this setting, and only formal incentives can induce better performance.

In contrast, informal incentives can have powerful effects in interactions modeled as infinitely or indefinitely repeated games, sometimes referred to as relational contracts. In such a setting, the players may exercise their discretionary powers to reward other players for desirable performance. Although not enforced by external institutions (e.g. the legal system), these informal incentives may be self-enforcing, so that each player finds it in his own interest to adhere to his non-binding promise (Tesler, 1980). In such an equilibrium, each player weighs the current costs of providing discretionary rewards (upholding the equilibrium strategy) against the future costs of punishment by other players as a response to a failure to provide the rewards.

In many real-world interactions, both formal and informal incentives may come into play. The availability of formal enforcement may vary across markets due to the different characteristics of the goods or services involved and the different institutions available for measuring performance. Enforcement options may also vary across nations, as the quality of the legal system will affect the feasibility and cost of writing and enforcing binding contracts (Dixit, 2004).

The variety of possible combinations raises the question of how formal and informal incentives interact (MacLeod, 2007), and the economics literature has begun to explore this area, using both theoretical models and empirical data. Baker, Gibbons, and Murphy (1994) show in a theoretical model that formal incentives can be *complements* to informal incentives, meaning that the use of formal incentives improves the outcomes possible in a relational contract setting. This effect occurs because formal incentives act to reduce both parties' potential gains from deviating from the terms of the agreement.

However, it also possible for the two types of incentives to act as *substitutes*, meaning that the availability of formal incentives eliminates desirable outcomes from the set of those that can be supported in equilibrium (Baker, Gibbons, and Murphy, 1994; Schmidt and Schnitzer, 1995). This effect occurs when the possibility of using formal incentives improves the outcomes that can be attained without any use of informal incentives (including the repeat-purchase mechanism), thereby decreasing the punishments that one party can impose on the other for deviating from the relational contract.

The concepts of complementarity and substitution discussed above are defined within a standard, neoclassical economics framework involving rational and self-interested actors. However, the choices made by actual individuals may be influenced by a host of psychological biases, which are often classified under the umbrella of behavioral economics. The literature on motivational crowding-out relates to the topic of the interaction of formal and informal incentives (e.g. Fehr and Gächter, 2002; Frey, 1997). In crowding-out models, the actors exhibit social preferences for reciprocity and cooperation or other types of intrinsic motivations for desirable activity. This theory postulates that the provision of extrinsic financial incentives for performance can reduce, or "crowd out," such unselfish motivations by devaluing the social norms on which they depend. Of course, it is also possible for extrinsic incentives to amplify intrinsic motivations (i.e. "crowding in"), such as when taxpayers' perception of tax laws as fair and respectful induce better compliance with those laws (Frey, 1997).

Some experimental studies have found evidence of motivational crowding out (e.g. Fehr and Gächter, 2002). However, these studies usually involve changes in cooperation in one-shot games, such as the gift-exchange scenario. In these settings, theoretical models predict that self-interested agents will not cooperate at all, so any observed cooperation likely stems from behavioral motivations such as social preferences for reciprocity. In a relational contract setting, by contrast, there are self-interested motivations for cooperation, due to the formal and informal incentives discussed earlier.

In a relational contract setting, some experimental studies (e.g. Lazzarini, Miller, and Zenger, 2004) have found evidence to support the complementarity effect. To our knowledge, however, no other experiment has tested both the complementarity and substitution effects within a repeated contract setting. The above authors, for example, consider motivational crowding out, but their specification does not allow for incentive substitution based on selfish behavior. The present study uses an experimental design that allows for both complementarity and substitution effects arising from self-interested agents, in order to examine whether both effects occur in observed behavior.

An important issue in considering the interaction of formal and informal incentives is the range of incentives available. Some of the current literature tends to focus on single-price contracts, in which the only informal incentive is continuation of the relationship (MacLeod, 2007) using the Klein and Leffler (1981) repeat-purchase mechanism. (E.g. Brown, Falk, and Fehr, 2004; Lazzarini, Miller, and Zenger, 2004) In these models, the principal must share the surplus with the agent, in the spirit of Shapiro and Stiglitz's (1984) efficiency-wage model, in order for the informal incentive to carry any impact. Additionally, the principal's only method for punishing poor performance with respect to a non-contractible variable is termination of the relationship. This design omits the possibility of discretionary price adjustments, such as a voluntary bonus payment to the seller for good performance or other types of informal incentives.

Other analyses, however, have incorporated the possibility of discretionary payments by the principal to reward the agent's good performance. (E.g. Bull, 1987; Levin, 2003; Baker, Gibbons, and Murphy, 2004; Wu and Roe, 2007a) In these models, the reward of continuing the relationship into the future is supplemented by additional payment in the current period, thereby strengthening the power of informal incentives and reducing the need for the principal to share surplus. The experimental design of the present study allows for a broad range of informal incentives, including a discretionary bonus payment in addition to the repeat-purchase mechanism.

Related to the question of complementarity or substitution, the issue of contract choice plays an important role in the interaction of formal and informal incentives. Bernheim and Whinston (1998) investigate the question of why many observed contracts are less complete than necessary. That is, why do parties often fail to include formal incentives that would be relatively easy to specify and enforce? If all performance variables are verifiable, then the parties could specify a complete contract, one that specifies formally enforceable contingent obligations for all possible states, and achieve a first-best outcome. However, if some performance variables cannot be verified, then some incompleteness in the contract is unavoidable. Using a theoretical model, those authors show that it may then be desirable for the parties to allow additional incompleteness, in the form of making otherwise enforceable terms discretionary. The resulting contracts exhibit such "strategic ambiguity," not because the prospective performance measure is hard to specify, but because an explicit, enforceable obligation would lead to greater inefficiency.

For example, consider a principal contracting with an agent to provide some service, with the expectation that the relationship will continue for a long time (e.g. an employment contract). If external enforcement institutions can verify only whether or not the agent performed some service, but not the agent's level of effort or quality, then making the principal's payment obligation enforceable will lead to an undesirable outcome. The agent will provide only a minimal level of effort, the principal will anticipate this, and the resulting contract will provide only minimal payment. If the principal's payment obligation is left unspecified, then the threat of punishment can induce the agent to provide higher levels of effort, which the principal will reward with higher payment (in a repeated interaction). Thus, the parties may find it in their collective interest to form a contract that is more incomplete than is strictly necessary. Making the contract as complete as possible may reduce the achievable joint surplus, so they choose to leave "extra" discretion in the relationship.

Using laboratory experiments involving repeated exchange, Wu and Roe (2007b) find evidence consistent with the conclusions of the strategic ambiguity model. Subjects in treatments that limited the discretion of the principal (i.e. required more contractual completeness) in adjusting current rewards for the agent's performance achieved worse outcomes than did those with a broader range of discretion for the principal. This supports the idea that "additional" incompleteness may improve the welfare of the contracting parties. However, in their experiment, the choice of contractual structure was exogenously imposed, leaving open the question of whether the parties would voluntarily choose the more discretionary form of contract. The experiment conducted for the present paper allowed the parties to choose whether to incorporate an additional formal incentive, thus making the structure of the contract endogenous.

In the next section, we develop a theoretical model that allows for both the complementarity and substitution effects by self-interested agents. The following section then describes the design of and results from an experimental test of these effects.

Notably, the design allows for separate tests of these effects, by creating treatments that favor each of them rather than presenting them as alternatives in a single institutional environment. The results show that the complementarity effect holds in the environment favorable to it. However, the substitution effect does not seem to be present when it is favored. Finally, we consider possible behavioral effects that might lead the subjects' choices to deviate from those predicted by the model, paying particular attention to mechanisms for punishing out-of-equilibrium behavior.

Theoretical Model

In this section, we develop a principal-agent model to provide a theoretical basis for discussing the effects of and interactions between formal and informal performance incentives. A key element of this model is the subjects' endogenous choice of the contract structure. That is, the principal has flexibility in determining whether to use only informal incentives in the contract or to include formal incentives in the offer. This choice allows for the possibility that rational players would choose not to use the formal terms. If the principal chooses to omit the formal incentive, creating a contract that is more incomplete than necessary, his behavior would be consistent with Bernheim and Whinston's strategic ambiguity.

Consider a buyer and seller, both risk-neutral, negotiating the exchange of a single unit of a good, which has two-dimensional quality that varies continuously on each dimension. That is, quality is expressed as $Q = (q_1, q_2)$, and $q_1, q_2 \in [q_{\min}, q_{\max}]$. The first dimension of quality, q_1, is verifiable; formally enforceable contract terms may be conditioned on q_1. In contrast, q_2 is merely observable by the parties but cannot be used as the basis for formally enforceable contract terms.

The seller's cost to produce one unit of the good is $C(q_1, q_2)$, with $C(Q_{\min}) = C_{\min} \geq 0$, where $Q_{\min} = (q_{\min}, q_{\min})$. We assume that production cost is strictly increasing in both arguments: $C_i > 0$ and $C_{ii} \geq 0$, for $i = 1, 2$. If the seller does not produce the good, she receives a reservation payoff of μ.

The buyer's value for a unit of the good is $V(q_1, q_2)$, with $V(Q_{\min}) = V_{\min} \geq 0$. We assume that value is likewise increasing in both arguments: $V_i > 0$ and $V_{ii} \leq 0$, for $i = 1, 2$. The buyer's reservation payoff is normalized to 0.

The buyer and seller make choices in the following sequence of events:

1. Buyer offers a contract (several types possible, see below)

2. Seller accepts or rejects offer. If he accepts, the seller chooses quality.

3. Buyer observes quality and chooses discretionary bonus

The buyer proposes a contract in which he requests quality $Q_R = (q_{1R}, q_{2R})$, which is a non-binding term. That is, the seller can choose to deliver a quality level Q that differs from Q_R. In exchange for the good, the buyer offers some combination of the following payment terms: a fixed price, a formal bonus, and a discretionary bonus. The fixed price, p, is binding, meaning that it is paid if the contract is accepted, regardless of the quality provided by the seller. A formal bonus[2], f, is binding and conditioned on the seller delivering quality such that $q_1 \geq q_{1R}$. Thus, the formal bonus allows the verifiable nature of q_1 to be used to describe a payment schedule that ties the seller's compensation to performance. Since q_2 is not verifiable by third-party enforcement mechanisms, no binding bonus can be conditioned on that aspect of quality. Including a binding bonus term (i.e. $f > 0$) imposes a transaction cost of x. The discretionary bonus is non-binding. The buyer may state a proposed discretionary bonus, d_R, in the offer, but he chooses the bonus actually paid, d, after observing the seller's choice of quality.

The range of contractual structures and the payoffs of both parties are summarized in the following table:

Contract	**Terms**	**Buyer's Payoff**	**Seller's Payoff**
Unconditional	(p, d)	$V(Q) - p - d$	$p + d - C(Q)$
Conditional	(p, f, d)	$V(Q) - p - f - d - x$, if $q_1 \geq q_{1R}$ $V(Q) - p - d - x$, if $q_1 < q_{1R}$	$p + f + d - C(Q)$, if $q_1 \geq q_{1R}$ $p - d - C(Q)$, if $q_1 < q_{1R}$
No exchange		0	μ

Table 1: Possible Payoffs

Note that these amounts are the actual payoffs received by the parties. Since p and f are binding, the promised values and the amounts actually paid will be the same for these variables, although f is conditional on the seller providing at least the promised q_1. In contrast, the quality actually provided and the discretionary bonus actually paid can differ from the promised amounts, $Q \neq Q_R$ and $d \neq d_R$. However, in the repeated game theoretical equilibrium, the actual values will equal the promised values.

[2] A binding deduct term could be used, but is theoretically equivalent to a bonus. To keep the analysis simpler, we ignore the possibility of a binding deduct term (and a discretionary deduct by the buyer), since it does not add any insights in the theoretical model.

First-Best Outcome

We define efficient quality as $Q^* = (q_1^*, q_2^*) \equiv \text{argmax } V(Q) – C(Q)$. Thus, Q^* is the quality that would maximize the joint surplus available to the buyer and seller. We restrict attention to cases in which exchange is desirable by assuming that $V(Q^*) – C(Q^*) > \mu$. For internal solutions, the first-order conditions are $V_i(Q) = C_i(Q)$ for $i = 1, 2$. For a corner solution, efficiency dictates that q_i be increased so long as $V_i(Q) \geq C_i(Q)$. The efficient quality, Q^*, and its associated joint surplus provides a benchmark for analyzing the choices made by buyers and sellers acting to maximize their own payoffs, both in the theoretical model and in the laboratory experiment.

The first-best outcome is for the seller to provide Q^* in response to the buyer offering the costless contract, (p, d). This assumes that $x > 0$; if $x = 0$, the choice of contract form is irrelevant for efficiency.

Stage Game

The stage game models the participants' behavior in a one-time interaction, with each player acting to maximize his or her own payoff for that round. The familiar principle of backward induction can be applied to find the equilibrium outcome of the stage game.

In step 3, the buyer will maximize his payoff by reneging on any promised discretionary bonus; thus, he will choose $d = 0$ regardless of the quality chosen by the seller.

In step 2, a seller who has accepted a contract will maximize her payoff while realizing that the buyer will choose $d = 0$. Since there is no credible reward for delivering a high q_2, she will always choose $q_2 = q_{\min}$. Her choice for q_1 depends on how the amount of the formal bonus relates to the cost of delivering the requested q_{1R}. She will choose $q_1 = q_{1R}$ if and only if $f \geq C(q_{1R}, q_{\min}) – C(q_{\min}, q_{\min})$, and she will choose $q_1 = q_{\min}$ otherwise.

The seller will accept the contract only when her payoff under the contract, given her expected choice for q_1, exceeds her reservation payoff. Thus, she will accept if and only if $p – C_{\min} + \max\{0, f – C(q_{1R}, q_{\min}) + C_{\min}\} \geq \mu$.

In step 1, the buyer chooses whether to offer a contract and the terms of the contract, with knowledge of the choice rules that will govern the subsequent steps. For simplicity, assume that the buyer will not offer a contract that he expects the seller to reject. Making such an offer is equivalent to the buyer choosing *no exchange* from the outset.

The buyer will use the formal bonus only if it is incentive-compatible. That is, the buyer will not offer $f > 0$ unless he expects the seller to comply by choosing $q_1 \geq q_{1R}$, because doing otherwise would incur the transaction cost x without affecting the seller's choice of quality. This incentive-compatibility condition requires that $f \geq C(q_{1R}, q_{\min}) - C_{\min}$ whenever $f > 0$.

If the buyer decides to offer a contract, he chooses the terms (Q_R, p, f) in order to maximize $V(q_{1R}, q_{\min}) - p - f - I(f)x$, where $I(f)$ is an indicator function with $I = 1$ for $f > 0$ and $I = 0$ for $f = 0$. Thus, there are three possible equilibrium outcomes for the stage game.

First, the buyer could offer a *conditional contract* requesting $q_{1R} = q_1{}^{**}$ (defined below) and offering to pay $p = C_{\min} + \mu$ and $f = C(q_1{}^{**}, q_{\min}) - C_{\min} > 0$. The seller accepts and provides $Q = (q_1{}^{**}, q_{\min})$. The buyer earns a payoff of $V(q_1{}^{**}, q_{\min}) - C(q_1{}^{**}, q_{\min}) - x - \mu$, and the seller earns a payoff of μ. Define $q_1{}^{**} \equiv \text{argmax } V(q_1, q_{\min}) - C(q_1, q_{\min})$, which is the buyer's optimal q_1, given that the seller will supply $q_2 = q_{\min}$. If the cross-partial derivates are zero, so that $V_{12} = V_{21} = 0$ and $C_{12} = C_{21} = 0$, then the buyer will request the first-best level for q_1, so $q_1{}^{**} = q_1{}^{*}$.

Second, the buyer could offer an *unconditional contract* requesting $q_{1R} = q_{\min}$ and offering to pay $p = C_{\min} + \mu$ and $f = 0$. The seller accepts and provides $Q = Q_{\min}$. The buyer earns a payoff of $V(Q_{\min}) - C_{\min} - \mu$, and the seller earns a payoff of μ.

The third possibility is that the buyer does not offer a contract, so *no exchange* is the outcome. The buyer earns his reservation payoff of 0 and the seller earns her reservation payoff of μ.

The equilibrium of the stage game depends on which of these three options yields the highest payoff for the buyer. If $V(q_1{}^{**}, q_{\min}) - C(q_1{}^{**}, q_{\min}) - x - \mu$ is the greatest of the three possible payoffs, then the conditional contract resulting in $Q = (q_1{}^{**}, q_{\min})$ is the stage-game equilibrium. Similarly, if $V(q_{\min}, q_{\min}) - C_{\min} - \mu$ is the highest, then an unconditional contract inducing $Q = (q_{\min}, q_{\min})$ is the equilibrium. If both of those payoffs are negative, then *no exchange* is the stage-game equilibrium. In the repeated-game model, the stage-game equilibrium is relevant mostly in determining what threatened punishments are credible for determining the incentive-compatibility constraints.

In terms of the seller's incentive compatibility in the repeated game, the possible stage-game outcomes are equivalent. Since the profit-maximizing buyer chooses the terms of the offer, in a stage-game setting he will always make the seller's participation constraint bind, so that $p + f - C(Q) = \mu$. Thus, the seller can expect a payoff of μ in every future period if he deviates from a relational contract equilibrium.

In terms of the buyer's incentive compatibility (when a discretionary bonus is used), the choice among credible threats is more important. In the stage game, the buyer captures all of the surplus from exchange, net of paying the seller's reservation utility. Thus, a comparison of the net surplus under each option determines which of the three threats is credible and what future payoff the buyer can expect if he deviates from a relational contract equilibrium. Thus, define $\Pi_{stage} = \max\{V(q_1^{**}, q_{min}) - C(q_1^{**}, q_{min}) - x - \mu, V(q_{min}, q_{min}) - C_{min} - \mu, 0\}$ to be the buyer's payoff in the stage game, reflecting which of the three possible outcomes will occur in equilibrium.

Repeated Interaction

When parties interact over long timeframes, their behavior in a given period is influenced not only by the current payoffs but also by the possibility of rewards or punishments in future periods. Relational contracting can be modeled as an infinitely repeated game[3], in which the stage game represents one period and payoffs in future periods are discounted at a rate δ. In such a model, each person i seeks to maximize $\sum_t \delta^t P_{it}$ for $t = 0, 1, 2,\ldots, \infty$, where P_{it} is person i's payoff in period t.

This type of game can be interpreted either as an infinitely repeated game with δ representing the person's rate of time preference or as a game of finite but uncertain duration, in which δ relates to the probability of playing period t. For this latter interpretation, consider a game in which at the end of each period there is probability of $(1- \delta)$ that the game terminates. Risk-neutral players would seek to maximize the sum of expected payoffs, which creates a structure equivalent to an infinitely repeated game with time discounting.

In this game, contracts are incomplete due to the unenforceability of contract terms based on q_2. However, both parties can observe the actions taken by the other and there is no asymmetric information. Following Levin (2003), optimal relational contracts in such a situation can be framed in stationary forms. In this analysis, a relational contract is an equilibrium outcome (p, d, f, Q) and associated strategies that are constant across periods.

A standard assumption is that the parties use trigger strategies[4] to ensure each others' compliance. Under such a strategy, each party will punish the other's deviation from the desirable equilibrium behavior by taking the action that most heavily penalizes the offender within the constraint that the action must be rational for the punisher. In this

[3] In laboratory experiments, results consistent with infinite repetition models have also been found with contracting games of finite, known duration. See Wu and Roe (2007b) for an example in the context of buyer-seller contracts. Kreps et al (1982) present a theoretical model explaining this phenomenon by the presence of "cooperative" types composing some fraction of the subject population, thereby supporting cooperative behavior even for selfish players in a finitely repeated game.
[4] This approach abstracts from the issue of renegotiation of the agreement, which is assumed to be impossible.

game, the harshest credible punishment is to revert to the stage-game equilibrium for all periods once the other party has deviated. Thus, deviation from the relational contract leads to the buyer receiving a payoff of Π_{stage} and the seller receiving a payoff of μ, in all future periods.

Unconditional Contracts

If the buyer forgoes the use of the formal bonus, *f*, then he loses one possible channel for providing performance incentives, but he may also avoid costs associated with creating and enforcing a legal instrument. An agreement without a formal bonus is labeled an unconditional contract, because the payments are not conditioned on the seller's performance in an explicit, enforceable manner.

In this model, the buyer chooses the terms in the offered contract. However, there are four constraints on this choice: the buyer's and seller's participation (individual rationality) constraints and the buyer's and seller's incentive-compatibility constraints. In equilibrium, the principal (the buyer, in this model) maximizes his payoff by choosing the terms of the relational contract while abiding by those four constraints.

The contract must satisfy the seller's participation constraint, meaning that the seller prefers exchange under the contract to rejecting the contract and receiving the reservation payoff, μ.

$$p + d \geq C(Q) + \mu \qquad \text{(U1)}$$

The left-hand side of (U1) represents the benefits the seller gains in each period from exchange under the equilibrium contract, while the right-hand side represents her costs for the exchange, including forgoing her reservation payoff, μ. (See Appendix C for a more complete derivation of (U1) and other results in the theoretical model.)

The contract must also satisfy the seller's incentive-compatibility constraint, meaning that the seller prefers to deliver the requested quality and continue to operate under the terms of the contract into the future than to deliver low quality this period and be punished by operating under the stage game in future periods.

$$p + \frac{d}{\delta} \geq \frac{C(Q)}{\delta} - \frac{1-\delta}{\delta} C_{\min} + \mu \qquad \text{(U2)}$$

When (U2) holds, the seller prefers to act in accordance with the relational contract, receiving $p + d$ in payment while incurring $C(Q)$ in costs, rather than deviate by providing low quality. By deviating, the seller could reduce her current cost to $C_{\min}$ and still receive the fixed price p in the current period, but would forgo the discretionary bonus d and be limited to a payoff of μ in all future periods. Note that the seller's payoff under the stage game, which is the deviation payoff, is equal to μ regardless of which stage-game outcome constitutes the equilibrium.

The contract must satisfy the buyer's participation constraint, meaning that the buyer prefers exchange under the contract to not offering a contract and receiving the reservation payoff of 0.

$$p + d \leq V(Q) \tag{U3}$$

The left-hand side of (U3) represents the buyer's cost in each period under the relational contract, while the right-hand side represents his benefit. Note that his reservation payoff is 0, which would otherwise be included on the left-hand side.

Finally, the contract must satisfy the buyer's incentive-compatibility constraint, meaning that the buyer prefers to pay the promised discretionary bonus and continue to operate under the terms of the contract into the future than to renege on that bonus in the current period and be punished by operating under the stage game in future periods.

$$p + \frac{d}{\delta} \leq V(Q) - \Pi_{\text{stage}} \tag{U4}$$

If the buyer reneges, he can avoid the payment of the discretionary bonus d in the current period while still paying the fixed price p and receiving $V(Q)$. However, the seller would punish this deviation by reverting to the stage-game equilibrium outcome for all future periods.

In combination, these conditions determine whether an unconditional contract is feasible for a given Q, meaning that an outcome (p, d, Q) exists that can be supported by a relational contract and that both parties find (weakly) preferable to *no exchange*. The combined feasibility condition can be expressed as:

$$V(Q) - \frac{C(Q)}{\delta} \geq \Pi_{\text{stage}} - \frac{1-\delta}{\delta} C_{\min} + \mu \tag{U5}$$

When (U5) holds for some range of Q, then the buyer can choose the contract terms to maximize his payoff under the constraints (U1)-(U4). He will choose the payment terms p^U and d^U such that $d^U \geq d_{\min} = C(Q^U) - C_{\min}$ and $p^U + d^U = C(Q^U) + \mu$.

Note that the buyer's payoff is $V(Q^U) - p^U - d^U = V(Q^U) - C(Q^U) - \mu$, so the buyer captures all of the net surplus. He will therefore choose $Q^U = Q^*$ if Q^* is feasible as expressed in (U5). Otherwise, the buyer will choose the Q^U that maximizes the net surplus subject to the feasibility constraint.

Conditional Contracts

If the buyer uses the formal bonus, *f*, then he has one additional method for providing an incentive for high quality, but he may also incur additional costs for using such an instrument. An agreement including a formal bonus is labeled a conditional contract, because the payments are enforceable and explicitly conditioned on the seller's performance. As before, the buyer will choose the terms of the offered contract in order to maximize his payoff, subject to the four types of constraint: the two participation constraints and the two incentive-compatibility constraints.

The seller's participation constraint requires that the seller prefer exchange under the contract to receiving her reservation payoff, μ. With the conditional contract, this constraint can be expressed as:

$$p + f + d \geq C(Q) + \mu \tag{C1}$$

The interpretation of (C1) and the other constraints are similar to those for the unconditional contract described previously. The difference is the effect of the formal bonus payment, *f*.

When the seller's incentive-compatibility constraint is met, the seller prefers to deliver the requested quality and continue under the contract than to deliver low quality this period, thereby lowering her costs, and be punished by operating under the stage game in future periods.

$$p + f + \frac{d}{\delta} \geq \frac{C(Q)}{\delta} - \frac{1-\delta}{\delta} C(q_1, q_{\min}) + \mu \tag{C2}$$

Under the conditional contract, the seller's best deviation is to provide quality of (q_1, $q_{\min}$), in order to receive the formal bonus payment in the current period. Thus, (C2) includes $C(q_1, q_{\min})$ on the right-hand side, rather than $C_{\min}$ as found in (U2). As under the unconditional contract, the seller's deviation payoff is μ, regardless of which stage-game outcome constitutes the equilibrium.

The buyer's participation constraint for the conditional contract is:

$$p + f + d \leq V(Q) - x \tag{C3}$$

The difference between (C3) and (U3) is the inclusion of the formal bonus, *f*, and the contracting cost, *x*, both of which reduce the buyer's net payoff.

Finally, the contract must satisfy the buyer's incentive-compatibility constraint, which reflects his decision to pay the promised discretionary bonus rather than to renege on that bonus in the current period and be punished by reversion to the stage game in future periods.

$$p + f + \frac{d}{\delta} \leq V(Q) - \Pi_{\text{stage}} - x \qquad \text{(C4)}$$

If the buyer reneges, he avoids the payment of the discretionary bonus *d* in the current period while still paying the fixed price *p* and the formal bonus *f* and receiving $V(Q)$ in return. He also incurs the contracting cost *x* in the current period. However, the seller would punish this deviation by reverting to the stage-game equilibrium outcome for all future periods.

In combination, these conditions determine whether a conditional contract is feasible for a given *Q*, meaning that an outcome (*p, f, d, Q*) exists that can be supported by a relational contract and that both parties find (weakly) preferable to *no exchange*. The combined feasibility condition can be expressed as:

$$V(Q) - \frac{C(Q)}{\delta} \geq \Pi_{\text{stage}} - \frac{1-\delta}{\delta} C(q_1, q_{\min}) + \mu + x \qquad \text{(C5)}$$

When (C5) holds for some range of *Q*, then the buyer can choose the contract terms to maximize his payoff under the constraints (C1)-(C4). He will choose the payment terms p^C and d^C such that $d^C \geq d_{\min} = C(Q^C) - C(q_1, q_{\min})$ and $p^C + f^C + d^C = C(Q^C) + \mu$.

Note that the buyer's payoff is $V(Q^C) - p^C - f^C - d^C - x = V(Q^C) - C(Q^C) - \mu - x$. Thus, the buyer captures all of the net surplus and will choose $Q^C = Q^*$ if Q^* is feasible. Otherwise, the buyer will choose the Q^C to maximize the net surplus subject to the feasibility constraint.

Choice of Contract

The theoretical model presents some interesting results regarding the buyer's choice of contract structure (conditional or unconditional) in the repeated game. When at least one of the two feasibility conditions is met for some *Q* (implying that outcome is preferable to *no exchange*), then the buyer will choose the contract that offers him the higher payoff. Thus, he will choose to offer an unconditional contract if $V(Q^U) - C(Q^U) - \mu > V(Q^C) - C(Q^C) - \mu - x$, and he will choose a conditional contract otherwise. In general, $Q^U \neq Q^C$, because the two types of contracts have different feasibility conditions. $Q^U = Q^C$ when the efficient quality Q^* is feasible under both types of contracts or when the upper limits of the feasible ranges just happen to coincide.

For some sufficiently low *x*, (C5) will be less constraining than (U5), meaning that the set of *Q* feasible under an unconditional contract would be a subset of the set feasible for a conditional contract. This result holds because $C(q_1, q_{\min}) > C_{\min}$ for $q_1 > q_{\min}$, so that the right-hand side of (C5) is less than the right-hand side of (U5), for a low *x*. In particular, use of the conditional contract would allow for higher quality levels. As long as the additional net surplus from higher quality is greater than the transaction cost, then the buyer would prefer the conditional contract to the unconditional contract, and the efficiency of the outcome would also be greater.

In other cases, however, the buyer will prefer the unconditional contract. This would occur when *x* is high enough to offset the potential improvement in quality that a conditional contract would allow. In the extreme, if the optimal quality Q^* is feasible under both contracts, then any $x > 0$ would induce the buyer to choose an unconditional contract, because extending the range of feasible *Q* has no benefit. In general, the model predicts that the buyer will choose an unconditional contract when *x* is high and a conditional contract when *x* is low.

Quality

The feasibility of a given quality level under the two contract types depends on the expected duration of partnerships, δ. This relationship can be seen more clearly when the two feasibility conditions are rewritten as follows:

$$V(Q) \geq \Pi_{\text{stage}} + \frac{1}{\delta}\left[C(Q) - C_{\min}\right] + C_{\min} + \mu \qquad \text{(U5')}$$

$$V(Q) \geq \Pi_{\text{stage}} + \frac{1}{\delta}\left[C(Q) - C(q_1, q_{\min})\right] + C(q_1, q_{\min}) + \mu + x \qquad \text{(C5')}$$

Given the initial assumption that $C_i(Q) > 0$ for $i = 1, 2$, the term in square brackets must be non-negative in both (U5') and (C5'). Thus, increasing δ makes each type of contract "more feasible," so that the feasibility conditions hold for larger ranges of *Q*. Thus, when the parties expect that interaction will continue for a long time, they are able to achieve higher-quality outcomes than when they expect relationships to be brief.

The quality of the good also depends on the transaction cost, *x*. As noted above, lower values of *x* will increase the quality feasible under a conditional contract relative to that feasible under the unconditional contract. All else equal, this would suggest that a lower *x* improve the quality level that can be achieved. However, the level of *x* has another effect on the feasible quality through its impact on the stage game outcome.

The transaction cost affects the desirability of a conditional contract in stage game. At high levels of *x*, the conditional contract will be unattractive to the buyer, who would either offer the unconditional contract for minimum quality, Q_{min}, or choose no exchange. At some threshold level of *x*, the conditional contract for $q_1 > q_{min}$ becomes the stage game outcome. For *x* below this threshold level, the feasible quality increases and the stage-game payoff for the buyer improves. By increasing the stage-game payoff, Π_{stage}, the lower value of *x* tends to reduce the level of quality feasible in the repeated game under both types of contracts.

Which of the effects of *x* on feasible quality dominates will depend on the functional forms of $V(Q)$ and $C(Q)$ and the other parameters. However, it is possible that a decrease in transaction cost, thereby making formal incentives easier to use, can lead to a decline in the quality and net surplus that the parties can achieve. This results contrasts to most intuitions about making formal incentives more available.

Experiment Design

We designed and carried out a laboratory experiment to test the predictions of the theoretical model outlined in the previous section. During August and September of 2008, we ran 19 experimental sessions: 5 each of the S, SX, and LX treatments and 4 of the L treatment. (The treatments are described below.) The subjects were undergraduate students of a variety of majors recruited via email from a major university. The experiments were conducted in a computer lab, using z-Tree software (Fischbacher, 2007). Each session involved from 6 to 12 subjects, with a total of 162 subjects over the 19 sessions.

The subjects were randomly assigned into pairs, with one buyer and one seller in each pair. Each pair played a repeated game of indefinite duration, creating an environment conducive to relational contracting.

Because the experiment incorporated the indefinite repetition element of the model, the sessions' durations varied. The average length of a session was 18.3 periods, with a minimum of 8 and a maximum of 37 (see Table 2). Although the experiment was designed so that the expected duration was roughly equal across treatments[5], the realized durations varied considerably, with the S and SX treatments generally having shorter overall durations than did the L and LX treatments. In recognition of the potential differences across treatments due to learning effects, we perform some tests for learning effects and also control for them in econometric analyses.

[5] Although the expected duration of partnerships, captured by the parameter δ, was intended to vary across treatments, the expected number of partnerships varied inversely to the expected duration. Thus, the S and SX sessions were intended to have more but shorter partnerships than were the L and LX sessions, but the total lengths of the various sessions were intended to be relatively similar, approximately 15 periods.

Treatment	Sessions	Number of Subjects Avg.	Min.	Max.	Duration (Periods) Avg.	Min.	Max.	Number of Partners Avg.	Min.	Max.
S	5	8.8	6	10	15.2	11	19	4.2	2	7
SX	5	8.4	6	10	14.4	11	17	4.0	2	6
L	4	8.0	6	10	17.75	8	23	2.0	1	3
LX	5	8.4	6	12	25.8	14	37	2.0	1	3
Overall	19	8.5	6	12	18.3	8	37	3.1	1	7

Table 2: Experimental Sessions

The game played by the subjects implements a particular specification of the theoretical model described in the previous chapter. The instructions (see Appendix B for a sample) were read aloud and each subject was given a printed copy for reference during the session. In addition, each subject answered several multiple-choice questions about hypothetical situations in the game, with the correct answers provided afterwards, in order to help them understand the structure of the game. Finally, the subjects played 3 practice rounds, identical to the normal rounds except that they had no effect on the subjects' earnings.

In each period, each buyer negotiates the exchange of a good with his seller partner. The good has a two-dimensional nature or quality, $Q = (q_1, q_2)$. Each dimension of quality can take on any integer value from 1 to 10, so $q_1, q_2 \in \{1,2,...,10\}$. The value of the good to the buyer (V) and its production cost to the seller (C) vary with its quality, and the functional forms are $V(Q) = v_1q_1 + v_2q_2$ and $C(Q) = c_1q_1 + c_2q_2$, with parameters $v_1 = v_2 = 10$, $c_1 = 5$, and $c_2 = 8$.

The first dimension of quality, q_1, is verifiable by third parties (e.g. courts). Thus, formally enforceable contract terms can be made contingent on q_1. On the other hand, q_2 is observable by the parties but not verifiable by third parties. Thus, incentives contingent on q_2 cannot be formally enforced. In the repeated game, however, the buyer can use informal incentives to encourage high q_2.

The sequence of decisions in each round is as follows:

Step 1: Buyer's Offer

In the negotiations for each period, the buyer makes an offer or chooses to exit. In the latter case, no exchange takes place and the buyer and seller each receive his or her reservation payoff (0 points for the buyer and 20 points for the seller). An offer consists of four terms: a quality request, a base price, a formal bonus, and an informal bonus.

With the *quality request*, the buyer specifies the two quality levels (q_{1R}, q_{2R}) that he would like to receive from the seller. This request is not enforced, so the seller can choose any quality he or she wishes (in step 2), assuming the offer is accepted.

The *base price* (p) is an unconditional payment made by the buyer to the seller. This price is enforced for any offer that is accepted, so the buyer pays this amount regardless of the quality that the seller delivers.

The buyer also specifies a *formal bonus* (f), which will be paid if the seller delivers q_1 (the verifiable dimension of quality) at least equal to the q_{1R} requested.[6] This formal bonus will be enforced if the seller's delivered quality meets the condition. The inclusion of this term (i.e. specifying a formal bonus greater than 0) triggers a transaction cost ($x = 0$ or 35, depending on the treatment) that the buyer must pay if the offer is accepted.

Finally, the buyer specifies a *discretionary bonus* (d_R) that he promises to pay if the seller delivers the requested quality (both q_1 and q_2) or better. This term is not enforced, so the buyer can choose any amount (including $d = 0$) for the actual discretionary bonus, regardless of the quality delivered by the seller. Specifying a discretionary bonus does not incur a transaction cost.

The allowed ranges for the terms of the offer are $1 \leq q_1 \leq 10$, $1 \leq q_2 \leq 10$, $0 \leq p \leq 200$, $0 \leq f \leq 200$, and $0 \leq d_R \leq 200$. Note that 200 is the benefit to the buyer of the maximum quality.

Step 2: Seller's Choice

Once the buyer makes an offer, the seller chooses whether to accept or reject it. If the seller rejects, then no exchange takes place and each party receives his or her reservation payoff for the period. If the seller accepts the offer, then he chooses the quality levels (q_1, q_2) for the delivered good. In implementing the experiment, the accept/reject decision and the choice of quality are separated into two sub-steps, to simplify the interface for the seller.

Step 3: Buyer's Discretionary Payment

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[6] In the theoretical model, the formal bonus is incentive-compatible (inducing the desired behavior from the seller) when $f \geq C(q_{1R}, q_{\min}) - C_{\min}$. The buyer would not offer a non-incentive-compatible formal bonus, because to do so would incur the contracting cost without affecting the seller's behavior. However, incentive-compatibility was not enforced in implementing the experiment. Thus, the subjects were free to offer any f they chose.

Once the buyer observes the quality delivered by the seller, he chooses the amount he will actually pay for the discretionary bonus (d). The discretionary bonus specified in the offer is not binding (i.e. $d \neq d_R$ is allowed); the buyer can choose any amount he wishes from 0 to 200. No discretionary payment is allowed if either party exits (i.e. following *no exchange*).

The following table summarizes the buyer's and seller's payoffs.

Offer Type	**Quality**	**Buyer's Payoff**	**Seller's Payoff**
No exchange		0	20
Formal ($f > 0$)	Actual $q_1 \geq$ requested q_{1R}	$V - p - f - d - x$	$p - C + f + d$
	Actual $q_1 <$ requested q_{1R}	$V - p - d - x$	$p - C + d$
Informal ($f = 0$)	Buyer exit or seller reject	$V - p - d$	$p - C + d$

Table 3: Experimental Payoffs

All payoffs are given in points. Subjects were paid in cash at the end of the experiment, at the rate of 50 points = $1. In addition to the points earned from exchange, each subject was given a 250-point starting balance, plus a $7 show-up fee.[7]

Based on the theoretically predicted behavior, the average player in the lowest-paying treatment (S) should earn 26 points per period. The average player in the highest-paying session (L) should earn 35 points per period. Based on an average duration of 15 periods (see below), the average subject should earn approximately $21-$22, including the starting balance and show-up fee.

At the end of each period, there is an exogenous chance that the relationship will terminate. The probability that the relationship continues is $\delta = 0.667$ or 0.9, depending on the treatment. If the relationship continues (i.e. does not terminate), then the subjects repeat the stage game with the same partners. This chance for continuation creates a repeated game of uncertain duration, which is structurally equivalent to an infinitely repeated game with discounting. If the relationship terminates, then either the subjects are randomly reassigned to new partners (creating a new relationship) or the session ends. All pairs use the same random draw for termination, so all subjects' relationships will be of the same length.

[7] For the last 6 sessions (3 of treatment L and 3 of treatment LX), the subjects were paid $12 as a show-up fee, because the high-δ sessions had proven to last significantly longer than the S and SX sessions. Since the extra $5 was paid as a lump sum, it should not have altered the subjects' behavior in the later sessions.

For the δ = 0.667 treatments, the first termination to occur in or after period 10 will lead to one final repetition of the treatment. In other words, only one new relationship will begin after period 10. For the δ = 0.9 treatments, the first termination in or after period 5 signals the start of the last relationship. The subjects were notified when the final relationship began.[8]

Treatments

The treatment variables are the transaction cost, x, and the probability of continuation, δ. Each variable takes on one of two possible values, giving rise to four treatments. In the S treatment, the contracting cost is $x = 0$ and the probability of continuation is $\delta = 0.667$. In the SX treatment, the contracting cost is $x = 35$ and the probability of continuation is $\delta = 0.667$. In the L treatment, the contracting cost is $x = 0$ and the probability of continuation is $\delta = 0.9$. In the LX treatment, the contracting cost is $x = 35$ and the probability of continuation is $\delta = 0.9$.

This set of treatments allows for the analysis of the two determinants of contract choice discussed earlier. With δ as a treatment variable, the impact of the expected length of partnerships on contract choice and welfare can be evaluated. Likewise, varying x across treatments allows for testing of theoretical predictions about the impacts of changing the availability of formal incentives. By applying the specifications of the experimental design to the model developed earlier, we determine the theoretical equilibrium for each of the treatments. These predicted outcomes, in turn, allow me to form hypotheses that can be tested with the data from the sessions.

First-Best

When transactions costs are positive ($x > 0$), the first-best outcome in each period is for the buyer to offer an unconditional contract (i.e. $f = 0$) and for the seller to supply the highest possible quality (10, 10). That produces the maximum joint surplus of 70, which will be allocated between the parties by the terms of the agreement. When transaction costs are zero ($x = 0$), a conditional contract ($f > 0$) could also be used in the first-best outcome to achieve quality of (10, 10).

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[8] For 3 of the 19 sessions, the session had to be ended when the maximum time was reached, rather than because the random draw indicated termination. In these 3 sessions, the subjects were notified at the beginning of the final session, and the data for those periods was deleted before analysis.

Treatment S

In treatment S, the values of the treatment parameters are $\delta = 0.667$ and $x = 0$, so S features short duration and low contracting cost relative to the other treatments. For the stage game, the equilibrium outcome is a conditional contract which the seller accepts, providing quality of (10, 1) and receiving total payment of $p + f = 78$, where the formal bonus is $f \geq 45$ contingent on delivery of $q_1 = 10$. In this equilibrium, the buyer earns a payoff of 32 and the seller earns a payoff of 20 (equal to his reservation payoff).

In the repeated game, the equilibrium outcome is the same as that of the stage game. The relatively attractive stage game outcome means that the buyer's punishment for deviation from a relational contract is mild. Thus, he cannot credibly promise to pay a discretionary bonus in return for the seller delivering higher quality; the incentive to cheat and withhold the bonus is too great to support such an equilibrium.

The buyer could feasibly achieve a higher-quality outcome by paying a rent to the seller (i.e. total payment greater than the seller's cost plus reservation level). However, such an arrangement is non-optimal for the buyer since the necessary additional payment would be greater than the benefit he receives from the higher quality.

Treatment SX

In treatment SX, the values of the treatment parameters are $\delta = 0.667$ and $x = 35$, so SX features short duration and high contracting cost relative to the other treatments. For the stage game, the equilibrium outcome is no exchange. In this equilibrium, the buyer earns a payoff of 0 and the seller earns a payoff of 20 (equal to his reservation payoff). The high transaction cost ($x = 35$) effectively precludes the use of the formal bonus in the stage game (and in the repeated game) and the discretionary bonus is non-credible. Without those performance-based incentives, the seller would supply only $Q =$ (1, 1), which does not generate enough joint surplus to support an individually rational exchange (i.e. one or both parties would earn less than their reservation payoffs).

In the repeated game, however, the buyer is able to promise a discretionary bonus that will induce higher quality from the seller. Since the stage game outcome is relatively unattractive, the buyer has little incentive to deviate from the equilibrium by withholding the promised bonus. In this context, the equilibrium outcome is an unconditional contract that the seller accepts, providing quality of (10, 5) and receiving total payments of $p + d =$ 110, with $f = 0$ and $d \geq 77$. In this equilibrium, the buyer earns a payoff of 40 and the seller earns a payoff of 20.

Treatment L

In treatment L, the values of the treatment parameters are $\delta = 0.9$ and $x = 0$, so L features long duration and low contracting cost relative to the other treatments. For the stage game, the equilibrium outcome is a conditional contract requesting quality of (10, 1) and total payment of $p + f = 78$, where the formal bonus is $f \geq 45$ contingent on delivery of $q_1 = 10$. In this equilibrium, the buyer earns a payoff of 32 and the seller earns a payoff of 20 (equal to his reservation payoff).

In the repeated game, however, the buyer is able to promise a discretionary bonus that will induce higher quality from the seller. Relative to treatment S, the higher probability of continuation makes this discretionary payment credible as part of the equilibrium strategy. A higher continuation probability increases the value of the buyer's future payoffs in excess of the stage game payoffs (his deviation payoffs), so he becomes less willing to deviate from the relational contract equilibrium.

In this treatment, the equilibrium outcome is a conditional contract that the seller accepts, providing quality of (10, 10) and receiving total payments of $p + f + d = 150$, with $f \geq 45$ and $d \geq 72$. In this equilibrium, the buyer earns a payoff of 50 and the seller earns a payoff of 20.

Treatment LX

In treatment LX, the values of the treatment parameters are $\delta = 0.9$ and $x = 35$, so LX features long duration and high contracting cost relative to the other treatments. For the stage game, the equilibrium outcome is no exchange. In this equilibrium, the buyer earns a payoff of 0 and the seller earns a payoff of 20 (equal to his reservation payoff). The high transaction cost ($x = 35$) effectively precludes the use of the formal bonus in the stage game (and in the repeated game) and the discretionary bonus is non-credible. Without those performance-based incentives, the seller would supply only $Q = (1, 1)$, which does not generate enough joint surplus to support an individually rational exchange (i.e. one or both parties would earn less than their reservation payoffs).

In the repeated game, however, the buyer is able to promise a discretionary bonus that will induce higher quality from the seller. Since the stage game outcome is relatively unattractive, the buyer has little incentive to deviate from the equilibrium by withholding the promised bonus. Relative to treatment SX, the higher probability of continuation means that even higher quality levels can be supported in equilibrium under treatment LX. In this context, the equilibrium outcome is an unconditional contract that the seller accepts, providing quality of (10, 10) and receiving total payments of $p + d = 150$, with $f = 0$ and $d \geq 117$. In this equilibrium, the buyer earns a payoff of 50 and the seller earns a payoff of 20.

Hypotheses

Expected Duration

When parties anticipate longer working relationships, the relational incentives stemming from promises or threats about future payoffs should be stronger. These improved incentives should, in turn, allow the parties to achieve more efficient outcomes. The efficiency of the outcomes can be measured by the parties' joint surplus, i.e. the sum of the buyer's and seller's payoffs for a period. The quality levels in a particular transaction are also related to the efficiency of the outcome.

In the experiment, the expected duration is captured by the treatment variable δ, reflecting the probability of continuing with the same partner in the following period. The high-δ treatments (L and LX) should achieve more efficient outcomes than the low-δ treatments (S and SX).

Hypothesis 1 – Joint surplus and quality will be higher in treatment L than in S, and also higher in LX than in SX.

Another aspect of the outcome is the distribution of welfare between the parties. Net payoffs can be defined as each party's payoff reduced by his reservation payoff, reflecting that party's gains from making an exchange. Net surplus can then be defined as the sum of the two parties' net payoffs, and the division of this net surplus between the parties can be analyzed.

In the theoretical model, the buyer captures all of the net surplus because he makes a take-it-or-leave-it offer. In experimental settings, however, it is common for the offer recipient to require more than her reservation payoff to acquiesce to the offer. Thus, it is likely that there will be some sharing of the net surplus between the buyer and seller. The theoretical model provide little or no guidance on this issue, since it predicts 100% of the net surplus will go to the buyer, but the empirical observations may provide some useful insights.

Hypothesis 2 – All net surplus will be captured by the buyer, so the seller's payoff will be equal to her reservation level.

Contract Cost

When formal incentives are more difficult to use, the parties in long-term interactions rely more heavily on informal incentives. In the experiment, this difficulty is captured by x, the cost of using the formal bonus. In the theoretical model, the buyer completely forgoes the use of the formal bonus in the high-cost treatments. In the low-cost treatments, the buyer should always use the formal bonus.

Hypothesis 3 – Use of the formal bonus will be less frequent in treatment LX than in L, and less frequent in SX than in S.

The effect of the contract cost, *x*, on the efficiency of outcomes is more complicated. As discussed in the theoretical model, the cost affects the feasibility conditions in two ways. It has a direct effect on the feasibility condition for conditional contracts, (C5), via the + *x* term on the right-hand side of the inequality. This effect reflects the greater difficulty in using formal incentives when their transactions costs are high. Considering this effect, a higher cost makes high quality less feasible using conditional contracts. When conditional contracts are preferred to unconditional contracts, this effect tends to reduce the quality that the parties can achieve. When unconditional contracts are preferred, raising the transaction cost does not produce this effect on quality and net surplus.

However, the contract cost can also have an indirect effect on the feasibility conditions of both the conditional and unconditional contracts via its impact on the stage-game equilibrium. This effect enters via the Π_{stage} term in the right-hand sides of (U5) and (C5). A higher contract cost decreases the attractiveness of using a formal bonus in a one-shot interaction, reducing the payoff available to buyer via formal incentives. When the stage-game outcome is based on using the formal incentive, this effect increases the punishment that a buyer faces for reneging on a promised discretionary bonus.

Based upon the equilibria predicted in the theoretical model, treatment LX outcomes should show the same welfare measures as do L outcomes. However, the feasibility constraint is looser for any given quality level in L than in LX, indicating that high quality is "more feasible" under L. Thus, we would expect L to produce better outcomes to the extent that the behavior under the two treatments is different. This expected difference in outcomes between L and LX corresponds to the complementarity effect noted by Baker, Gibbons, and Murphy (1994).

Hypothesis 4 – The joint surplus and quality in treatment L will be greater than or equal to those in treatment LX.

In the model, treatment SX results in more efficient outcomes than does S, because of the effect that the transaction cost has on the buyer's incentive-compatibility constraint. In treatment S, the lack of a transaction cost means that the buyer could use a formal bonus to induce reasonably good outcomes in the stage game. However, that weakens his incentive to comply with a promised discretionary bonus in a repeated interaction. In treatment SX, the poor stage outcome (no exchange) creates a harsher punishment for deviations in the repeated game, thus allowing the buyer to more credibly promise a discretionary bonus for high quality. This expected difference in outcomes between S and SX corresponds to the substitution effect noted by Baker, Gibbons, and Murphy (1994) and Schmidt and Schnitzer (1995).

Hypothesis 5 – The joint surplus and quality in treatment S will be less than those in treatment SX.

Experimental Results

Table 4 below presents a summary of the data observed in the four treatments. The unit of analysis is a partnership-period. There were 1,467 observations, of which 806 resulted in an exchange.

	S	SX	L	LX
Offer %	0.96	0.91	0.93	0.87
Accept %	0.69	0.46	0.68	0.55
Formal %	0.91	0.40	0.95	0.40
Desired q_1	9.07	8.35	9.00	9.18
Desired q_2	6.54	6.37	5.09	7.56
Actual q_1	8.58	6.35	8.41	7.97
Actual q_2	4.57	3.79	3.46	5.18
Buyer's payoff	24.75	3.36	16.39	12.56
Seller's payoff	27.29	21.95	32.55	23.82
Net surplus	32.04	5.32	28.94	16.38
Buyer %	0.77	0.63	0.57	0.77

Table 4: Summary Data for Experiment

In Table 4, *Offer %* shows the proportion of periods in which the buyer made an offer. *Accept %* shows the proportion of those offers that were accepted by the seller. The remaining variables are restricted to offers that were accepted. *Formal %* is the proportion of accepted offers that used the formal bonus, meaning that a formal bonus greater than 0 was promised in the offer. *Desired* q_1 and *Desired* q_2 are the average quality levels specified in the buyer's offer (ranging from 1 to 10). *Actual* q_1 and *Actual* q_2 are the average quality levels delivered by the seller. *Buyer's payoff* and *Seller's payoff* are the average earnings (in points) per period. *Net surplus* is the sum of the parties' payoffs less their reservation values. *Buyer %* shows the proportion of the net surplus captured by the buyer.

The descriptive statistics presented in Table 4 are indicative of the overall results. Formal hypothesis tests and regression analyses were conducted and are discussed in the following sections. Kruskal-Wallis hypothesis tests for the differences among treatments are provided in Table 10 (at end of paper).

Choice of Contract Structure

Hypothesis 3 predicts that use of the formal bonus will be less frequent in treatments SX and LX, when it is more costly, than in treatments S and L. The data strongly support this hypothesis. In both of the low-cost treatments, use of the formal bonus was approximately 90%, very close to the theoretical benchmark of 100%. In the high-cost treatments, use of the formal bonus was approximately 40%, markedly lower than in S and L but still higher than the theoretical benchmark of 0%. Kruskal-Wallis tests indicate that the differences in the use of the formal incentive between S and SX and between L and LX are significant ($p < 0.001$ in both cases).

The institutional environment affects the choice of contract structure by influencing the types of agreements that will be feasible and, ultimately, the payoff that each party expects to earn. In this experiment, the buyer has sole control over the structure of the contract offered, so his potential payoff under the various contractual structures is paramount. In general, the buyer is expected to choose the contractual structure that offers him the greatest payoff.

This intuition can be tested by within-treatment comparisons of the outcomes for buyers who chose to use formal incentives and those for buyers who did not. Table 5 presents the results for these comparisons, with *F* representing the partition within a treatment of accepted contracts that contained a formal bonus and *No F* representing the partition containing those that omitted the formal incentive. The *p*-value shows the results of a Kruskal-Wallis hypothesis test regarding the difference between the *F* and *No F* partitions within each treatment.

		n	Desired q_1	Desired q_2	Actual q_1	Actual q_2	Buyer's Payoff	Seller's Payoff	Net Surplus
S	F	202	9.28	6.41	8.89	4.39	25.53	27.69	33.23
	No F	20	6.95	7.85	5.45	6.40	16.85	23.20	20.05
	p-value		< 0.001	0.162	< 0.001	0.069	0.055	0.508	0.035
SX	F	52	8.40	6.67	6.52	3.62	-14.10	18.92	-15.17
	No F	78	8.31	6.17	6.23	3.91	15.00	23.97	18.97
	p-value		0.761	0.346	0.558	0.628	< 0.001	0.189	< 0.001
L	F	241	9.09	4.98	8.68	3.59	19.61	30.96	30.57
	No F	13	7.38	7.00	3.31	1.08	-43.23	61.92	-1.31
	p-value		0.005	0.038	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
LX	F	79	9.19	7.03	8.33	4.13	1.19	13.71	-5.10
	No F	121	9.17	7.91	7.74	5.86	19.98	30.42	30.40
	p-value		0.298	0.010	0.706	0.001	< 0.001	< 0.001	< 0.001

Table 5: Effects of Contract Choice

In treatments SX and LX, buyers using the formal incentives had significantly lower payoffs than did those who used only informal incentives. Interestingly, the average quality levels induced by the two contractual structures were similar within each treatment, so the differences in net surplus were very close to the transaction cost of x = 35. Differences in actual q_1 were not significant at standard confidence levels, while the difference in q_2 was significant for treatment LX, but not for SX.

For treatments S and L, using the formal bonus improved outcomes, generally increasing quality levels and the buyer's earnings. These differences were generally significant at standard levels, except in treatment S where differences in actual q_2 and buyer's payoff were somewhat outside the $p = 0.05$ threshold. Some caution in interpreting these results is warranted, since there were relatively few observations without the formal incentive in these two treatments.

A comparison of the high- and low-cost treatments therefore suggests that the buyers generally did respond to the payoff potential in selecting which incentives to offer, although the usage of formal incentives was substantially higher in absolute terms in treatments SX and LX than the theoretical predictions suggest. This result is consistent with the strategic ambiguity theory of Bernheim and Whinston (1998).

One phenomenon sometimes observed in experiments is that subjects go through a learning period. In such cases, their behavior may deviate substantially from the theoretical equilibrium in earlier periods, but over time they learn from their experiences, adjusting their choices to converge toward the outcome predicted by theory.

Table 11 (end of paper) presents the results from comparing subjects' earlier decisions to their later ones. For each treatment, the data was partitioned into two groups. *Early* observations are those up to and including the 8th period in each session, which is the shortest duration of any of the sessions. *Later* observations are those occurring after the 8th period. Table 11 shows the mean choices for these partitions in each treatment, as well as Kruskal-Wallis hypothesis tests for the differences between the early and later observations.

With regard to the choice of contract structure, use of the formal incentive appeared to be increasing over time in treatments S and L and decreasing for SX and LX. However, only for treatment S was the difference in usage significant at standard levels. Figure 1 illustrates these trends, presenting the average frequency of using the formal incentive by period. Note that later periods contained fewer observations.

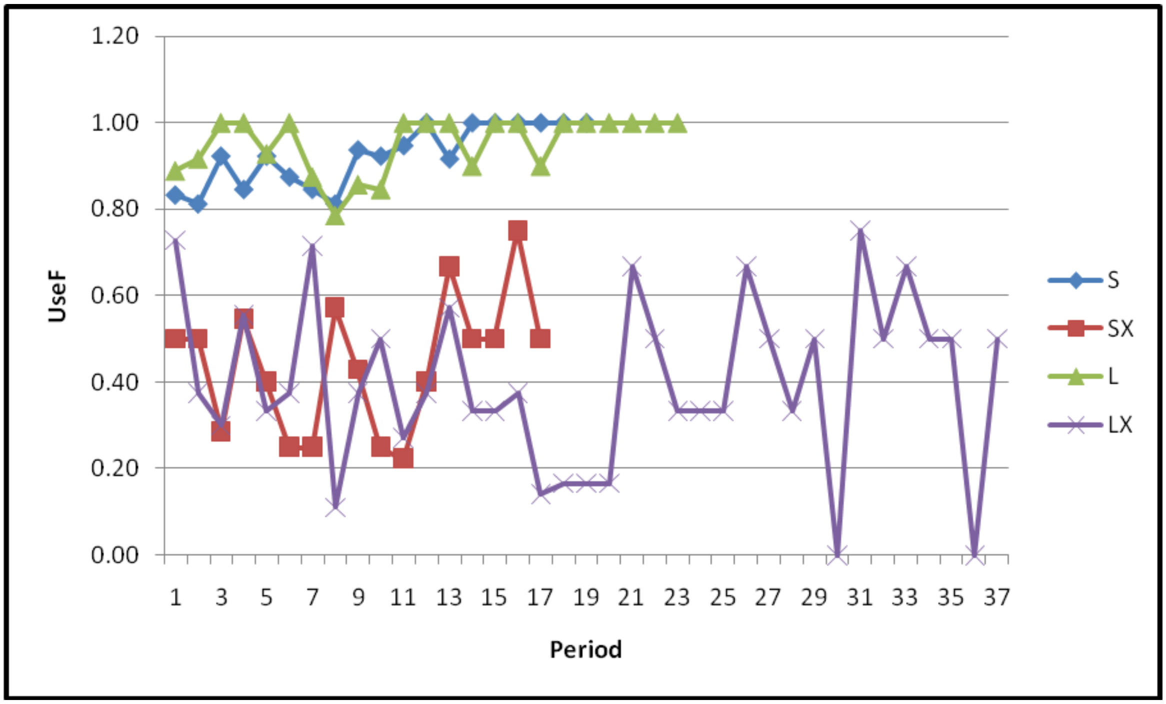

Figure 1: Use of Formal Incentives Over Time

Effects of Institutions on Welfare and Efficiency

The treatment variables represent exogenous institutional characteristics that affect the choices of the contracting parties, which in turn affect the gains they realize from participating in exchange. From Hypothesis 1, a longer expected length of partnerships is predicted to improve the net surplus and quality levels achieved by the parties. As Table 5 shows, the subjects did achieve more efficient outcomes in treatment LX than they did in SX. Kruskal-Wallis tests indicate that the differences are significant ($p < 0.001$ for actual q_1 and net surplus, $p < 0.002$ for actual q_2). These results are generally consistent with the theoretical predictions of the model, in which the difference between the equilibrium outcomes for SX and LX stems from the improved effectiveness of informal incentives when the expected duration is longer. Although the model predicts that actual q_1 will be the same for these two treatments, the equality is an artifact of reaching a corner solution, since the predicted q_1 is the maximum allowed. The experimental results suggest that an improvement in informal incentives may also improve the verifiable quality (q_1) that the parties can achieve, at least in the context of the high-cost treatments.

The data are mixed with respect to treatments L and S and Hypothesis 1. For the quality and net surplus variables, treatment S showed results approximately equal to or better than those for treatment L. Kruskal-Wallis tests indicate that the differences are significant with respect to actual q_2 ($p = 0.023$) and net surplus ($p < 0.001$), but not with respect to actual q_1 ($p = 0.096$). According to the model, the q_1 achieved in these treatments should be similar and high, which is consistent with the data. However, the model predicts that actual q_2 and net surplus will be higher under treatment L than under S, while the opposite was observed in the experiment. This results contrasts with the notion that longer expected durations would improve the outcomes achieved.

Learning effects may contribute somewhat to reconciling the observations with the theoretical predictions. From Table 11, the mean q_2 appears to be decreasing over time for treatment S and increasing over time for L, although only the former is significant at standard levels. As a result, the net surplus is increasing under treatment L ($p < 0.001$) but not under treatment S.

It is also to be expected that theoretical predictions about the effect of expected duration would be stronger for the high-cost treatments (SX and LX) than for the low-cost treatments. In the high-cost treatments, the outcomes depend more heavily on the use of informal incentives, since the formal bonus is costly and therefore used less. Expected duration is an important factor in the effectiveness of relational contracting and informal incentives, so the difference between SX and LX should make a large impact in this context. For the low-cost treatments, on the other hand, the formal incentive plays a larger role and the expected duration matters little for its efficacy. Thus, one would expect the impact of expected duration to be less in the comparison between S and L, and possibly outweighed by other factors not incorporated into the theoretical model.

In additional to the total amount of net surplus (i.e. efficiency), its division between the parties is important in analyzing their welfare. As stated in Hypothesis 2, the theoretical model predicts that the buyer will capture the entire net surplus, leaving the seller with only her reservation payoff in each period. However, a common phenomenon in experimental settings is that subjects share net surplus to greater degree than predicted by a model of rational, self-interested agents.[9]

In this experiment, the buyer received the majority of the net surplus but less than 100%, ranging from 57% (in treatment L) to 77% (in LX) of the net surplus. These values are consistent with the idea that some sharing will occur, rather than the buyer capturing the entire surplus via a take-it-or-leave-it offer. The amount of sharing does not seem to be obviously correlated with the expected duration, the contracting cost, or the size of the net surplus.

The other treatment variable is the contracting cost, which represents the availability of effective third-party enforcement mechanisms for formal incentives. Hypotheses 4 and 5 express the complementarity and substitution hypotheses, respectively, discussed in the previous literature. In general, the subjects' behavior provides some evidence for a complementarity effect and argues against a substitution effect.

Hypothesis 4 (complementarity) predicts that quality levels and net surplus will be higher in treatment L than in LX. The theoretical mechanism underlying this prediction is that the formal incentive not only induces high q_1 directly, but that it also strengthens informal incentives used to promote higher q_2. This strengthening occurs for two reasons. First, the presence of the formal incentive reduces the seller's potential gain from deviation, because the savings in cost is partially offset by a reduction in payment (the forgone bonus). Second, it reduces the buyer's incentive to withhold payment, because less of the total payment is discretionary, decreasing the buyer's potential gains from deviation.

As seen in Table 4, the net surplus achieved in treatment L was higher than that in LX, and the difference was statistically significant (Kruskal-Wallis $p < 0.001$), as predicted by the model. The apparent difference with respect to actual q_1 is not significant ($p = 0.87$), again consistent with the theoretical model. However, the actual q_2 was lower in treatment L than in LX, which is inconsistent with the model and the notion of a complementarity effect.

These results raise the question of how the treatment L subjects were able to achieve higher net surplus when their average q_1 was similar to that of the treatment LX subjects and their average q_2 was lower. Given the functional forms for the buyer's value and the seller's cost, the q_1 dimension of quality has a substantially greater impact on net surplus than does the q_2 dimension. Thus, the higher average q_1 in L, although

[9] Wu and Roe (2007a) report a very similar result, also in an experiment with a contracting game.

statistically insignificant, partially offset the lower q_2. Perhaps more importantly, those buyers in LX who did use the formal incentive incurred a large contracting cost, which decreased the net surplus for given quality levels.

In order to control for the effects of the contracting cost on the net surplus, we make another comparison using only those LX observations that did not use the formal incentive. The results are presented in Table 6.[10]

	L (All)	LX (No F only)	*p*-value
DesiredQ1	9.00	9.17	0.016
DesiredQ2	5.09	7.91	< 0.001
Q1	8.41	7.74	0.667
Q2	3.46	5.86	< 0.001
BEarn	16.39	19.98	< 0.001
SEarn	32.55	30.42	0.725
NetSurplus	28.94	30.40	0.014

Table 6: Test for Complementarity Effect

The results for actual q_1 and q_2 are similar to those of the previous comparison: no significant difference for q_1 and LX has a higher q_2. However, the net surplus can be more easily compared because none of the observations incur a contracting cost. In this case, the subset of LX has a slightly but significantly higher net surplus than does L. Thus, the difference between the net surpluses in the prior comparison is primarily attributable to the payment of the contracting cost in treatment LX, rather than a complementarity between the formal and informal incentives in L.

As mentioned earlier, one possible consideration in reconciling the observations to theoretical predictions is learning effects. From Table 11, it appears that q_1 is increasing over time for both L and LX ($p < 0.001$). However, only treatment LX shows a significant increase in q_2 over time ($p = 0.012$). Thus, it may be that the absence of a complementarity effect is due in part to subjects' insufficient experience with this particular decision-making situation.

[10] Another possible comparison is to use only the observations conforming to the equilibrium contract structures in both treatments. The results were very similar to those presented in Table 7, because 90% of the treatment L buyers used the formal incentive.

An assumption underlying the theoretical model is that, in equilibrium, cooperation occurs from the initial period of the partnership. If the parties fail to coordinate, and particularly if such a failure varies systematically across treatments, then that failed assumption may account for some of the observed deviation from the predictions of the model. This line of reasoning can be investigated by partitioning the data to include only those partnerships that display cooperation initially.

Table 12 (at end of paper) presents a comparison of the treatments based on such a partition. Initial cooperation is defined to occur when the seller accepts an offer and provides at least the requested quality on both dimensions in the initial period of the partnership, regardless of what may occur in later periods. Of the 243 partnerships in the data, 60 met this criterion of initial cooperation.

Among initial cooperators, a comparison of treatments L and LX does present some support for a complementarity effect. Treatment L has a significantly higher q_1 than does LX ($p = 0.004$), while there is no significant difference in q_2. The difference in net surplus, although still affected by the contracting cost paid by some buyers in LX, now reflects an underlying improvement in quality. This difference is consistent with an improvement in the informal incentives brought about by better availability of the formal incentive. Thus, the complementarity effect does appear to be present to some degree, although it is not robust in the face of coordination failures among the parties.

Turning to the substitution effect, Hypothesis 5 predicts that quality levels and net surplus will be higher in treatment SX than in S. The theoretical mechanism underlying this prediction is that relative unavailability of formal incentives in SX greatly reduces the buyer's payoff in the stage game, thus increasing the severity of the punishment he faces for deviation and allowing the seller to better trust that high quality will be rewarded via the discretionary bonus. In treatment S, by contrast, the stage game is relatively rewarding for the buyer, so the seller should have less faith in the buyer's promise to pay the discretionary bonus.

Table 5 shows results opposite to those predicted: subjects in treatment S achieved better results on both quality dimensions and on net surplus than did those in SX. Kruskal-Wallis tests indicate that the differences are significant for actual q_1 and net surplus ($p < 0.001$ for both). This observation casts serious doubt regarding the presence of the substitution effect as predicted by the model.

As before, we investigate possible explanations for the divergence between the observations and the theory. One possible factor is learning effects. From Table 15, actual q_1 seems to be increasing over time in treatment S while actual q_2 is decreasing. The overall effect on net surplus is ambiguous. There are no significant learning trends for treatment SX. Thus, learning effects do not present a compelling explanation for the divergence.

We also consider the assumption of initial cooperation, as we did in the analysis of the complementarity hypothesis. In the sub-samples restricted to initial cooperation, presented in Table 12, the observed behavior is similar to that in the broader subject population. Both quality levels and net surplus are higher in treatment S than in SX ($p < 0.001$ for all three comparisons), suggesting that the absence of the substitution effect is not merely a failure of the parties to coordinate in the early rounds of the partnership.

The results in the theoretical model rely heavily on reversion to the stage-game outcomes as the basis for punishing uncooperative behavior. The substitution effect, in particular, relies on the difference between credible punishments in treatments S and SX. The model assumes that the worst credible punishment will be enacted in a trigger-strategy response to deviations from the terms of the relational contract. If the subjects' expectations about punishment do not conform to this assumption, then the substitution effect could fail. The subjects' use of punishment is explored in the next section.

Shirking and Punishment

There are two situations in which a subject might punish his partner for deviation from the relational contract. First, if a buyer deviates by reneging on the promised discretionary payment after the seller has delivered the promised quality, then the seller may punish the buyer. Second, if the seller "shirks" by supplying less than the promised quality, then the buyer may punish the seller. Punishment can take several forms. After a seller's deviation, the buyer can withhold payment of the discretionary bonus. After either party's deviation, punishment may take the form of terminating the relationship (i.e. no exchange) or continuing on less favorable terms. On the latter issue, the theoretical model provides clear predictions that deviation in the high-cost treatments will lead to termination, since a formal-incentive based exchange is not feasible, whereas deviation in the low-cost treatments will lead to exchange based on the formal incentive only.

Table 7 presents a comparison of the seller's acceptance rates following periods in which the seller performed as promised and the buyer either conformed by paying the promised discretionary bonus or deviated by paying less (or nothing).

	S	**SX**	**L**	**LX**
Buyer conformed	0.76563	0.4255	0.7525	0.70833
Buyer deviated	0.71111	0.31	0.669	0.4491

Table 7: Seller's Acceptance Rates Indicating Punishment

At first appearances, these differences among treatments in punishment by the seller appear to be consistent with the theoretical model. In treatments SX and LX, the stage-game outcome is no exchange, and the sellers exhibited much lower acceptance rates after a buyer deviation than after conforming behavior. In treatments S and L, by contrast, the stage-game outcome is exchange based solely on the formal incentive. In these treatments, the difference in sellers' acceptance rates is much smaller. However, this simple comparison ignores the issue of whether the contracts offered after deviation were less attractive to sellers. To investigate this aspect of seller's behavior, we estimated a logit model for the probability of the seller accepting a contract in periods after the seller had performed as promised. The explanatory variables include the terms of the contract (payment terms and requested quality level) and dummy variables for treatment effects. The dummy variable for S is dropped to avoid the dummy variable trap, so it becomes the baseline for comparison. The effect of primary interest is a dummy variable for whether the buyer paid less than the promised discretionary bonus, which is then interacted with dummy variables for the treatments. (Again, S serves as the baseline for comparison.) Since the game is repeated, the regressors also include variables to capture possible effects from the parties' history, including the seller's prior-period earnings and the duration of the partnership to that point. We control for possible learning effects by including linear and quadratic variables for the period.

Table 13 (at end of paper) shows the results of this estimation. As expected, higher payment terms increase the probability of the seller accepting the contract, although the effect of a promised discretionary bonus is significant at a lower level and has a smaller magnitude than the other two, possibly indicating that sellers did not trust buyers to uphold those promises. None of the estimated coefficients for the buyer's deviation were significant, and a Wald test did not reject the hypothesis that all four of these coefficients were jointly equal to 0 ($p = 0.784$). This result argues against the assumption in the model that sellers use rejection to punish deviating buyers. The lack of a credible threat of rejection means that buyers have more motivation to withhold discretionary bonuses, even after satisfactory performances by the sellers, thereby weakening the use of informal incentives to achieve higher-quality outcomes. In particular, this result shows one possible reason for why the substitution effect was not observed in the experimental data. The substitution hypothesis relies on the threat of rejection to create harsher penalties for the buyer's deviation in treatments L and LX, thereby strengthening the power of informal incentives in those environments. If this threat is absent, then the ability of formal incentives to reduce the seller's potential gains from deviations and thus increase the efficacy of informal incentives (the complementarity effect) dominates the interaction between these two types of incentives.

Table 8 compares the buyers' decision to pay or withhold the promised discretionary bonus, depending on whether the seller met quality specifications or not.

Since both the discretionary bonus payment and the quality levels chosen are (approximately) continuous variables, we categorize the seller's actions as either conforming (providing at least the promised quality on both dimensions) or shirking (providing less than promised quality on at least one dimension). Similarly, the buyer's actions are categorized as either withholding (paying less than the promised bonus) or not.

	S	**SX**	**L**	**LX**
Seller conformed	0.42056	0.28205	0.47552	0.38542
Seller shirked	0.85217	0.86813	0.78378	0.85577

Table 8: Buyers' Withholding of Discretionary Bonus as Punishment

As expected, the buyers in all treatments tended to withhold the discretionary bonus payment much more frequently after shirking than after conforming behavior. In order to analyze the buyer's behavior more fully, we estimated a logit model for the probability of the buyer paying less than the promised discretionary bonus. From the buyer's incentive-compatibility constraints in the model, (C5) and (U5), the buyer should weigh his expected payoffs in future periods under the relational contract against the short-term gain from not paying the bonus and then receiving stage-game payoffs in the future. To represent the buyer's expected payoffs under the relational contract, we use his payoff under the current contract, $V(Q) - p - f - d - x$, with f and x set to zero if he is operating under an unconditional contract. $V(Q)$ is the buyer's value for the quality actually delivered by the seller in the current period. Note that the amount of the discretionary bonus enters both sides of the tradeoff, but it has a larger impact on the deviation payoff due to discounting. The estimation model also includes dummy variables for treatment effects, with treatment S dropped, so that it becomes the baseline for comparison. The effect of primary interest is a dummy variable for whether the seller shirked by providing less than the promised quality (on either dimension). To capture possible effects from the parties' history, the regressors include the buyer's prior-period earnings and the duration of the partnership to that point. We include linear and quadratic terms for the period to control for possible learning effects.

The results of this estimation are presented in Table 14 (at end of paper). The coefficient estimates for $V(Q)$, price, and the formal bonus are all significant and of the expected sign, suggesting that buyers do respond to these as indicators of what they can expect as payoffs in future periods under relational contracts. The contract fee parameter estimate is positive, as expected, although not significant. The estimate for the discretionary bonus is positive, indicating that higher promised amounts increase the buyers' incentives to renege on those promises. Also, the results suggest that buyers do withhold discretionary payments as a response to shirking by sellers.

The incentive-compatibility constraints in the theoretical model suggest that, ceteris paribus, the buyer should be more likely to renege on the discretionary bonus in treatments S and L than in SX and LX, due to differences in the stage-game payoffs. In the first group, the stage-game payoff is relatively attractive, because the low contracting cost makes possible a profitable exchange based solely on the formal incentive. In the second group, by contrast, it is impossible to construct an exchange that is advantageous for both parties, so a reversion to stage-game outcome would be more costly to the buyer. However, there seems to be little or no difference in the treatment effects for the buyer's probability of withholding payment. A Wald test did not reject the hypothesis that all of the treatment effects were equal ($p = 0.308$). This result is consistent with the analysis that indicates unwillingness by the seller's to use rejection as a punishment mechanism; if buyers expect that sellers will not increase rejection rates in response to withholding of payments, then the differences among treatments in the stage-game payoffs become much less relevant in the buyer's decision.

In addition to withholding discretionary payments, buyers can punish shirking by their actions in subsequent periods, either terminating the relationship altogether or offering less attractive contracts to the seller. Table 9 compares buyers' offer rates in the periods following either shirking or conforming behavior by the seller.

	S	**SX**	**L**	**LX**
Seller conformed	0.95062	0.89091	0.91698	0.82699
Seller shirked	0.96429	0.90769	0.94898	0.95833

Table 9: Buyers' Offer Rates as Punishment

Surprisingly, the buyers do not generally appear to punish shirking by withholding offers in the following period. In fact, the mean offer rates were slightly higher in periods following shirking. Again, a simple comparison of offer rates glosses over the important issue of whether the terms of the offer varied with prior shirking, an issue explored below, but this result indicates that punishment by terminating the relationship does not seem to occur as the theoretical model assumes for treatments SX and LX.

Another mechanism for punishment involves continuing the relationship, but at terms less favorable to the deviating party. In treatments S and L, for example, the worst credible punishment threat in the model is exchange based solely on the formal incentives. That is, a high q_1 is induced by use of the formal bonus, but $q_2 = q_{min}$, because the discretionary bonus and other informal incentives are ignored.

Table 15 (at end of paper) compares the terms of offers made in periods following cooperation with those following deviations (shirking or reneging). Note that there are few instances in which the seller shirked but the buyer did not withhold the discretionary bonus, which is consistent with the earlier observation about the buyer's tendency to use withholding to punish shirking sellers. Thus, the variance is relatively high for that subset of the data in each treatment. From an inspection of Table 15, some general patterns can be observed. In treatments S and LX, the desired q_1 does not vary much with the prior cooperation or deviation of the parties, whereas the desired q_2 seems to decrease more substantially in response to deviations. This pattern is consistent with the hypothesis that parties revert to exchange based more on formal incentives and less on informal incentives in periods following deviation, because a formal-only contract is able to support a high q_1, but a high q_2 requires the use of informal incentives. In treatment L, both quality requests decrease after deviations. In treatment SX, there does not appear to be systematic difference in the requested quality based on the parties' prior cooperation or deviation.

Desired q_1 has direct impact on payoffs when a formal bonus is used, so its value can be viewed as indicative of the true expectations of the parties. Desired q_2, in contrast, may be viewed more as cheap talk by the buyer, because its value does not create any binding commitments for either party. Thus, that variable may not reflect the true expectations of the parties, and this may be especially true in periods following one or both parties' deviation.

Interestingly, use of the formal incentive in offers is highest in periods following the *buyer's* deviation and the seller's cooperation. This result could be interpreted as an attempt by the buyer to protect himself from retribution. Similarly, the unconditional price is also lowest in those periods, reducing the scope for reciprocation by the seller.

Table 16 (at end of paper) presents an econometric investigation of the how the terms of offers vary with prior shirking by the seller or reneging on discretionary payments by the buyer. Column (A) shows the results of a logit estimation for the probability that the offer includes a formal incentive. Columns (B) and (C) present censored regression (Tobit) estimations for the desired q_1 and q_2, respectively. For all three models, the regressors included dummy variables for treatment effects (with S dropped, so it serves as the baseline), dummy variables for prior shirking and reneging behavior that were interacted with the treatment effects, and controls for the parties' history (buyer's prior-period earnings and current duration) and learning effects (linear and quadratic terms for the period).

The results of these estimations support the general patterns discussed for Table 15. The requested q_1 appears to vary little with prior shirking or reneging behavior, as indicated by the fact that few of the estimated coefficients for those effects were significant at standard levels. Desired q_2 does show more correlation with the prior behavior of the parties, although the effect seems to stem primarily from the buyer's deviations, rather than the seller's. The use of the formal incentive varies greatly with the treatment, with higher use in S and L and less in SX and LX. It is also varies with shirking by the seller, although in an unexpected way. In treatments S and L, seller shirking decreases the use of the formal incentive. This might be explained as an attempt by the buyer to make payments less binding, allocating more of the total payment into the discretionary bonus, so that he can more harshly punish deviating sellers. However, this reaction was less in treatments SX and LX. Wald tests for the total effect of shirking in SX and LX (baseline S plus the difference for SX or LX) did not reject the null hypotheses that the shirking did not affect the use of formal incentives ($p = 0.606$ for SX and $p = 0.347$ for LX). As noted for Table 19, the use of the formal incentive also increases with reneging by the buyer, possibly to shift more to formal incentives since his unreliability with the discretionary bonus weakens the use of informal incentives.

Table 17 compares the outcomes of exchange by the parties in periods following cooperation and deviation. Again, there were relatively few periods in which the seller shirked and the buyer did not withhold the discretionary bonus, so the means for those partitions should be viewed with caution. Comparing the other three partitions within each treatment reveals patterns similar to those from the comparison of offers after deviation. The actual quality levels achieved after deviation were generally less than those after cooperation, with a greater difference in q_2 than in q_1. This supports the idea that the parties tend to move closer to a formal-incentive-only exchange after deviation, relying less on informal incentives. The theoretical model predicts this behavior for treatments S and L, in which the formal-incentive-only contract is feasible in the stage game, but the predictions that parties revert to no exchange in treatments SX and LX do not hold up. Instead, it seems that the parties in all treatments reduce their reliance on informal incentives, but do not abandon them altogether, following deviations.

Table 18 presents the results on econometric analyses of the outcomes of exchange following deviation by one or both parties. Columns (A) and (B) show the results of a censored regression (Tobit) for the determinants of q_1 and q_2, respectively. Column (C) presents a regression model for the buyer's share of the net surplus. For all three models, the regressors included treatment effects (with S dropped, so it serves as the baseline), variables for prior shirking and reneging that were interacted with the treatments, and controls for the parties' history (buyer and seller earnings in the previous period and the current duration of the partnership) and learning effects (linear and quadratic terms for the period).

These results support the general patterns observed in Table 17 and provide some additional detail. Both q_1 and q_2 are reduced following shirking by sellers, although these effects are more pronounced for treatments S and L than for SX and LX. In fact, Wald tests did not reject the null hypotheses that the total effects of shirking on q_1 and q_2 were 0 for treatments SX and LX. (For q_1, $p = 0.234$ in SX and $p = 0.303$ in LX. For q_2, $p = 0.510$ in SX and $p = 0.950$ in LX.) Buyers' reneging behavior does not seem to influence the q_1 achieved in the next periods, although it decreased the q_2 achieved.

As mentioned earlier, another possible form of punishment is for the parties to continue exchange under a relational contract but redistribute the net surplus away from the deviating party. The buyer share reported in Table 17 shows how the surplus is distributed among the parties in periods following the various combinations of cooperation and deviation. In general, the results do not support the hypothesis of punishment via redistribution. That hypothesis would predict that the buyer's share would be less when only the buyer deviates than when both parties cooperate. However, the buyer's share is roughly the same in these two cases under treatments L and S, and it is actually greater following the buyer's deviation under treatment LX. In treatment SX, the buyer's earnings decline dramatically (negative on average), but the average net surplus is negative, so a share calculation does not hold much meaning.

The redistribution hypothesis predicts that the buyer's share would increase following the seller's deviation, perhaps to a lesser extent if the buyer has already enacted some punishment via withholding the discretionary bonus in the prior period. This prediction holds for treatment S, with the buyer's share increasing substantially after the seller's deviation, regardless of whether the buyer withheld the discretionary bonus. However, the results are mixed at best in the other treatments. In Table 22 (C), none of the coefficient estimates are significant at standard levels, indicating that the buyer's share of the net surplus does not seem to correlate in an obvious way with the shirking and reneging behavior of the parties.

The difference between subjects' observed behavior and the assumption of the theoretical model regarding punishment strategies provides one possible avenue for explaining why some of the model's predictions for outcomes did not hold. The substitution hypothesis in particular relies heavily on assumptions about the stage-game equilibria as the expected punishments for deviations from the relational contract. However, neither buyers nor sellers appear to use termination of the relationship as a punishment mechanism.

One possible explanation for this apparent lack of a termination threat is that subjects are unwilling to "miss out" on the possibility to earn rewards themselves in order to punish their errant partners. In contrast, they do seem willing to use mechanisms such as buyers' withholding of discretionary bonuses to apply punishment. The latter mechanism does not cost the punisher anything; in fact, it increases the buyer's current-period payoff. There is also some evidence that parties rely more heavily on formal incentives and less on informal incentives in periods following deviating behavior.

Conclusions

The observed behavior corroborates a number of hypotheses about parties' behavior in repeated interactions, while also presenting several results that contrast with theoretical predictions and assumptions. As expected, longer expected durations of partnerships improved the parties' abilities to use informal incentives to achieve high-quality outcomes. This effect is more apparent in situations in which the parties must rely heavily on informal incentives, such as when formal incentives are less available due to high transactions costs.

The parties tend to select the contract structures that allow for higher gains from exchange. In particular, parties in the high-cost treatments chose to use contracts without formal incentives in 60% of exchanges, when formal incentives create a drag on net surplus by incurring an additional cost as well as possibly interfering with the operation of informal incentives. This result about endogenous choice among contracts provides support for the strategic ambiguity theory of Bernheim and Whinston (1998), complementing evidence from prior experimental studies (e.g. Wu and Roe, 2007b) that less complete contracts may be efficiency-enhancing in some environments.

The observations also present some unusual results regarding the complementarity and substitution effects hypothesized by Baker, Gibbons, and Murphy (1994) and others. The complementarity effect was supported by the observations in the treatments in which the theoretical model predicted its existence. However, the effect did appear to be sensitive to whether the parties were able to coordinate in the initial stages of their relationship.

By contrast, in the treatments for which the substitution effect was favored, the results showed the opposite of the predicted effect. This surprising outcome suggests that there may be behavioral effects that lead to important differences between the ways that informal incentives actually operate and the ways that theoretical models predict they will operate. In particular, subjects appear unlikely to use some of the punishment mechanisms that are available and that theory predicts they will use. The experimental subjects were generally willing to use withholding of discretionary payments as a means to punish shirking. They also appeared to rely more on formal incentives and less on informal incentives following deviations. However, they appeared unwilling to use termination of the relationship as a punish mechanism, nor did they reallocate the net surplus in subsequent periods away from the deviating party. The types of punishment did not vary with treatments in the ways that the theory assumed, suggesting that predictions relying on punishment differing across situations may not be robust. This non-differentiation is punishment may account to some degree for the failure of the substitution hypothesis.

	Means				Kruskal-Wallis (*p*-values)			
	S	SX	L	LX	SX vs LX	S vs L	L vs LX	S vs SX
UseF	0.91	0.40	0.95	0.40	0.928	0.096	< 0.001	< 0.001
DesiredQ1	9.07	8.35	9.00	9.18	< 0.001	0.092	0.019	< 0.001
DesiredQ2	6.54	6.37	5.09	7.56	< 0.001	< 0.001	< 0.001	0.36611
Q1	8.58	6.35	8.41	7.97	< 0.001	0.096	0.870	< 0.001
Q2	4.57	3.79	3.46	5.18	0.002	0.023	< 0.001	0.265
BEarn	24.75	3.36	16.39	12.56	0.008	< 0.001	0.372	< 0.001
SEarn	27.29	21.95	32.55	23.82	0.942	0.036	< 0.001	0.017
NetSurplus	32.04	5.32	28.94	16.38	< 0.001	0.007	< 0.001	< 0.001

Table 10: Hypothesis Tests for Treatment Effects

	S			SX			L			LX		
	Early	Later	*p*-value	Early	Later	*p*-value	Early	Later	*p*-value	Early	Later	*p*-value
UseF	0.86	0.96	0.006	0.40	0.40	0.941	0.92	0.97	0.087	0.43	0.37	0.408
DesiredQ1	8.64	9.50	< 0.001	8.24	8.52	0.380	8.54	9.30	< 0.001	8.66	9.48	< 0.001
DesiredQ2	6.91	6.15	0.188	6.28	6.52	0.495	5.48	4.83	0.067	7.05	7.86	0.019
Q1	8.20	8.97	0.003	5.99	6.96	0.095	7.93	8.71	< 0.001	7.27	8.38	< 0.001
Q2	5.04	4.08	0.028	3.60	4.13	0.386	3.00	3.75	0.077	4.28	5.70	0.012
BEarn	25.29	24.20	0.480	0.35	8.50	0.393	8.86	21.21	< 0.001	10.05	14.02	0.567
SEarn	25.78	28.83	0.948	22.70	20.69	0.337	36.79	29.84	0.045	19.73	26.22	0.008
Net Surplus	31.07	33.03	0.871	3.05	9.19	0.368	25.65	31.05	< 0.001	9.78	20.25	0.011

Table 11: Hypothesis Tests for Learning Trends

	Means				Kruskal-Wallis (p-values)			
	S	SX	L	LX	SX vs LX	S vs L	L vs LX	S vs SX
UseF	0.93	0.43	0.99	0.43	0.987	0.045	< 0.001	< 0.001
DesiredQ1	9.67	7.98	9.62	9.27	< 0.001	0.260	0.513	< 0.001
DesiredQ2	8.15	6.28	5.87	7.82	< 0.001	< 0.001	< 0.001	< 0.001
Q1	9.43	6.64	9.49	8.32	0.001	0.348	0.004	< 0.001
Q2	7.63	4.48	5.40	5.51	0.095	0.001	0.985	< 0.001
BEarn	32.61	8.95	28.76	9.07	0.965	0.011	< 0.001	< 0.001
SEarn	29.81	18.12	29.52	28.45	0.106	0.035	0.087	< 0.001
NetSurplus	42.42	7.07	38.28	17.51	0.045	0.004	< 0.001	< 0.001

Table 12: Initial Cooperation

Regressor	Coefficent (Std Err)
Price	0.044*** (0.008)
Formal Bonus	0.021*** (0.006)
Discretionary Bonus (Offered)	0.006* (0.004)
Requested q_1	0.100* (0.055)
Requested q_2	-0.136*** (0.051)
SX	-1.341*** (0.486)
L	-0.845* (0.512)
LX	-0.008 (0.895)
Buyer Deviate	-0.375 (0.437)
Buyer Deviate*SX	0.201 (0.685)
Buyer Deviate*L	0.295 (0.512)
Buyer Deviate*LX	-0.381 (0.923)
Seller's Previous Earnings	0.038* (0.021)
N = 783 Log pseudo likelihood = -393.19 Pseudo R2 = 0.259	

Table 13: Probability of Seller's Acceptance

Asterisks indicate the significance level of the estimate: * at the 10% level, ** at the 5% level, and *** at the 1% level. The estimation procedure was a logit, and the standard errors reported are robust and adjusted for clustering on buyer-seller pairs. Additional control variables included but not reported are the current length of the partnership and linear and quadratic terms for the period. (None were significant at the 10% level.)

Regressor	Coefficient (StdErr)
V(*Q*)	-0.040*** (0.012)
Price	0.034** (0.014)
Formal Bonus	0.048*** (0.015)
Contract Fee (If formal)	0.012 (0.021)
Discretionary Bonus (Offered)	0.051*** (0.012)
SX	0.789 (0.666)
L	0.135 (0.487)
LX	-0.360 (0.650)
Shirk	0.753* (0.413)
Buyer's Previous Earnings	-0.002 (0.008)
N = 653 Log pseudo likelihood = -296.13 Pseudo R2 = 0.310	

Table 14: Probability of Buyer's Withholding Discretionary Bonus

Asterisks indicate the significance level of the estimate: * at the 10% level, ** at the 5% level, and *** at the 1% level. The estimation procedure was a logit, and the standard errors reported are robust and adjusted for clustering on buyer-seller pairs. Additional control variables included but not reported are the current length of the partnership and linear and quadratic terms for the period. (None were significant at the 10% level.)

	Previous Period	*n*	Terms of Offers					
			Desired q_1	**Desired q_2**	**Formal**	**Price**	**Formal Bonus**	**Discretionary Bonus**
S	Cooperation	64	8.83	7.52	92.2%	26.61	63.75	38.34
S	Only buyer deviates	90	8.54	4.88	97.8%	29.40	54.49	43.81
S	Seller shirks, no withholding	12	7.58	4.25	58.3%	33.25	37.92	11.67
S	Seller shirks and buyer withholds	69	8.72	6.01	89.9%	29.62	46.59	52.57
SX	Cooperation	47	7.72	6.51	40.4%	48.34	14.40	32.98
SX	Only buyer deviates	100	7.90	7.18	50.0%	27.19	34.41	62.62
SX	Seller shirks, no withholding	6	9.00	7.50	50.0%	21.83	28.33	82.50
SX	Seller shirks and buyer withholds	53	7.75	6.09	43.4%	48.40	22.00	40.09
L	Cooperation	101	9.24	5.33	97.0%	44.21	56.12	15.67
L	Only buyer deviates	142	8.73	4.63	97.9%	38.82	50.92	24.54
L	Seller shirks, no withholding	20	7.80	3.95	80.0%	35.50	33.65	13.35
L	Seller shirks and buyer withholds	73	7.96	4.21	90.4%	43.55	31.36	31.49
LX	Cooperation	72	8.99	8.10	18.1%	59.10	12.11	65.75
LX	Only buyer deviates	167	8.31	6.32	48.5%	24.41	30.40	73.54
LX	Seller shirks, no withholding	14	8.71	8.00	21.4%	62.79	20.00	43.57
LX	Seller shirks and buyer withholds	78	8.83	6.54	41.0%	35.99	23.91	81.06

Table 15: Post-Deviation Offers

Dep. Var. Model	(A) Formal Logit	(B) Desired q_1 Tobit	(C) Desired q_2 Tobit
Regressor	Coefficient (Std Err)	Coefficient (Std Err)	Coefficient (Std Err)
SX	-2.82*** (0.629)	-1.62 (0.998)	0.15 (0.789)
L	0.81 (0.696)	0.39 (0.886)	-1.49*** (0.953)
LX	-4.04*** (0.695)	0.49 (0.984)	1.28*** (0.896)
Seller shirks	-1.89*** (0.607)	-0.53 (0.792)	0.23 (0.661)
Seller shirks (SX)	1.71** (0.705)	1.03 (1.144)	-0.72 (0.792)
Seller shirks (L)	0.04 (0.744)	-0.48 (1.031)	-0.55 (0.798)
Seller shirks (LX)	1.62** (0.674)	2.16** (1.059)	0.27 (0.854)
Buyer reneges	1.65** (0.647)	-0.27 (0.826)	-1.50*** (0.635)
Buyer reneges (SX)	-1.42* (0.747)	0.55 (1.185)	2.03*** (0.827)
Buyer reneges (L)	-1.03 (0.837)	-0.50 (1.049)	1.13* (0.884)
Buyer reneges (LX)	-0.31 (0.817)	-1.15 (1.117)	-0.02 (0.885)
Buyer's earnings	0.00 (0.005)	0.05*** (0.007)	0.02*** (0.006)
N	1108	1108	1108
Log pseudo likelihood	-466.91	-1673.51	-2263.95
Pseudo R2	0.324	0.039	0.032

Table 16: Terms of Post-Deviation Offers

Asterisks indicate the significance level of the estimate: * at the 10% level, ** at the 5% level, and *** at the 1% level. For the logit (A), the standard errors reported are robust and adjusted for clustering on buyer-seller pairs.

	Previous Period	*n*	Exchange	q_1	q_2	Buyer's Earnings	Net Surplus	Buyer Share %
S	Cooperation	69	71.0%	9.20	7.76	29.63	41.53	71.4%
S	Only buyer deviates	93	68.8%	8.39	3.39	21.27	28.73	74.0%
S	Seller shirks, no withholding	12	75.0%	7.44	2.89	21.00	23.00	91.3%
S	Seller shirks and buyer withholds	72	56.9%	8.59	3.63	28.61	30.20	94.7%
SX	Cooperation	52	38.5%	7.20	4.60	10.70	16.45	65.0%
SX	Only buyer deviates	113	27.4%	5.16	2.74	-3.35	-5.65	N/A
SX	Seller shirks, no withholding	7	28.6%	10.00	7.00	5.00	9.00	55.6%
SX	Seller shirks and buyer withholds	58	51.7%	6.27	3.77	-3.77	3.70	-101.8%
L	Cooperation	114	66.7%	8.72	4.76	22.07	33.14	66.6%
L	Only buyer deviates	151	62.9%	8.69	3.28	19.68	30.04	65.5%
L	Seller shirks, no withholding	22	63.6%	7.14	2.79	19.36	21.29	90.9%
L	Seller shirks and buyer withholds	76	57.9%	8.02	2.27	9.36	24.66	38.0%
LX	Cooperation	108	47.2%	9.20	8.53	27.59	38.24	72.2%
LX	Only buyer deviates	181	41.4%	7.23	3.65	3.32	2.91	114.2%
LX	Seller shirks, no withholding	14	50.0%	7.86	6.86	14.43	28.00	51.5%
LX	Seller shirks and buyer withholds	82	54.9%	7.58	3.87	10.80	13.18	82.0%

Table 17: Post-Deviation Exchanges

Dep. Var. Model	(A) q_1 Tobit	(B) q_2 Tobit	(C) Buyer Share Regression
Regressor	Coefficient (Std Err)	Coefficient (Std Err)	Coefficient (Std Err)
SX	-2.28 (2.143)	-1.39 (1.715)	-0.18 (0.300)
L	-1.87 (1.643)	-3.85*** (1.269)	-0.20 (0.226)
LX	-1.25 (1.923)	3.11** (1.470)	-0.38 (0.342)
Seller shirks	-2.96* (1.516)	-4.68*** (1.273)	0.19 (0.165)
Seller shirks (SX)	5.18** (2.394)	5.80*** (2.101)	-0.07 (0.693)
Seller shirks (L)	-0.39 (1.941)	-0.40 (1.714)	0.14 (0.483)
Seller shirks (LX)	4.39** (2.063)	4.61*** (1.733)	-0.45 (0.988)
Buyer reneges	0.91 (1.579)	-3.43*** (1.257)	-0.26 (0.243)
Buyer reneges (SX)	-4.25 (2.586)	1.14 (2.159)	0.80 (0.896)
Buyer reneges (L)	0.24 (1.935)	2.94* (1.559)	-0.17 (0.240)
Buyer reneges (LX)	-1.96 (2.203)	-1.13 (1.750)	0.35 (0.519)
Buyer's earnings	0.17*** (0.020)	0.18*** (0.017)	-0.00 (0.007)
Seller's earnings	0.19*** (0.028)	0.22*** (0.024)	-0.05** (0.020)
N	653	653	525
Log pseudo likelihood	-918.33	-1087.49	
Pseudo R2	0.228	0.384	
R2			0.134

Table 18: Outcomes of Post-Deviation Exchanges

Notes for Table 18: Asterisks indicate the significance level of the estimate: * at the 10% level, ** at the 5% level, and *** at the 1% level. For the regression (C), the standard errors reported are robust and adjusted for clustering on buyer-seller pairs.

APPENDIX A

SAMPLE INSTRUCTIONS FOR EXPERIMENT

Session SX Instructions

Welcome to today's experiment! Thank you for participating and helping with our economics research.

Payment and ID Numbers

Your monetary compensation will depend on the decisions you make during the experiment. You start with a balance of 250 points. Based on your decisions and those of your trading partners, you can accumulate additional points, which will be converted into money at the rate of **50 points = $1**. All money will be paid at the end of the experiment.

For this experiment, you will be identified by the ID number we assigned to you when you checked in. You will remain anonymous in the data we collect, so that no one will know what decisions you made or how much money you earned.

We do have a few ground rules for the experiment:

- Please do not talk to other participants during the experiment. You will interact with others through the computer game that you will play, but any other communication is prohibited.
- If you have any questions or problems during the experiment, please ask one of the researchers.
- Please turn off all cell phones, pagers, etc. for the duration of the experiment.

At this time, please enter your ID number in the appropriate field on your computer screen and click the *OK* button.

Overview

You (the participants) will be divided equally into two groups: half of you will be **buyers** and the other half will be **sellers**. Each of you will be randomly assigned to one of these roles and will remain in that role for the entire experiment.

Buyers and sellers will be **randomly matched into pairs**, with one buyer and one seller per pair. Each buyer-seller pair will have the opportunity to make one or more transactions of hypothetical products.

In each period, each buyer-seller pair can make one transaction involving two important characteristics: **quantity** and **quality**. The buyer earns points from a transaction, with the total number of points depending on the quantity and quality provided. Likewise, the seller incurs a cost to carry out the transaction, also depending on the quantity and quality provided. In addition, the buyer makes payments to the seller.

A buyer-seller pair will remain matched together for a **random number of periods**. In each period, the buyer can make an offer specifying the quantity and quality s/he wants and the payments s/he will make to the seller.

Quantity and Quality

Quantity

The seller can provide any **quantity** from **1 to 10** (whole numbers only). A higher quantity provides more points to the buyer than a low quantity, but it also costs more for the seller to produce.

Quality

Similarly, the **quality** delivered by the seller can range from **1 to 10**. A product with high quality is worth more to the buyer than one with low quality, but it also costs more for the seller to produce.

Benefits and Costs

The points a buyer earns (i.e. buyer's revenue) from a transaction is expressed by the equation:

Buyer's revenue = (10 × quantity) + (10 × quality)

Similarly, the production cost for the seller (in points) in a transaction is given by:

Seller's cost = (5 × quantity) + (8 × quality)

The table attached to these instructions lists the buyer's revenue and the seller's cost for each possible combination of quantity and quality.

Offers

To initiate a transaction, the buyer makes an offer to the seller, who may then accept or reject it. The terms of the offer determine how much the buyer will pay the seller for the transaction. There are several terms that the buyer can include in his offer: **desired product** (quantity and quality), **formal payment terms** (base price and formal bonus), and **discretionary bonus**.

Desired Product

The buyer's offer specifies the **quantity** and **quality** desired by the buyer. However, these terms are **not binding**. If the seller accepts the offer, s/he can choose to provide any quantity and quality, not necessarily those specified in the offer.

Formal Payment Terms

In the offer, the buyer can specify two formal payment terms. The **base price** is an amount that the buyer will pay regardless of the quantity or quality provided. The base price may range from 0 to 200 points.

The offer may also specify a **formal bonus**, an additional payment that the buyer must make if the seller provides *at least the quantity specified* in the offer. The formal bonus amount can range from 0 to 200 points. This term allows the buyer to make the seller's compensation depend, at least partially, on what the seller provides. Using a formal bonus term incurs a **contract fee** of **35 points**, which the buyer pays if the seller accepts the offer. (Note: The buyer avoids this contract fee if s/he chooses 0 for the formal bonus amount.) The formal bonus is similar to a real-world contract that ties part of the payment to achieving some measurable benchmark, such as completing a project on schedule.

The two formal payment terms are **binding**, which means that they are like a formal written contract that will be legally enforced. The buyer must pay the specified base price if the seller accepts the offer, regardless of what quantity and quality are provided. The buyer must pay the specified formal bonus amount whenever the seller provides *at least the quantity specified*, regardless of the quality provided.

The quantity of a transaction is relatively easy to measure, which is why a formal bonus based on quantity is binding (i.e. enforced by the computer). Quality, on the other hand, is subjective, so it is difficult to measure. For this reason, it is impossible to make a binding formal bonus that depends on quality.

Discretionary Bonus

In addition to the formal payment terms, the buyer can offer a **discretionary bonus**. In the offer, the buyer specifies an amount ranging from 0 to 200 points for this bonus. The buyer pays **no cost** for specifying a discretionary bonus.

The discretionary bonus term is **not binding**, which means that it is like a "handshake agreement" that cannot be legally enforced. Regardless of the amount specified in the offer, the buyer can choose any amount from 0 to 200 points for the discretionary bonus once s/he sees the quantity and quality delivered by the seller.

Earnings

The numbers of points that the buyer and seller earn in a period depend on the buyer's revenue, the seller's production cost, the formal payment terms specified in the contract (base price and/or formal bonus), and the discretionary bonus chosen by the buyer.

If **no offer** is made or the offer is **rejected**:

- The buyer earns 0 points.
- The seller earns 20 points.

If an offer with a **formal bonus** (i.e. greater than 0) is accepted and the quantity provided is *equal to or greater than* the quantity specified in the offer:

- Buyer's earnings = (revenue) – (base price) – (formal bonus)
– (discretionary bonus) – (contract fee)
- Seller's earnings = (base price) + (formal bonus) + (discretionary bonus)
– (production cost)

If an offer with a **formal bonus** (i.e. greater than 0) is accepted and the quantity provided is *less than* the quantity specified in the offer:

- Buyer's earnings = (revenue) – (base price) – (discretionary bonus)
– (contract fee)
- Seller's earnings = (base price) + (discretionary bonus)
– (production cost)

If an offer with **no formal bonus** (i.e. equal to 0) is accepted:

- Buyer's earnings = (revenue) – (base price) – (discretionary bonus)
- Seller's earnings = (base price) + (discretionary bonus) – (production cost)

It is possible for buyers and/or sellers to lose points (i.e. have negative earnings) in a period. If this occurs, the points will be subtracted from that person's point balance.

Sequence of Choices

In each period, the buyer's and seller's choices follow a particular sequence.

1. Buyer makes an offer.
2. Seller accepts or rejects the offer,
3. If accepted, the seller chooses quantity and quality.
4. Buyer chooses discretionary bonus.

Next, we'll look at the details of each step.

1. Buyer Makes Offer

The buyer chooses whether to make an offer for the period. If the buyer chooses to **make an offer**, s/he must specify the desired product (quantity and quality), the formal payment terms (base price and formal bonus), and the discretionary bonus.

- The buyer must fill in the *Quantity* and *Quality* fields with numbers from 1 to 10. These desired amounts are not binding on the seller, who can choose to provide any quantity and quality s/he desires (later, in step 3).
- The buyer must fill in the *Base Price* field with a number from 0 to 200. The base price is binding on the buyer.
- The buyer can fill in the *Formal Bonus* field with a number from 0 to 200. Remember that specifying a number greater than 0 means that the buyer will pay a contract fee of 35 points if the seller accepts the offer.
  - The formal bonus is binding on the buyer, which means that if the seller provides at least the <u>quantity</u> specified in the offer, the buyer must pay the formal bonus. If the seller provides a lower quantity than that specified in the offer, then the formal bonus is not paid.
  - You can think of the contract fee for offering a formal bonus as the legal costs of writing and enforcing a formal contract (e.g. lawyers and court fees).
- The buyer must fill in the *Discretionary Bonus* field with a number from 0 to 200. The discretionary bonus is not binding on the buyer, who can choose any amount once s/he sees the quantity and quality provided by the seller.
- Each buyer has **120 seconds** to make an offer. If s/he does not make an offer within this limit, then the default is *No Offer* for that period.

All numbers must be whole numbers.

Once the buyer specifies the terms of the offer, s/he clicks the *Offer* button to submit the offer to the seller.

If the buyer chooses **not to make an offer**, then the buyer receives 0 points and the seller receives 20 points for that period. To choose not to make an offer, the buyer clicks the *No Offer* button.

2. Seller Accepts or Rejects

When the buyer makes an offer, the seller will see the details of the offer and then choose whether to accept it or reject it. If the buyer did not make an offer, then the seller does not make any decision for that period.

If the seller **accepts** the offer, the points earned by the buyer and seller depend on the terms of the offer and the quantity and quality that the seller chooses in the next step. To accept the offer, the seller clicks the *Accept* button.

- Each seller has **90 seconds** to choose between accepting and rejecting the offer. If s/he does not choose within this limit, then the default is *Reject* for that period.

If the seller **rejects** the offer, then the buyer receives 0 points and the seller receives 20 points for that period. To reject the offer, the seller clicks the *Reject* button.

3. Seller Chooses Quantity and Quality

If the seller accepts the offer, s/he next must fill in the *Quantity* and *Quality* fields (each ranges from 1 to 10) and then click the *Continue* button. The combination of quantity and quality affects her production costs, as described earlier.

4. Buyer Chooses Discretionary Bonus

If the buyer makes an offer and the seller accepts it, then the buyer will have the opportunity to choose a discretionary bonus to pay to the seller once s/he sees the quantity and quality provided.

The buyer must enter the amount in the *Discretionary Bonus* field (a number from 0 to 200) and then click the *Continue* button. Note that the buyer can choose a discretionary bonus that is different from that specified in the offer.

Summary Screen

After all decisions are made for a period, both the buyer and the seller will see summary screens displaying the following information about their transaction for that period:

Terms specified in the offer:

- Desired quantity
- Desired quality
- Base price
- Formal bonus
- Discretionary bonus

Seller's choices:

- Accept or reject the offer
- Quantity provided
- Quality provided

Payment details:

- Buyer's revenue
- Seller's production cost
- Formal bonus paid
- Discretionary bonus paid
- Contract fee (if formal bonus is used)
- Buyer's earnings
- Seller's earnings

You can use the attached worksheet to track your transactions over time and with different partners. Once you have finished looking at the summary screen, please click the *Continue* button.

Changing Partners

At the end of each period, the computer will randomly determine whether the current buyer-seller pair will remain matched together. There is a two-thirds (approx. 67%) probability that the buyer and seller will remain matched together for another period.

You can think of this probability as though the computer randomly draws a number from 1 to 100. If the number drawn is in the 1-67 range, then buyers and sellers remain with their current partners for another period. If the number drawn is in the 68-100 range, then that pairing ends, and either the participants will be randomly matched with new partners or the experiment will end.

Thus, the number of times you will interact with each partner is random, but the average duration is approximately 3 periods. Once 10 periods have been played, the next pairing will be the last one for the experiment. When the random draw ends that final pairing, the experiment as a whole will end. The researchers will announce when the final pairing begins.

Example Questions and Trial Periods

To make sure that you understand the experiment, we will conduct two additional activities before you start earning points. First, you will answer a short series of multiple-choice questions that test your understanding of the rules and structure. Please feel free to refer to these instructions or to ask questions of the researchers.

Second, we will play 3 trial periods of the game. These trial periods are exactly like the regular experiment, with two exceptions:

- Your decisions in the trial periods do not affect how much money you will earn, and
- You will be matched with your partner for exactly 3 periods, rather than a random number of periods.

After the trial periods end, you will be matched with a new partner to begin the scored periods. Now is a good time for you ask any questions you may have about the experiment, before we begin the example questions and trial periods.

APPENDIX B

DERIVATIONS OF RESULTS THEORETICAL MODEL

This section shows the calculations and assumptions used to derive the various conditions discussed for each of the contracts discussed in the theoretical model.

B.1 Seller's Participation Constraints

Since the seller has an outside option that pays μ per period, he will enter the relational contract only if his expected payoff under that contract is at least as great as μ per period. The contract covers multiple periods with a probabilistic termination, which is mathematically equivalent to an infinite time horizon with discounting.

Under the conditional contract, the seller receives a fixed price, *p*, a formal bonus, *f*, and a discretionary bonus, *d*, and pays the production cost, *C*(*Q*), in each period. Following Levin (2003), we analyze stationary contracts only, since any optimal contract has an equivalent stationary contract under the assumptions of this model. The requirement that the seller's expected payoff under the contract exceed her reservation payoff can be written as:

$$\sum_{t=0}^{\infty} \delta^t \left[p + f + d - C(Q)\right] \geq \sum_{t=0}^{\infty} \delta^t \mu$$

Factoring out the stationary payment terms on each side of the inequality yields:

$$\left[p + f + d - C(Q)\right] \sum_{t=0}^{\infty} \delta^t \geq \mu \sum_{t=0}^{\infty} \delta^t$$

Replacing the sum of the geometric series, $\sum_{t=0}^{\infty} \delta^t$, with its limit, dividing by that limit, and then rearranging terms leads to the expression given in (C1):

$$p + f + d \geq C(Q) + \mu$$

With regard to (U1), note that in the unconditional contract, the seller faces the same payoff structure except that *f* is constrained to be zero.

B.2 Seller's Incentive-Compatibility Constraints

The seller incentive-compatibility (IC) constraint incorporates the idea that a rational seller would deviate from the equilibrium behavior if and only if the net payoff from such a deviation (accounting for credible punishments by the buyer) is larger than her payoff in equilibrium.

The following derivations assume that the buyer will use a "grim trigger" strategy, in which any deviation by the seller results in the buyer abandoning offers relying on relational incentives and instead making the optimal (for the buyer) stage-game offer in each period. In the stage game, the optimizing buyer will always reduce the payments to the seller until the seller's payoffs are equal to μ, his reservation payoff. Also, when *no-exchange* is the stage equilibrium outcome, the seller's payoff is still μ. Thus, regardless of the parameterization, the threat of the grim trigger strategy is always to reduce the seller's future payoffs to μ.

In equilibrium under an unconditional contract, the seller's payoff is $p + d - C(Q)$. The left-hand side (LHS) of the condition below reflects the expected value of receiving that payoff indefinitely into the future, as would occur in equilibrium. If the seller chooses to deviate, his best option is to produce the minimum quality in the current period, yielding a payoff of $p - C_{\min}$, since producing other quality levels would reduce his current payoff without changing his payoffs for future periods. Also, the buyer is forced to pay the fixed price, p, but would withhold the discretionary bonus in the event of the seller's deviation and terminate the relationship for all future periods. As noted above, the seller's payoffs for all future periods will be μ. The right-hand side (RHS) of the condition below is the sum of the current payoff and the discounted payoffs from future periods.

$$\sum_{t=0}^{\infty} \delta^t \left[p + d - C(Q)\right] \geq p - C_{\min} + \sum_{t=1}^{\infty} \delta^t \mu$$

Substituting the limit of the sum for geometric series leads to the following expression:

$$\frac{1}{1-\delta}\left[p + d - C(Q)\right] \geq p - C_{\min} + \frac{\delta}{1-\delta}\mu$$

Multiplying both sides by $(1 - \delta)$, dividing by δ, and rearranging terms leads to the condition as expressed in (U2):

$$p + \frac{d}{\delta} \geq \frac{C(Q)}{\delta} - \frac{1-\delta}{\delta} C_{\min} + \mu$$

In equilibrium under a conditional contract, the seller's payoff is $p + f + d - C(Q)$. The left-hand side (LHS) of the condition below reflects the expected value of receiving that payoff indefinitely into the future, as would occur in equilibrium. If the seller chooses to deviate, his best option is either to produce $(q_1, q_{\min})$ and receive both the price and the bonus or to produce the minimum quality $Q_{\min}$ and receive only the price.

Producing a q_1 that is more than $q_{\min}$ but less than the requested level is inferior to producing $q_{\min}$ since it increases the seller's production cost without increasing his payment. A rational buyer would ensure that the amount of *f* is incentive-compatible, so that the seller's best deviation will be to produce (q_1, $q_{\min}$) and receive the formal bonus while incurring a cost of $C(q_1, q_{\min})$. The RHS of the condition below reflects the seller's expected payoffs from deviation.

$$\sum_{t=0}^{\infty}\delta^t\left[p+f+d-C(Q)\right]\geq p-C(q_1,q_{\min})+\sum_{t=1}^{\infty}\delta^t\mu$$

Substituting the limits for the sums of the geometric series and using manipulations similar to those above leads to the expression for (C2):

$$p+f+\frac{d}{\delta}\geq\frac{C(Q)}{\delta}-\frac{1-\delta}{\delta}C(q_1,q_{\min})+\mu$$

B.3 Buyer's Participation Constraints

The buyer's reservation payoff is assumed to be normalized to 0. A rational buyer would enter the relational contract only if the expected payoff under that offer is greater than 0 per period. In equilibrium, the buyer receives the good from the seller and pays under the contract terms, so therefore his anticipated benefits from the good less the payments must be greater than 0.

Under an unconditional contract, the buyer pays the fixed price, *p*, and the discretionary bonus, *d*, in each period, while receiving the value of the good, $V(Q)$. His expected payoff over the life of the contract forms the LHS of the expression below. His expected payoff if he does not enter a contract is zero, forming the RHS of the condition.

$$\sum_{t=0}^{\infty}\delta^t\left[V(Q)-p-d\right]\geq 0$$

Substituting for the limit of the sum of the geometric series and rearranging terms yields the expression for (U3):

$$p+d\leq V(Q)$$

In a conditional contract equilibrium, the buyer pays the fixed price, *p*, the formal bonus, *f*, and the discretionary bonus, *d*, while receiving the value of the good, $V(Q)$, in each period. He must also pay the transaction cost, *x*, for using the formal incentive. Thus, the expected value of his payoff under the contract is given by the LHS of the expression below. His expected payoff if he does not enter a contract is zero, forming the RHS of the condition.

$$\sum_{t=0}^{\infty} \delta^t \left[V(Q) - p - f - d - x\right] \geq 0$$

Substituting for the limit of the sum of the geometric series and rearranging terms yields the expression for (C3):

$$p + f + d \leq V(Q) - x$$

B.4 Buyer's Incentive-Compatibility Constraints

At the end of each period, the buyer must decide whether to pay the promised discretionary bonus or not. If he withholds the bonus payment, then he saves that expense in the current period but then the seller will punish him by reverting to the stage-game outcome for all periods in the future (the grim trigger strategy). A rational buyer would therefore deviate from the equilibrium behavior if and only if the net payoff from such a deviation (accounting for credible punishments by the buyer) is larger than his payoff in equilibrium.

The buyer's payoff under the stage game is represented by Π_{stage}, as defined in the body of the paper. The amount depends on which of the three types of stage-game outcomes is the equilibrium, which in turn depends on the functional forms and parameter values of the problem.

Under an unconditional contract, a buyer choosing to pay the discretionary bonus receives his equilibrium payoff, $V(Q) - p - d$, in each period into the future, so that his expected payoff is represented by the LHS of the condition below. If he chooses to deviate, then he increases his current payoff by the amount of the withheld bonus, but then he will receive his stage-game payoff for all subsequent periods. The expected value of this series of payoffs is given by the RHS of the condition below.

$$\sum_{t=0}^{\infty} \delta^t \left[V(Q) - p - d\right] \geq V(Q) - p + \sum_{t=1}^{\infty} \delta^t \Pi_{\text{stage}}$$

Substituting the limits for the sums of the geometric sequences yields:

$$\frac{1}{1-\delta}\left[V(Q)-p-d\right]\geq V(Q)-p+\frac{\delta}{1-\delta}\Pi_{\text{stage}}$$

Rearranging terms leads to the expression for (U4):

$$p+\frac{d}{\delta}\leq V(Q)-\Pi_{\text{stage}}$$

Under a conditional contract, the buyer receives the payoff of $V(Q) - p - f - d - x$ each period in equilibrium. The expected value is given by the LHS of the condition below. If he deviates by withholding the discretionary bonus, then he increases his current payoff by *d* but receives only the stage-game payoff for all subsequent periods, as shown in the RHS of the condition.

$$\sum_{t=0}^{\infty}\delta^{t}\left[V(Q)-p-f-d-x\right]\geq V(Q)-p-f-x+\sum_{t=1}^{\infty}\delta^{t}\Pi_{\text{stage}}$$

Substituting for the limits of the sums of the infinite series and rearranging terms leads to the expression for (C4):

$$p+f+\frac{d}{\delta}\leq V(Q)-\Pi_{\text{stage}}-x$$

B.5 Feasibility Conditions

The four participation and incentive-compatibility constraints for each contract type can be combined to determine whether an equilibrium under that contract type is feasible for the parameters of the model and a given quality request (*Q*). In general, some of the constraints may be redundant, meaning that meeting one constraint automatically implies that the other is met. When possible, we remove the “looser” constraints from the analysis.

First, consider the unconditional contract and its four equilibrium constraints. Compare the buyer’s constraints, (U3) and (U4), which can be rewritten as (U3’) and (U4’), respectively:

$$V(Q) - p - d \geq 0 \qquad \text{(U3’)}$$

$$V(Q) - p - \frac{d}{\delta} - \Pi_{\text{stage}} \geq 0 \qquad \text{(U4')}$$

Since the RHS are equal, the condition with the lesser LHS will be the binding constraint. Compare the two LHS of (U3') and (U4'), with <??> representing an unknown inequality operator.

$$V(Q) - p - d < ?? > V(Q) - p - \frac{d}{\delta} - \Pi_{\text{stage}}$$

Combining similar terms yields the following:

$$\Pi_{\text{stage}} + \frac{1-\delta}{\delta} d < ?? > 0$$

Given that $\delta > 0$, $\Pi_{\text{stage}} \geq 0$ and $d \geq 0$, the LHS must be greater than or equal to zero, implying that (U4) binds and (U3) does not.

Next, compare the seller's constraints, (U1) and (U2), by rewriting them as the following (U1') and (U2'), respectively:

$$p + d - C(Q) - \mu \geq 0 \qquad \text{(U1')}$$

$$p + \frac{d}{\delta} - \frac{C(Q)}{\delta} + \frac{1-\delta}{\delta} C_{\min} - \mu \geq 0 \qquad \text{(U2')}$$

Since the RHS are equal, the condition with the lesser LHS will be the binding constraint. Compare the two LHS of (U1') and (U2'), with <??> representing an unknown inequality operator.

$$p + d - C(Q) - \mu < ?? > p + \frac{d}{\delta} - \frac{C(Q)}{\delta} + \frac{1-\delta}{\delta} C_{\min} - \mu$$

Combining similar terms yields the following:

$$\frac{1-\delta}{\delta}\left[C(Q) - C_{\min} - d\right] < ?? > 0$$

The LHS will equal zero for $d = \hat{d}^U = C(Q) - C_{\min}$. Substituting $\hat{d}^U$ back into either condition and requiring equality yields a $\hat{p}^U = C_{\min} + \mu$. Thus, for any given Q there is a contract $(\hat{p}^U, \hat{d}^U, Q)$ for which the (U1) and (U2) constraints are equivalent. That is, the contract will either meet both conditions or neither.

Consider the case when both (U2) and (U4) hold. This implies that the following double inequality is true:

$$V(Q) - \Pi_{\text{stage}} \geq p + \frac{d}{\delta} \geq \frac{C(Q)}{\delta} - \frac{1-\delta}{\delta} C_{\min} + \mu$$

In this case, *any* (*p*, *d*) that makes (U2) hold with equality will also meet the (U4) condition. Since $(\hat{p}^U, \hat{d}^U)$ is one such pair, then (U1) can also be met in this case. Thus, if (U2) and (U4) can both be met, then (U1) can also be met, meaning that we can reduce the feasibility analysis to considering whether (U2) and (U4) can both be met. This simplification allows the expression of the feasibility condition for an unconditional contract as (U5):

$$V(Q) - \frac{C(Q)}{\delta} \geq \Pi_{\text{stage}} - \frac{1-\delta}{\delta} C_{\min} + \mu$$

When (U5) is true for a given Q, there is at least one (*p*, *d*) contract that supports an equilibrium that both parties find preferable to no-exchange and in which neither party will deviate, for fear of punishment.

Next, consider the conditional contract and its equilibrium constraints. The buyer's constraints, (C3) and (C4), which can be rewritten as (C3') and (C4'), respectively:

$$V(Q) - p - f - d - x \geq 0 \qquad \text{(C3')}$$

$$V(Q) - p - f - \frac{d}{\delta} - x - \Pi_{\text{stage}} \geq 0 \qquad \text{(C4')}$$

Since the RHS are equal, the condition with the lesser LHS will be the binding constraint. Compare the two LHS with <??> representing an unknown inequality operator.

$$V(Q) - p - f - d - x <??> V(Q) - p - f - \frac{d}{\delta} - x - \Pi_{\text{stage}}$$

Combining similar terms yields the following:

$$\Pi_{\text{stage}} + \frac{1-\delta}{\delta} d < ?? > 0$$

Given that $\delta > 0$, $\Pi_{\text{stage}} \geq 0$ and $d \geq 0$, the LHS must be greater than or equal to zero, implying that (C4) binds and (C3) does not.

Next, compare the seller's constraints and rewrite them as (C1') and (C2'):

$$p + f + d - C(Q) - \mu \geq 0 \qquad \text{(C1')}$$

$$p + f + \frac{d}{\delta} - \frac{C(Q)}{\delta} + \frac{1-\delta}{\delta} C(q_1, q_{\min}) - \mu \geq 0 \qquad \text{(C2')}$$

Since the RHS are equal, the condition with the lesser LHS will be the binding constraint. Compare the two LHS with <??> representing an unknown inequality operator.

$$p + f + d - C(Q) - \mu < ?? > p + f + \frac{d}{\delta} - \frac{C(Q)}{\delta} + \frac{1-\delta}{\delta} C(q_1, q_{\min}) - \mu$$

Combining similar terms yields the following:

$$\frac{1-\delta}{\delta} \left[C(Q) - C(q_1, q_{\min}) - d \right] < ?? > 0$$

The LHS will equal zero for $d = \hat{d}^C = C(Q) - C(q_1, q_{\min})$. Substituting $\hat{d}^C$ back into either condition and requiring equality yields possible pairs $\left(\hat{p}^C, \hat{f}^C\right)$ such that $\hat{p}^C + \hat{f}^C = C(q_1, q_{\min}) + \mu$.Thus, for any given Q there is a contract $\left(\hat{p}^C, \hat{f}^C, \hat{d}^C, Q\right)$ for which the (C1) and (C2) constraints are equivalent. That is, the contract will either meet both conditions or neither.

Consider the case when both (C2) and (C4) hold. This implies that the following double inequality is true:

$$V(Q) - \Pi_{\text{stage}} - x \geq p + f + \frac{d}{\delta} \geq \frac{C(Q)}{\delta} - \frac{1-\delta}{\delta} C(q_1, q_{\min}) + \mu$$

In this case, *any* (*p*, *d*) that makes (C2) hold with equality will also meet the (C4) condition. Since $\left(\hat{p}^C, \hat{d}^C\right)$ is one such pair, then (C1) can also be met in this case. Thus, if (C2) and (C4) can both be met, then (C1) can also be met, meaning that we can reduce the feasibility analysis to considering whether (C2) and (C4) can both be met. This simplification allows the expression of the feasibility condition for a conditional contract as (C5):

$$V(Q) - \frac{C(Q)}{\delta} \geq \Pi_{\text{stage}} - \frac{1-\delta}{\delta} C(q_1, q_{\min}) + \mu + x$$

When (C5) is true for a given *Q*, there is at least one (*p*, *d*) contract that supports an equilibrium that both parties find preferable to no-exchange and in which neither party will deviate, for fear of punishment.

REFERENCES

Baker, G., R. Gibbons, and K. J. Murphy, 1994. "Subjective Performance Measures in Optimal Incentive Contracts," *Quarterly Journal of Economics* 109: 1125-1156.

Bernheim, B.D. and M.D. Whinston, 1998. "Incomplete Contracts and Strategic Ambiguity," *American Economic Review* 88: 902-932.

Brown, M., A. Falk, and E. Fehr, 2004. "Relational Contracts and the Nature of Market Interactions." *Econometrica* 72(3): 747-780.

Dixit, A., 2004. Lawlessness and Economics. Princeton, NJ: Princeton University Press.

Dmitri, C., 2003. "Contracting in Tobacco? Contracts Revisited," Washington: U.S. Dept. of Agriculture, Economic Research Service, TBS 254-01.

Fehr, E. and S. Gächter, 2002; "Do Incentive Contracts Undermine Voluntary Cooperation?" Working Paper No. 34, Institute for Empirical Research in Economics, University of Zurich.

Fischbacher, U., 2007. "z-Tree: Zurich Toolbox for Ready-made Economic Experiments." *Experimental Economics*, 10: 171-178.

Frey, B., 1997. "A Constitution for Knaves Crowds Out Civic Virtues," *The Economic Journal* 107: 1043-1053.

Klein, B, and K. Leffler, 1981. "The Role of Market Forces in Assuring Contractual Performance," *Journal of Political Economy* 89(4): 615-641.

Kreps, D.M., P. Milgrom, J. Roberts, and R. Wilson, 1982. "Rational Cooperation in the Finitely Repeated Prisoners' Dilemma," *Journal of Economic Theory* 27: 245-252.

Lazzarini, S.G., G.J. Miller, and T.R. Zenger, 2004. "Order with Some Law: Complementarity versus Substitution of Formal and Informal Arrangements," *Journal of Law, Economics, and Organization* 20: 261-298.

Levin, J., 2003. "Relational Incentive Contracts," *American Economic Review* 93: 835-857.

MacDonald, J., J. Perry, M. Ahearn, D. Banker, W. Chambers, C. Dmitri, N. Key, K. Nelson, and L. Southard, 2004. "Contracts, Markets, and Prices: Organizing the Production and Use of Agricultural Commodities," Washington: U.S. Dept. of Agriculture, Economic Research Service, Agricultural Economic Report No. 837.

MacLeod, W.B., 2007. “Reputations, Relationships, and Contract Enforcement,” *Journal of Economic Literature* 45: 595-628.

Schmidt, K.M. and M. Schnitzer, 1995. “The Interaction of Explicit and Implicit Contracts,” *Economics Letters* 48: 193-199.

Shapiro, C. and J. Stiglitz, 1984. “Equilibrium Unemployment as a Worker Discipline Device,” *American Economic Review* 74(3): 433-444.

Tesler, L.G., 1980. “A Theory of Self-Enforcing Agreements,” *Journal of Business* 53(1): 27- 44.

Wu, S.Y. and B. Roe, 2007a. “Contract Enforcement, Social Efficiency, and Distribution: Some experimental Evidence,” *American Journal of Agricultural Economics* 89(2): 243-258.

Wu, S.Y. and B. Roe, 2007b. "Discretionary Latitude and Relational Contracting," IZA Discussion Papers 2879, Institute for the Study of Labor (IZA).