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Holdups, Standard Breach Remedies, and Optimal Investment

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In bilateral trading problems, the parties may be hesitant to make relationship-specific investments without adequate contractual protection. We postulate that the parties can sign noncontingent contracts prior to investing, and can freely renegotiate them after information about the desirability of trade is revealed. We find that such contracts can induce one party to invest efficiently when courts impose either a breach remedy of specific performance or expectation damages. Moreover, specific performance can induce both parties to invest efficiently if a separability condition holds. Expectation damages, on the other hand, is poorly suited to solve bilateral investment problems. (*JEL* K12, L22, C7, D8)

This paper integrates two literatures: the literature on "holdups" and specific investments; and the literature on legal remedies for breach of contract. We investigate when simple fixed-price contracts, enforced with standard legal breach remedies, can provide efficient investment incentives. Our analysis reveals circumstances where contractually specified renegotiation processes are not necessary. It also provides support for recent trends toward applying specific performance in commercial contexts.[1]

The so-called holdup problem has received considerable attention. Oliver E. Williamson (1975, 1985) and others have argued that holdups are common when one or both of two trading partners make relationship-specific investments, that is, investments that enhance the value of trade but that are of substantially less value outside the relationship.[2] The holdup literature postulates that parties cannot sign "complete" contracts which specify efficient trade for each possible state of the world. Yet, investments must be sunk before the state uncertainty is resolved, and so in subsequent negotiations a party will lose part of the returns to his or her relationship-specific investment. This literature consequently suggests that incomplete contracts lead to underinvestment in specific assets.[3,4]

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[1] Although expectation damages is the more typical remedy, the Official Comment to the Uniform Commercial Code §2-716 indicates that specific performance is increasingly used in commercial contexts and not just for "the sale of heirlooms or priceless works of art which were usually involved in the older cases."

[2] Relationship-specific investments take many forms, including human, organizational, and physical capital. Classic examples are the specialized dies used by Fisher Body to stamp out auto bodies for GM cars (Benjamin Klein et al., 1978), and the "cheek-by-jowl" or "mine-mouth" locations of electrical power plants near coal mines (Paul L. Joskow, 1987).

[3] This holdup literature spans industrial organization, labor, and comparative institutions (see, for example, Williamson, 1975, 1985; Benjamin Klein et al., 1978; Oliver D. Hart and John D. Moore, 1988; and Paul Grout, 1984). Holdups play a central role in recent attempts, for example, Sanford J. Grossman and Hart (1986), to broaden and deepen the investigation begun by Ronald H. Coase (1937) into the boundaries of the firm.

[4] We use the term "incomplete" as economists are accustomed (for example, Hart and Moore, 1988). It means the contract is insufficiently contingent, requiring actions that are often inefficient. In contrast, to a lawyer, "incomplete" means that the obligations of the parties are not

The literature on legal remedies for breach of contract predicts the reverse. Most notably, Steven Shavell (1980) and William P. Rogerson (1984) observe that the prevailing breach remedies are overzealous in protecting investments. For instance, an investment may create no social value in contingencies where it is inefficient for the parties to trade; nonetheless, an expectation damages remedy will give the victim of breach the returns that her investment would have yielded if the contract had been performed. This overcompensation drives the overinvestment problem that many in the law and economics literature cite as a feature of standard legal remedies (see, for example, A. Mitchell Polinsky, 1989 p. 37).

Our paper integrates the intuition of the legal remedies literature with that of the holdup literature. We show that noncontingent fixed-price contracts can often provide efficient investment incentives by balancing "holdup contingencies" where an investment is undercompensated against "breach contingencies" where it is overcompensated. The overinvestment problem that Rogerson and Shavell identify is not an essential feature of legal remedies, but stems from the particular contracting options they consider.

We investigate and compare two familiar breach remedies: *expectation damages* and *specific performance*. The expectation damages remedy is more common in practice, though less common in economic models. Under this rule, a buyer (seller) may unilaterally decide to breach a contract if he pays the seller (buyer) an amount sufficient to give the seller (buyer) what her profits would have been under performance, measured ex post. The specific performance remedy is often denied, but courts sometimes grant it if they deem damages "inadequate"; in such cases, unilateral breach is not possible, since either party can insist that the contract be performed according to its terms.

In our model, the parties sign a fixed-price contract prior to investing. Subsequently, they will usually have an incentive to renegotiate the contract when information about the value of trade is revealed. The fixed-price contract and the governing breach remedy together frame renegotiation, determining the surplus over which the parties bargain. We consider a wide class of *monotonic* surplus sharing rules which have the property that each party's gain from renegotiation is increasing in the size of the surplus.

We find that for any monotonic sharing rule, a well-designed fixed-price contract can give one party efficient investment incentives under either expectation damages or specific performance. The expectation remedy is, however, poorly suited when both parties invest, generally implying that no fixed-price contract can provide incentives for efficient investment by both parties. On the other hand, the application of specific performance allows the parties to solve bilateral investment problems provided a separability condition obtains, and the parties get a constant share of the bargaining surplus.

To understand these results, consider contingencies where it is efficient to trade less than the contract requires. Although the specialized assets may yield scant social returns, breach remedies bite and the effective return to investment will be high, corresponding to the high asset use under the contracted production level. We call this excess of the realized return over the social return to investment a *breach subsidy* and note that this subsidy encourages overinvestment.

In contrast, when the efficient level of trade exceeds what the contract requires, the specialized assets yield high social returns. However, since contractual rights are limited to the quantities promised in the contract, the parties must bargain over the social gains from increasing trade. These gains include some of the social return to investment, and if they are shared, the investing party faces a *holdup tax*, a tax which discourages investment.

The contracted quantity should be chosen so that *on average* the investor's marginal return from investment equals the marginal social return. Sometimes the investor faces a holdup tax, other times a breach subsidy. Balancing the two can provide efficient incentives for one party to invest, under either expectation damages or specific performance.

clearly specified—that important terms like price, quantity, time of delivery and quality are not in the contract. This distinction is brought out well in Ian Ayres and Robert H. Gertner (1992).

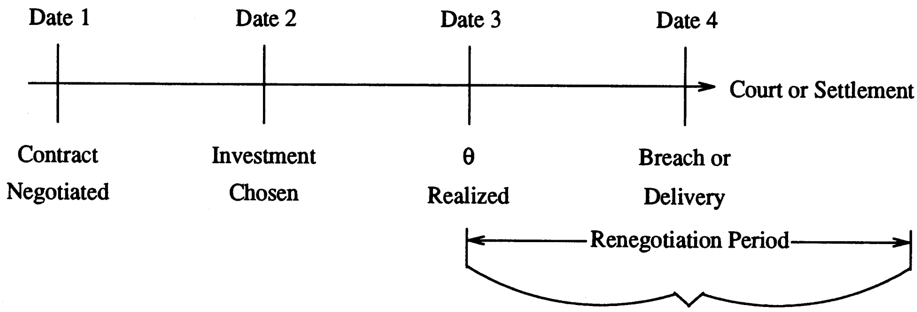


FIGURE 1. TIME LINE

For bilateral investment problems, however, the expectation damages remedy will generally not lead to efficiency. A tension arises because some intermediate quantity will balance the breach subsidy and the holdup tax for the victim of breach. In contrast, the contract breacher receives no breach subsidy and so his incentives are efficient only when an extremely high quantity is chosen. Under specific performance, no such tension arises because *both buyer and seller* get a breach subsidy when efficient trade is lower and a holdup tax when it is higher than the contracted level of trade. When the parties contract to trade the expected efficient quantity, we find that their incentives will be aligned at once, provided their cost and valuation functions satisfy a separability condition.

Recent literature on solutions to the holdup problem can be divided into two camps. Some papers consider revelation mechanisms in which the parties' messages to some central agent determine the ex post outcome.[5] Others, like us, consider fixed-price contracts which may be renegotiated.[6] Papers in this second camp are linked by the feature that one party receives the entire renegotiation surplus in equilibrium. In contrast, we investigate the consequences of sharing this renegotiation surplus. As Section IV discusses, sharing can occur if the parties cannot commit to the renegotiation processes considered in Chung (1991) and Aghion et al. (1990, 1994). Surplus sharing may also result if the parties follow an exogenous bargaining process different from those in Hart and Moore (1988), MacLeod and Malcomson (1993) or Nöldeke and Schmidt (1995).

The remainder of this paper is organized as follows. Section I presents the unilateral investment model. Section II shows that under either breach remedy, investment is efficient if the contract quantity is chosen to balance the holdup tax against the breach subsidy. Section III demonstrates that the specific performance remedy provides better incentives than expectation damages for bilateral investment problems. Section IV provides a more detailed comparison with the literature and Section V discusses the relevance of our findings for the choice of remedy and for the theory of vertical integration.

I. Model Description

Our model has two risk-neutral parties who wish to trade some good. They have the opportunity at date 1 to write a fixed-price contract to exchange the good at date 4 (see Figure 1). Their main motive for the long-term contract is that the seller must decide at date 2 how much to invest in a relationship-specific

[5] These papers include Rogerson (1992), Jerry R. Green and Jean-Jacques Laffont (1992), Benjamin E. Hermalin and Michael L. Katz (1993), and Akira Konakayama et al. (1986).

[6] See Tai-Yeong Chung (1991), Philippe Aghion et al. (1990, 1994), William B. MacLeod and James M. Malcomson (1993), Georg Nöldeke and Klaus M. Schmidt (1995), and Hart and Moore (1988). Hart and Moore is probably better known for its formalization of the underinvestment from Williamson's holdup problem (proposition 4), than for its efficiency result (proposition 3).

asset that lowers the subsequent cost of producing the good. The investment might entail time or money spent on R&D, building a factory, preparing for production, or creating human and organizational capital. We follow the literature in assuming that the investment is not contractible, either because it is nonverifiable or because its description is prohibitively difficult. Whether the investment itself is observable to both parties is not of consequence to us.

After the investment is made, some state uncertainty θ is resolved at date 3. It may affect both the seller's cost, C, and the buyer's valuation, V, each of which is observable to both buyer and seller. The two remedies we consider impose different informational requirements on the court. To calculate expectation damages, the court must observe the breach victim's cost or valuation, or at least be able to estimate it in an unbiased way. In contrast, to administer specific performance, it need only observe delivery and payment.

After C and V are realized, the buyer and seller are free to renegotiate. If the breach remedy is expectation damages, either party may unilaterally breach the contract and pay damages according to an expectation damages formula. Subsequently, production and trade occur, and the parties receive their payoffs, which consist of their (undiscounted) ex post payoffs less any ex ante investment expenditures. We employ the following notation:

$(\bar{q}, \bar{p}, T)$: contract to trade quantity $\bar{q}$ at per-unit price $\bar{p}$, where T denotes an up-front payment the parties may use to divide ex ante gains from contracting;
$S \in [0, S^{\max}]$: specific investment;
$\Theta \subset \mathbb{R}^n$: compact set of possible contingencies;
$F(\theta)$: cumulative distribution function for contingencies $\theta \in \Theta$;
$V(q, \theta)$: value placed by the buyer on quantity $q \in [0, q^{\max}]$. $V(\cdot, \theta)$ is increasing and strictly concave in q for all θ, and $V(0, \cdot) \equiv 0$;
$C(S, q, \theta)$: variable cost of producing quantity $q \in [0, q^{\max}]$ given investment S and state θ. $C(S, \cdot, \theta)$ is increasing and convex in q for all S and θ, and $C(\cdot, 0, \cdot) \equiv 0$. The cross-partial derivative C_{qS} exists and satisfies $C_{qS} \leq 0$.

The specific investment S has no outside value. It serves only to lower the variable production costs, as reflected in the assumption that $C_{qS} \leq 0$. Once the investment S is made, and the contingency θ is realized, the socially optimal level of production q^* is given by

$$q^*(\theta, S) \equiv \operatorname*{argmax}_{q \in [0, q^{\max}]} \{ V(q, \theta) - C(S, q, \theta) \}.^7$$

Since the parties are risk neutral, the socially optimal level of investment S^* maximizes total surplus $Z(S)$, where

$$Z(S) \equiv \int [V(q^*, \theta) - C(S, q^*, \theta)] \, dF - S.$$

We assume that the maximizing level of investment, denoted by S^*, is unique and interior to the interval $[0, S^{\max}]$.

Throughout the paper, we set aside questions of negotiation and litigation costs in order to focus on efficient investment incentives. When parties are free to renegotiate, they trade an ex post efficient quantity regardless of the breach penalty. Therefore, a contract coupled with a breach remedy is efficient if and only if it induces efficient investment. Our focus on ex ante incentives makes the paper more comparable to Rogerson (1984), who also assumed renegotiation was costless, than to Shavell (1980), who assumed it was impossible.[8]

We call the potential gains from renegotiation the *renegotiation surplus*. It is computed with respect to the disagreement point; that is,

[7] The quantity q^* is socially optimal in that it maximizes the sum of the payoffs to the buyer and seller. If some third party were to act strategically, for example, to choose a monopoly price, then q^* would not necessarily maximize the sum of the payoffs to all three. See Kathryn E. Spier and Michael D. Whinston (1995) for such a framework.

[8] In contrast, the earlier law and economics literature on the "efficient breach" problem focused on ranking breach remedies according to the efficiency of exchange, implicitly presuming that renegotiation was prohibitively costly (see, for example, John H. Barton, 1972; or Charles J. Goetz and Robert E. Scott, 1977). For this sort of analysis, see also Robert E. Hall and Edward P. Lazear (1984).

with respect to the utilities that will result if the parties do not strike a bargain and must seek the best they can get through noncooperative action. Such noncooperative action would often involve bringing a suit in court, so the relevant remedy affects the disagreement point. We assume the renegotiation surplus is divided according to some sharing rule $\gamma(\cdot) \in [0, 1]$, where $\gamma(\cdot)$ may depend on θ, S, $\bar{q}$ and $\bar{p}$. In our analysis below, we restrict attention to a class of sharing rules which we refer to as *monotonic*. For such rules the payoff each party receives from bargaining is (weakly) increasing in the size of the renegotiation surplus.

While we treat the sharing rule $\gamma(\cdot)$ as a primitive throughout the body of the paper, we examine an explicit renegotiation game in Appendix A that involves a sequence of alternating offers. In equilibrium, the parties will immediately settle on the efficient trade quantity q^*, and the monetary transfers correspond to a sharing rule $\gamma(\cdot)$ which is identically equal to some constant close to $1/2$. In other games, the sharing rule might not be constant, but Hermalin and Katz (1993) give general conditions under which bargaining results in the efficient outcome q^*.

II. Holdup Taxes and Breach Subsidies

To find an efficient contract for the unilateral investment problem, the parties must choose a contractual quantity $\bar{q}$ that balances two regions: contingencies where $q^*(\theta, S) > \bar{q}$ and the seller faces a holdup tax on the return to her investment, and contingencies where $q^*(\theta, S) < \bar{q}$ and the breach subsidy augments social returns to investment. Although some of our discussion of breach remedies will be couched as if the remedy selection were made by courts, in principal, the contract may itself specify a remedy. In a jurisdiction where parties can freely choose a remedy, the paper can be interpreted as an analysis of the consequences of parties choosing some particular standard legal remedy—and by implication, as an analysis of what remedies they should choose.

A. *Specific Performance*

We analyze specific performance first because it is the remedy most familiar to economic theorists, even though it is most commonly applied in cases that concern real property.[9] Specific performance corresponds to the direct and most obvious meaning of "enforcing" a contract. When one party sues for specific performance, he is asking the court to force the second party to do exactly what the contract specifies. The court can order the second party to perform, and, if she is already under such an order, can hold her in contempt of court.

We now consider how specific performance will affect the parties' negotiations, and hence their investment incentives. After uncertainty is resolved, the parties know the realized cost and valuation, as well as the efficient quantity $q^*(\theta, S)$. Most likely $q^*(\theta, S) \neq \bar{q}$, so the parties can benefit by renegotiating to trade $q^*(\theta, S)$. Depending upon the price $\bar{p}$ that the parties specified, the relevant threat point or status-quo point in their renegotiation might be "no trade," or it might be the seller producing $\bar{q}$, and forcing the buyer to pay $\bar{p}\cdot\bar{q}$ for the goods. The question is whether, if negotiations break down, the seller would prefer to enforce the contract or forget the matter and not trade at all. Rogerson (1984 p. 50) ensures that suing is a credible threat because his contract price makes specific performance attractive to one party. Chung (1991) and others assume implicitly that courts will step in unrequested to enforce contracts.

In practice, either the buyer or the seller must sue for breach, so if neither would credibly sue under the contract absent negotiations, then the contract becomes irrelevant to the negotiations. In such a case the holdup problem may come to dominate, leading to underinvestment. Avoiding this possibility is in the parties' ex ante interest. They may do so by choosing a trading price that is sufficiently high so that the seller will enforce the contract,

[9] For instance, if a landlord promises to supply rental services to a tenant, the tenant can insist upon performance: the landlord cannot unilaterally use his property for other purposes and pay the tenant damages, as he could if a liability rule of expectation damages applied. For a general discussion of the differences between property and liability rules, see Guido Calabresi and A. Douglas Melamed (1972) or William M. Landes and Richard A. Posner (1987).

or sufficiently low so that the buyer will. Which they choose does not matter since they may arbitrarily divide the ex ante gains from trade using a suitable up-front payment T. Specifically, for given $\bar{q}$, the parties may choose $\bar{p}$ so that

$$(1)\quad \bar{p}\cdot\bar{q} - C(S, \bar{q}, \theta) > 0 \quad \text{for all } S \text{ and } \theta.$$

Since $\bar{q}$ is determined endogenously in the analysis below, we let $\bar{p}^{SP}(\bar{q})$ denote some price that the parties choose so as to satisfy inequality (1). Such a price ensures that if negotiations break down and the parties cannot come to some agreement, the seller will enforce the contract and they will trade $\bar{q}$. The parties can avoid the inefficient trade of $\bar{q}$, by agreeing upon some division of the renegotiation surplus:

$$(2)\quad RS(S, \bar{q}, \theta) \equiv V(q^*, \theta) - C(S, q^*, \theta) - [V(\bar{q}, \theta) - C(S, \bar{q}, \theta)].$$

If they split the surplus according to the sharing rule $\gamma(\cdot)$, the seller's ex post payoff becomes[10]

$$(3)\quad R^{\text{seller}} = \bar{p}^{SP}(\bar{q})\cdot\bar{q} - C(S, \bar{q}, \theta) + \gamma(S, \bar{q}, \theta)\cdot RS(S, \bar{q}, \theta).$$

In contrast, the ex post "social" payoff is

$$R^{\text{social}} \equiv V(q^*, \theta) - C(S, q^*, \theta).$$

To provide intuition for why there exists a contracted quantity $\bar{q}$ that gives the seller the desired investment incentive, we first consider the special case where the sharing rule $\gamma(\cdot)$ is a constant (denoted by γ). Comparing the seller's marginal return to investment with the marginal social return, the set Θ is naturally partitioned into two sets of contingencies. In the first, θ is such that $q^*(\theta, S) < \bar{q}$ and the seller is overcompensated for investment. In the second, θ is such that $q^*(\theta, S) > \bar{q}$ and the seller is undercompensated.

Breach Subsidy: Contingencies Where $q^*(\theta, S) < \bar{q}$.—Consider a state θ, where it is efficient to trade less than the contract specifies. By the Envelope Theorem, the marginal social return to investment, dR^{social}/dS is simply $-C_S(S, q^*, \theta)$. This implies that the seller's marginal return to investment exceeds social returns by

$$(4)\quad \frac{dR^{\text{seller}}}{dS} - \frac{dR^{\text{social}}}{dS} = -(1-\gamma) \times [C_S(S, \bar{q}, \theta) - C_S(S, q^*, \theta)].$$

The right-hand side of (4) is nonnegative since $C_{qS} \leq 0$. Aggregating over contingencies θ such that $q^* < \bar{q}$, we get the *breach subsidy* to investment:

$$(5)\quad \int_{\{\theta | q^* < \bar{q}\}} -(1-\gamma) \times [C_S(S, \bar{q}, \theta) - C_S(S, q^*, \theta)]\, dF.$$

This is the amount by which the seller is overcompensated for her investment relative to the social return at the margin. The overcompensation leads us to call it a subsidy (just why we call it a "breach" subsidy will become clearer when we analyze expectation damages). Naturally, the subsidy encourages the seller to overinvest.

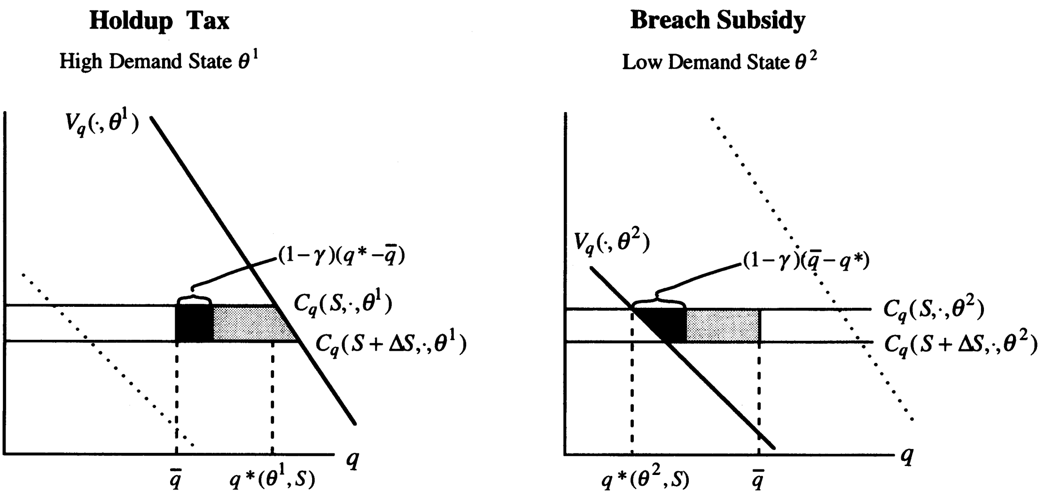
Holdup Tax: Contingencies Where $q^*(\theta, S) > \bar{q}$.—The seller is correspondingly undercompensated for her investment when $q^* > \bar{q}$. In these contingencies, the realized marginal social return to investment exceeds the seller's return by

$$(6)\quad \frac{dR^{\text{social}}}{dS} - \frac{dR^{\text{seller}}}{dS} = -(1-\gamma) \times [C_S(S, q^*, \theta) - C_S(S, \bar{q}, \theta)].$$

Aggregating these contingencies together, we get the *holdup tax*:

$$(7)\quad \int_{\{\theta | q^* > \bar{q}\}} -(1-\gamma) \times [C_S(S, q^*, \theta) - C_S(S, \bar{q}, \theta)]\, dF.$$

[10] For brevity, we write $\gamma(S, \bar{q}, \theta)$ instead of $\gamma(S, \bar{p}^{SP}(\bar{q}), \bar{q}, \theta)$.



High Demand State θ^1

Increase in renegotiation surplus caused by incremental investment ΔS

Holdup tax on incremental investment ΔS (share of added surplus accruing to buyer)

Low Demand State θ^2

Reduction in renegotiation surplus caused by incremental investment ΔS

Breach subsidy to incremental investment ΔS (share of reduction borne by buyer and not seller)

FIGURE 2. SPECIFIC PERFORMANCE

The figure compares changes in the social return and the seller's return between investment levels S and $S + \Delta S$ under the specific performance remedy. The figure depicts linear costs and a constant sharing rule.

We call this quantity the holdup tax because it is what the buyer takes (taxes) at the margin from the seller's return to investment through ex post renegotiation. This tax discourages the seller from investing.

Figure 2 illustrates the holdup tax and breach subsidy under specific performance for a constant marginal cost of production. In the breach region of low trade, if renegotiation were impossible, the benefits from incremental investment would be captured by the seller-investor on all the contracted output. However, since renegotiation is possible, the seller bears a share of the reduction in renegotiation surplus from incremental investment. Consequently, the seller does not receive the full *potential* cost savings on producing units between the efficient quantity q^* and the contracted quantity $\bar{q}$. Observe that in the limiting case where the seller has all the bargaining power ($\gamma = 1$), the seller-investor only receives the reduced cost from extra investment on the efficient quantity q^*, exactly as in the total surplus maximization problem.

Balancing Holdup Tax Against Breach Subsidy.—When $\bar{q} = 0$, there is no breach subsidy, only a holdup tax. As $\bar{q}$ increases, the breach subsidy grows and the holdup tax shrinks (holding S constant). Eventually, the holdup tax on investment becomes less than the breach subsidy. Since the holdup tax and the breach subsidy are both continuous functions of $\bar{q}$, some contract quantity $\bar{q}^{SP}$ makes the holdup tax equal the breach subsidy.[11] The first-order necessary condition for a quantity $\bar{q}^{SP}$ to induce optimal investment S^* is that the holdup tax balances the breach subsidy at S^*, that is,

$$(8)\quad -(1-\gamma)\int_{\{\theta|q^*>\bar{q}^{SP}\}}[C_S(S^*,q^*,\theta) - C_S(S^*,\bar{q}^{SP},\theta)]\,dF = -(1-\gamma) \times \int_{\{\theta|q^*<\bar{q}^{SP}\}}[C_S(S^*,\bar{q}^{SP},\theta) - C_S(S^*,q^*,\theta)]\,dF.$$

In fact, as shown below in Proposition 1, a balancing quantity $\bar{q}^{SP}$ exists not only for any fixed γ, but for a wide class of sharing rules $\gamma(S, \bar{q}, \theta)$. In particular, we consider monotonic sharing rules. Under a monotonic rule, each party's payoff is (weakly) increasing in the size of the surplus bargained over. In the context of our model, monotonicity requires that for any θ, $\bar{q}$, S and $\hat{S}$: $RS(S, \bar{q}, \theta) \geq RS(\hat{S}, \bar{q}, \theta)$ implies

$$(9)\quad \gamma(S,\bar{q},\theta)\cdot RS(S,\bar{q},\theta) \geq \gamma(\hat{S},\bar{q},\theta)\cdot RS(\hat{S},\bar{q},\theta),$$

and $(1-\gamma(S,\bar{q},\theta))\cdot RS(S,\bar{q},\theta)$

$$\geq (1-\gamma(\hat{S},\bar{q},\theta))\cdot RS(\hat{S},\bar{q},\theta),$$

where $RS(\cdot)$ is the renegotiation surplus defined in (2).

The seller's ex ante investment problem is to choose S so as to maximize the expected value of $R^{\text{seller}}(\cdot)$, given in (3), minus the cost of the investment S. Hence, the seller's objective function at date 2 is to maximize:

$$(10)\quad M(S;\bar{q}) \equiv \int [\bar{p}^{SP}(\bar{q})\cdot\bar{q} - C(S,\bar{q},\theta) + \gamma(S,\bar{q},\theta)\cdot RS(S,\bar{q},\theta)]\,dF - S.$$

Let

$$\phi(\bar{q}) \equiv \underset{S\in[0,S^{\max}]}{\operatorname{argmax}}\{M(S;\bar{q})\}.$$

We make the following assumption.

(A1) The correspondence $\phi(\cdot)$ has a continuous selection $\bar{S}(\cdot)$.

The existence of a continuous selection may depend upon the function $\bar{p}^{SP}(\bar{q})$. Although we have treated $\bar{p}^{SP}(\bar{q})$ as fixed, the parties may choose any function satisfying inequality (1). For the purpose of Proposition 1 below, it is sufficient that for some suitable $\bar{p}^{SP}(\cdot)$, the correspondence $\phi(\cdot)$ have a continuous selection. We note that for constant sharing rules (A1) will be satisfied if $\bar{p}^{SP}(\cdot)$ is chosen to be some large constant and if $C(\cdot, q, \theta)$ is strictly convex in S, as Chung (1991) and others assume. Even without such a convexity assumption, (A1) will hold whenever there is a unique maximizer.[12]

PROPOSITION 1: *Suppose the parties expect the court to impose specific performance. Given (A1) and any monotonic sharing rule $\gamma(\cdot)$, there exists a quantity $\bar{q}^{SP}$ such that the seller has an incentive to choose the first-best investment S^* under any contract $(\bar{q}^{SP}, \bar{p}^{SP}(\bar{q}^{SP}), T)$.*

PROOF:

It suffices to show that

$$(11)\qquad \bar{S}(0) \leq S^* \leq \bar{S}(q^{\max}),$$

[11] If $q^* = \bar{q}$ with positive probability, the holdup tax would not be differentiable, but the reader can check that even then it would be continuous.

[12] By Berge's Maximum Theorem, $\phi(\cdot)$ is upper-hemicontinuous, and hence, if $\phi(\cdot)$ is single valued it is a continuous function. In a related problem, Nöldeke and Schmidt (1995) derive sufficient conditions for the optimal investment level to be unique.

since assumption (A1) then allows us to apply the Intermediate Value Theorem to conclude that a $\bar{q}^{SP}$ exists such that $\bar{S}(\bar{q}^{SP}) = S^*$.

To establish the inequalities in (11), we analyze the seller's return from an increase in investment, and compare it to the social return. For $\bar{q} = 0$ and $S > \hat{S}$, we find that

$$(12) \quad M(S;0) - M(\hat{S};0) = \int [\gamma(S,0,\theta)\cdot RS(S,0,\theta) - \gamma(\hat{S},0,\theta)\cdot RS(\hat{S},0,\theta)]\,dF + \hat{S} - S \leq \int [RS(S,0,\theta) - RS(\hat{S},0,\theta)]\,dF + \hat{S} - S = Z(S) - Z(\hat{S}).$$

The first equality follows from expression (10) since $C(\cdot,0,\cdot) \equiv 0$. The inequality arises as follows: since $C_{Sq} \leq 0$, $RS(S,0,\theta) \geq RS(\hat{S},0,\theta)$, which together with the monotonicity of $\gamma(\cdot)$ implies that $[1 - \gamma(S,\cdot)]\cdot RS(S,\cdot) \geq [1 - \gamma(\hat{S},\cdot)]\cdot RS(\hat{S},\cdot)$.

To conclude that $S^* \geq \bar{S}(0)$, suppose the opposite. Then, inequality (12) implies

$$Z(\bar{S}(0)) - Z(S^*) \geq M(\bar{S}(0);0) - M(S^*;0).$$

Yet, since $\bar{S}(0)$ is a maximizer of $M(\cdot;0)$, $M(\bar{S}(0);0) - M(S^*;0) \geq 0$. This implies that $Z(\bar{S}(0)) - Z(S^*) \geq 0$, contradicting that S^* is the unique maximizer of $Z(\cdot)$. Thus $S^* \geq \bar{S}(0)$.

The proof that $S^* \leq \bar{S}(q^{\max})$ follows the same sequence of arguments while reversing the inequalities. In particular, the seller's payoff from renegotiation decreases as $RS(\cdot)$ decreases from increased investment.

From the above proof, we note that Proposition 1 only requires a weak form of monotonicity: the sharing rule $\gamma(\cdot)$ must be monotonic when restricted to $\bar{q} = 0$ and $\bar{q} = q^{\max}$.

Proposition 1 implies that an efficient contract exists whenever the bargaining process follows an Outside Option Principle as in John Sutton (1986). In MacLeod and Malcomson (1993) and Hart and Moore (1988), the price $\bar{p}$ is set sufficiently high so that the seller's outside option binds. This makes $\gamma = 0$, and such a sharing rule is monotonic. See Edlin (1993) for details.

In general, the quantity $\bar{q}^{SP}$ will depend on the sharing rule $\gamma(\cdot)$ and the function $\bar{p}^{SP}(\cdot)$. However, the quantity $\bar{q}^{SP}$ is invariant when $\gamma(\cdot)$ is a constant sharing rule, that is, when there exists a constant $\gamma \in [0, 1]$ such that $\gamma(\cdot) \equiv \gamma$. This property is suggested by equation (8) after dividing by $(1 - \gamma)$, and is proven below.

PROPOSITION 2: *The same contractual quantity $\bar{q}^{SP}$ induces the seller to choose S^* for any constant sharing parameter γ and any contract $(\bar{q}^{SP}, \bar{p}^{SP}(\bar{q}^{SP}), T)$.*

PROOF:

Consider the $\bar{q}^{SP}$ that induces efficient investment for some $\gamma \neq 1$. It balances the holdup tax against the breach subsidy for this particular γ, and therefore for all $\gamma' \neq \gamma$ as well. (Divide equation (8) by $1 - \gamma$.) For $\gamma' \neq 1$, no other quantity will balance the holdup tax and breach subsidy when $S = S^*$, because the holdup tax is strictly decreasing and the breach subsidy strictly increasing in $\bar{q}$. Thus $\bar{q}^{SP}$ is the only candidate to induce efficient investment for γ'. It must do so since Proposition 1 guarantees some quantity is efficient. Finally, note that the quantity $\bar{q}^{SP}$ also induces efficient investment when $\gamma' = 1$, since any $\bar{q}$ does so when $\gamma' = 1$.

For constant sharing rules, Proposition 2 gives our results additional robustness, since the optimal contractual quantity $\bar{q}^{SP}$ is not affected by the seller's bargaining power. If the parties discover after signing the contract that their ex post bargaining power differs from what they expected, this will not require contractual modification. More important, the efficiency of the contract will be unaffected even if the parties adopt different expectations about the subsequent division of ex post surplus. Although they may disagree about the likely division, the parties will agree that the contract provides incentives for efficient investment.

B. *Expectation Damages*

We now turn to the more typical remedy of expectation damages. The essential difference from specific performance is that under a damage rule neither party can be forced to perform the contract. Either is free to breach the contract unilaterally, provided he pays the damages given by the expectation formula. Expectation damages are measured ex post and are calculated to make the injured party exactly as well off as if the contract were fully performed. For example, if a farmer promises to deliver 100 bushels of wheat, the buyer's damages for failure to deliver is the market price at the appointed delivery date minus the contract price.

The analysis under a damage rule may differ depending upon whether the contract is viewed as "divisible" or "entire." Divisible contracts are legally equivalent to a large number of independent contracts in which the seller supplies one individual unit of the good and the buyer pays the unit price.[13] We focus on how the parties can write an efficient divisible contract, because analyzing the breach of such a contract is particularly clean. The formal analysis would be unchanged if we assumed instead that the contract were entire, but that delivery was to be over time, as in a lease.

Suppose the buyer notifies the seller before production that he will only accept delivery of quantity $q < \bar{q}$, and that he intends to breach the contract for the remaining goods. This is called an *anticipatory breach*, since it occurs before the maturation of the duty to accept the goods and make the payment. One might first guess that the buyer would have to pay damages of $\bar{p}\cdot(\bar{q} - q)$; but this amount overstates the seller's economic damages. After all, the seller saves the ex post costs of producing the unused units.[14] The expectation damages formula requires that if the buyer breaches, he pay the seller an amount equal to the contract price, that is, $\bar{p}\cdot\bar{q}$, less her cost savings from the avoided production. The resulting payment by the buyer becomes $\bar{p}\cdot\bar{q} - [C(S, \bar{q}, \theta) - C(S, q, \theta)]$. If the seller produces more than q after being notified of the anticipated breach, the seller cannot recover her costs because she is obligated to *mitigate* damages.[15] Damages would be higher if the buyer breached after the seller incurs unnecessary costs, so the buyer will notify the seller of any breach before such costs are incurred.

In contrast to our specific performance analysis, where the court only needs to observe delivery, here we assume that, given S and θ, the court can assess the difference $C(S, \bar{q}, \theta) - C(S, q, \theta)$. Although this may be an optimistic view of courts, it lets us compare our results with previous authors, particularly Rogerson (1984) and Shavell (1980).[16]

We now analyze the investment incentives that arise under a rule of expectation damages and show that the parties can sign a contract that gives the seller efficient investment incentives. For any $\bar{q}$, the parties may choose $\bar{p}$ such that:

$$(1') \quad \bar{p} - C_q(S, \bar{q}, \theta) > 0 \quad \text{for all } S \text{ and } \theta.$$

As before, let $\bar{p}^{\mathrm{ED}}(\bar{q})$ denote a price the parties may choose to satisfy (1′), given a particular $\bar{q}$. For such a price, the seller will not want to breach any part of the contract. For, if the seller produces and delivers $\bar{q}$, her payoff is $\bar{p}^{\mathrm{ED}}(\bar{q})\cdot\bar{q} - C(S, \bar{q}, \theta)$. If she only produces $q < \bar{q}$, she receives $\bar{p}^{\mathrm{ED}}(\bar{q})\cdot q - C(S, q, \theta)$, and the buyer may sue for any damages he suffers from the breach.[17] Even if the buyer

[13] For discussion of divisible contracts, see Arthur Linton Corbin (1960 §§694–699), or Edward Allan Farnsworth (1982 pp. 596–99).

[14] Any costs incurred before the buyer can notify the seller should be included in the investment expenditure S.

[15] See, for example, Rockingham County v. Luten Bridge Co., 35 F.2d 301 (1929), 4th Cir., where Luten Bridge Co. continued building a bridge after Rockingham County cancelled. Rockingham succeeded in arguing that it owed Luten only the "damages which the company would have sustained, if it had abandoned construction at that time."

[16] See Edlin (1994) for a related analysis when the courts' damage assessment is uncertain.

[17] For the seller, there is no need to distinguish between anticipatory and ex post breach. Suppose the seller delivers $q < \bar{q}$, fulfilling her obligation on q units and breaching on $\bar{q} - q$ units. What must the buyer pay? Since the contract is divisible, the buyer must pay $\bar{p}\cdot q$ for the delivered units; however, the buyer can deduct or set off any losses he may incur from the seller's breach. If the buyer is not injured by the breach, he will have no "set off." Thus the buyer pays

$$\min\{\bar{p}\cdot q, \bar{p}\cdot q - [V(\bar{q}, \theta) - V(q, \theta) - \bar{p}(\bar{q} - q)]\}.$$

does not sue, (1′) implies that the seller's payoff is maximized by delivering $\bar{q}$.

Breach Subsidy: Contingencies Where $q^*(\theta, S) < \bar{q}$.—If efficient trade is low, as depicted by θ^2 in Figure 3, the buyer will not want to purchase all of $\bar{q}$. Before the seller starts production, or at least before she produces more than q, the buyer will announce that he will accept no more than some quantity q which solves

$$(13) \quad \max_{q \leq \bar{q}} \{ V(q,\theta) - (\bar{p}^{\mathrm{ED}}(\bar{q}) \cdot \bar{q} - (C(S,\bar{q},\theta) - C(S,q,\theta))) \}.$$

The amount $(\bar{p}^{\mathrm{ED}}(\bar{q}) \cdot \bar{q} - C(S, \bar{q}, \theta))$ depends only on the contract and the sunk investment but not on the quantity traded. Therefore, under expectation damages, the buyer chooses q ex post to maximize social surplus from trade, $V(q, \theta) - C(S, q, \theta)$, and so unilaterally chooses the socially optimal quantity $q^*(\theta, S)$.[18] Since the efficient output can be reached unilaterally, there is no room for renegotiation; only movements along the Pareto frontier are possible, and one party or the other would veto these.

The seller's ex post return equals the buyer's payment (including damages) less the cost of producing q^*. This gives the seller the expectancy interest that the law protects:

$$(14) \quad R^{\text{seller}} = \bar{p}^{\mathrm{ED}}(\bar{q}) \cdot \bar{q} - [C(S,\bar{q},\theta) - C(S,q^*,\theta)] - C(S,q^*,\theta) = \bar{p}^{\mathrm{ED}}(\bar{q}) \cdot \bar{q} - C(S,\bar{q},\theta).$$

Therefore, when $q^* < \bar{q}$, the marginal investment return to the seller exceeds social returns by $-[C_S(S, \bar{q}, \theta) - C_S(S, q^*, \theta)]$ (using the Envelope Theorem again). Aggregating over all states where breach occurs, we obtain the *breach subsidy:*

$$(15) \quad \int_{\{\theta | q^* < \bar{q}\}} - [C_S(S, \bar{q}, \theta) - C_S(S, q^*, \theta)] \, dF.$$

The breach subsidy is the result of the court guaranteeing the seller the cost savings from increased investment on the entire contracted quantity $\bar{q}$, even though it is only efficient to produce q^*. For the q^* units that the seller produces, the investment returns derive from production-cost savings; for the remaining $\bar{q} - q^*$ units, from increased damage payments. This overinsurance of the returns to investment generalizes the Rogerson-Shavell result obtained in a discrete framework, where $q \in \{0, 1\}$. The breach subsidy under expectation damages is depicted in Figure 3.

Holdup Tax: Contingencies Where $q^*(\theta, S) > \bar{q}$.—Under an expectation damages remedy, when q^* exceeds $\bar{q}$, neither the buyer nor seller can have an incentive to breach. To see this, suppose the buyer breaches, and cancels his order beyond some quantity $q < \bar{q}$. The seller can deliver q and then choose whether to sue. If she sues, she gets her expectancy $\bar{p}^{\mathrm{ED}}(\bar{q}) \cdot \bar{q} - C(S, \bar{q}, \theta)$, and if she chooses not to sue, this must be because her payoff from trading $\bar{q}$ already exceeds her expectancy. Since $RS(S, q, \theta) \geq RS(S, \bar{q}, \theta)$, and since the bargaining is monotonic, after renegotiation to trade q^*, the seller will continue to be at least as well off if the buyer breaches. The buyer will, therefore, be (weakly) worse off, and so has no incentive to breach. It is likewise unattractive for the seller to breach, since then the buyer's payoff will be at least $V(\bar{q}, \theta) - \bar{p} \cdot \bar{q}$ before any renegotiation. Otherwise, he would sue to get this payoff. Since the renegotiation surplus is also enlarged by the seller's breach, the buyer will (weakly) benefit from the seller's breach. The seller, therefore, cannot benefit from breach. Thus both parties perform, and they split the value of the units

This payment can be viewed as a payment $\bar{p} \cdot q$ for the units delivered minus damages in the amount of $[V(\bar{q}, \theta) - V(q, \theta)] - \bar{p} \cdot (\bar{q} - q)$, if there is an injury.

[18] If the seller did not supply the first q^* units, the buyer could sue the seller for breach of contract, securing the same payoff as above. The buyer can sue under a divisible contract, because the duty of the seller to supply the q^* is separate from the contract to trade the remaining units, so the seller's duty is not "discharged" by the buyer's breach on the remaining units. The buyer might also have the right to successfully sue even if the contract were "entire," as discussed in Edlin and Reichelstein (1994).

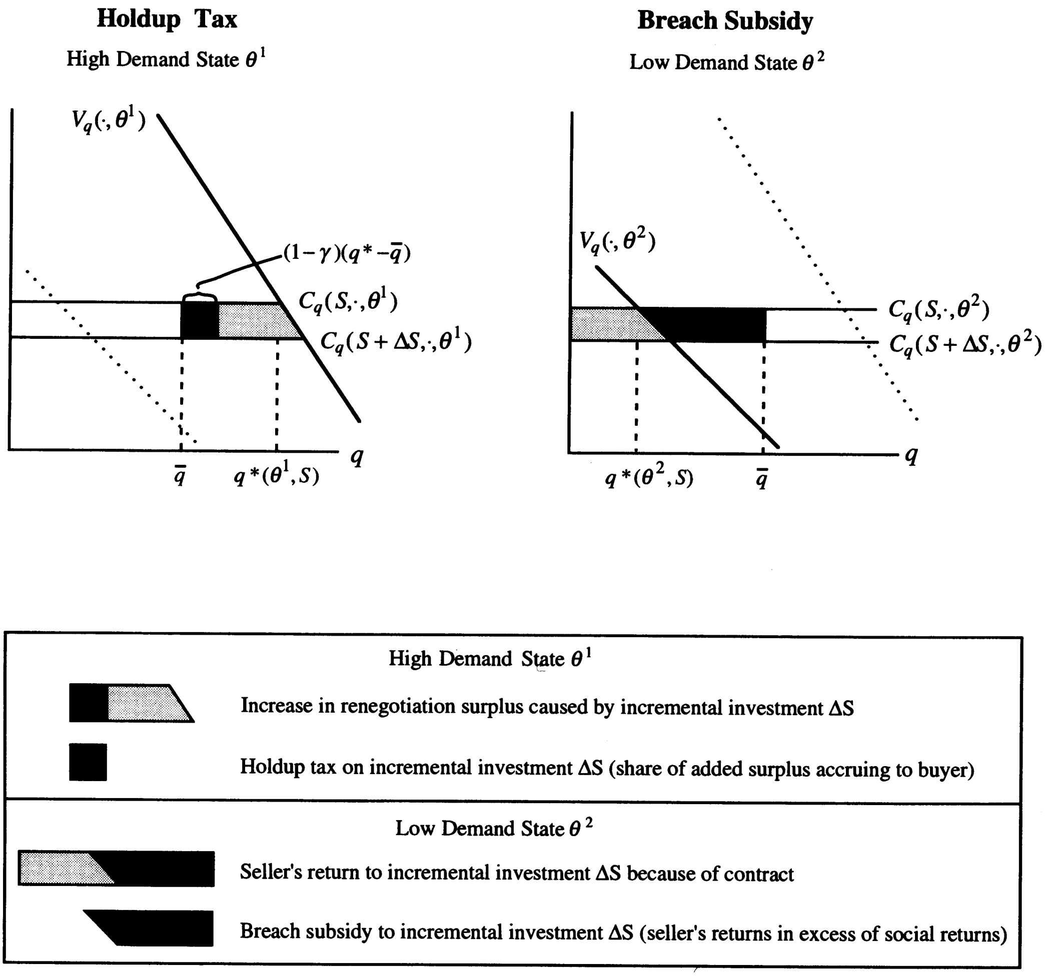


FIGURE 3. EXPECTATION DAMAGES

The figure compares changes in the social return and the seller's return between investment levels S and $S + \Delta S$ under the expectation damages remedy. The figure depicts linear costs and a constant sharing rule.

between $\bar{q}$ and q^* to which they have no contractual claim. The seller's ex post return is

$$R^{\text{seller}} = \bar{p}^{\text{ED}}(\bar{q})\cdot\bar{q} - C(S,\bar{q},\theta) + \gamma(S,\bar{q},\theta)\cdot RS(S,\bar{q},\theta), \tag{16}$$

just as it was under specific performance when $q^* > \bar{q}$. For a constant sharing rule, we therefore obtain the same *holdup tax* as under specific performance:

$$-(1-\gamma)\int_{\{\theta|q^*>\bar{q}\}} [C_S(S,q^*,\theta) - C_S(S,\bar{q},\theta)]\, dF. \tag{17}$$

This tax decreases the seller's incentive to invest. When $\bar{q} = 0$, there is only a holdup tax, and this causes underinvestment. As $\bar{q}$ becomes sufficiently large, the breach subsidy exceeds the holdup tax, and this causes overinvestment. An intermediate quantity $\bar{q}^{ED}$ balances these effects.

To establish the existence of a balancing quantity, $\bar{q}^{ED}$, for general sharing rules $\gamma(\cdot)$, we recall that the seller's expected payoff is given by:

$$(18)\quad \tilde{M}(S;\bar{q}) \equiv \int \tilde{R}^{\text{seller}}(S,\bar{q},\theta)\,dF - S,$$

where

$$\tilde{R}^{\text{seller}}(S,\bar{q},\theta) \equiv \begin{cases} \bar{p}^{ED}(\bar{q})\cdot\bar{q} - C(S,\bar{q},\theta) \\ \qquad \text{if } \quad q^*(S,\theta) \leq \bar{q} \\ \bar{p}^{ED}(\bar{q})\cdot\bar{q} - C(S,\bar{q},\theta) \\ + \gamma(S,\bar{q},\theta)\cdot RS(S,\bar{q},\theta) \\ \qquad \text{if } \quad q^*(S,\theta) > \bar{q}. \end{cases}$$

Let

$$\tilde{\phi}(\bar{q}) \equiv \operatorname*{argmax}_{S\in[0,S^{\max}]} \tilde{M}(S;\bar{q}).$$

Instead of (A1), Proposition 3 uses (A1′).

(A1′) The correspondence $\tilde{\phi}(\cdot)$ has a continuous selection $\tilde{S}(\cdot)$.

PROPOSITION 3: *Suppose the parties expect the court to impose expectation damages. Given (A1′) and any monotonic sharing rule $\gamma(\cdot)$, there exists a quantity $\bar{q}^{ED}$ such that the seller has an incentive to choose the first-best investment S^* under any contract $(\bar{q}^{ED}, \bar{p}^{ED}(\bar{q}^{ED}), T)$.*

PROOF:

The proof parallels that of Proposition 1. It suffices to show that $\tilde{S}(0) \leq S^* \leq \tilde{S}(q^{\max})$. To demonstrate that $\tilde{S}(0) \leq S^*$, we apply the same arguments as in Proposition 1, since the seller's payoff function is the same for both remedies when $\bar{q} = 0$, that is, $M(\cdot\,;0) \equiv \tilde{M}(\cdot\,;0)$. As in the proof of Proposition 1, the claim that $S^* \leq \tilde{S}(q^{\max})$ follows by reversing the inequalities in (12). In particular for $S > \hat{S}$,

$$\begin{aligned}\tilde{M}(S;q^{\max}) &- \tilde{M}(\hat{S};q^{\max}) \\ &= \int [-C(S,q^{\max},\theta) + C(\hat{S},q^{\max},\theta)]\,dF \\ &\quad + \hat{S} - S \\ &\geq \int [RS(S,q^{\max},\theta) - RS(\hat{S},q^{\max},\theta) \\ &\quad - C(S,q^{\max},\theta) + C(\hat{S},q^{\max},\theta)]\,dF + \hat{S} - S \\ &= Z(S) - Z(\hat{S}).\end{aligned}$$

The inequality follows since $RS(S,q^{\max},\theta) \leq RS(\hat{S},q^{\max},\theta)$.

For the special case of a constant sharing rule, $(\gamma(\cdot) \equiv \gamma)$, $\bar{q}^{ED}$ decreases as the seller's bargaining power increases. This follows because for fixed $\bar{q}$, higher levels of γ cause more investment; to counteract this effect, $\bar{q}^{ED}$ must be decreased, taking advantage of the fact that $\tilde{M}_{Sq} \geq 0$. This contrasts with the situation under specific performance, where the appropriate contract does not vary with bargaining power.

We conclude this section by comparing the contracted quantities under expectation damages and specific performance.

PROPOSITION 4: *Assume $q^*(\theta, S^*)$ has positive variance and $C_{Sq} < 0$. Then, for any constant sharing parameter γ, $\bar{q}^{ED} < \bar{q}^{SP}$ for $\gamma > 0$, and $\bar{q}^{ED} = \bar{q}^{SP}$ for $\gamma = 0$.*

PROOF:

Consider first the case where $\gamma > 0$. Since $C_{Sq} < 0$ and $q^*(\theta, S^*)$ has positive variance, the set $\{\theta \mid q^*(\theta, S^*) < \bar{q}^{ED}\}$ must have positive probability (otherwise $\bar{q}^{ED}$ would not balance the holdup tax against the breach subsidy). We note that

$$\begin{aligned}\tilde{M}_S(S;\bar{q}) &- M_S(S;\bar{q}) \\ &= -\gamma \int_{\{\theta \mid q^*(\theta,S) < \bar{q}\}} [C_S(S,\bar{q},\theta) \\ &\quad - C_S(S,q^*,\theta)]\,dF.\end{aligned}$$

Thus $\tilde{M}_S(S; \bar{q}) - M_S(S; \bar{q}) \geq 0$ for all $\bar{q}$, and the inequality is strict whenever $\{\theta | q^*(\theta, S) < \bar{q}\}$ has positive probability. Setting $\bar{q} = \bar{q}^{\text{ED}}$, it follows that

$$0 = \tilde{M}_S(S^*; \bar{q}^{\text{ED}}) > M_S(S^*; \bar{q}^{\text{ED}}).$$

Finally, suppose $\bar{q}^{\text{ED}} \geq \bar{q}^{\text{SP}}$. Since $M_{Sq} \geq 0$, we obtain

$$M_S(S^*; \bar{q}^{\text{ED}}) \geq M_S(S^*; \bar{q}^{\text{SP}}).$$

However, that would contradict the first-order necessary condition that $M_S(S^*; \bar{q}^{\text{SP}}) = 0$. Thus, $\bar{q}^{\text{ED}} < \bar{q}^{\text{SP}}$.

For the remaining case where $\gamma = 0$, $M(\cdot) \equiv \tilde{M}(\cdot)$, and so $\bar{q}^{\text{ED}} = \bar{q}^{\text{SP}}$.

Finally, we note that the noncontingent contracts examined above are by no means a unique solution to the contracting problem. We have focused on prices satisfying inequality (1′) for which the seller always wants to breach, but efficient contracts may have other prices as well. The simplest is described in Edlin (1994) and involves a low unit price (say zero), accompanied by the contract quantity $q^{\max}$. The seller, and not the buyer, always breaches such a contract. Although it leads to efficient investment because the seller *always* receives the social return to her investment, such a contract may be problematic. It involves an extreme choice of quantity and a large up-front payment made to the seller who promises to provide $q^{\max}$ later for nothing. A variety of factors including solvency constraints may prevent parties from choosing such a contract.

We presented the balancing contract with an intermediate quantity because one of our goals has been to describe commonplace contracts. It may be that the prices we have considered in (1′) share some of the faults of a zero price. Perhaps a more realistic scenario is that parties choose an intermediate price exceeding zero, but not satisfying inequality (1′). Efficient contractual quantities $\bar{q}$ may be chosen for such prices as well. Since the buyer will sometimes breach, these contracts will involve intermediate contractual quantities that balance under- and overinvestment effects, much as we have discussed. The analysis would be complicated, though, by the possibility of seller breach, as illustrated in Appendix B.

III. Bilateral Investment

This section extends our previous analysis to situations where the buyer can also make a relationship-specific investment to improve his valuation. It may seem unlikely that the parties can ever find a fixed-price contract giving both of them efficient investment incentives, since the contract entails only one instrument, namely $\bar{q}$. Our analysis below confirms this intuition only for the case of expectation damages. Surprisingly, we find that the parties can solve the bilateral investment problem under specific performance for an important class of problems.

Let the buyer's valuation function now be $V(I, q, \theta)$, where $I \in [0, I^{\max}]$ denotes relationship-specific investment undertaken by the buyer. The unique efficient quantity to trade ex post becomes

$$q^*(S, I, \theta) = \underset{q \in [0, q^{\max}]}{\operatorname{argmax}} \{V(I, q, \theta) - C(S, q, \theta)\}.$$

At date 2, the efficient investment levels maximize

$$Z(S, I) \equiv \int [V(I, q^*, \theta) - C(S, q^*, \theta)]dF - S - I.$$

We assume that $Z(\cdot, \cdot)$ has a unique maximizer, (S^*, I^*), in the interior of $[0, S^{\max}] \times [0, I^{\max}]$. Moreover, we assume that $q^*(S^*, I^*, \theta)$ has a positive variance so that it is not equal to any given value with probability one. Finally, in addition to the requirements imposed on $C(\cdot)$ and $V(\cdot)$ in Section I, we now also assume that $V_{Iq} > 0$ and $C_{Sq} < 0$.

A. *Expectation Damages*

Unlike a specific performance remedy, the expectation damages remedy entails asymmetric treatment of the contract breacher and the victim of breach. This asymmetry creates a tension between providing efficient incentives for one party and providing incentives for the other. We illustrate this tension below, and show that for a particular class of valuation functions, no efficient fixed-price contract exists when an expectation damage remedy is applied.

Consider a contingency where $q^* < \bar{q}$ and breach occurs. Because damages give the injured party exactly her expectancy, only she is overcompensated for her investment; the breacher winds up with the residual, and so receives exactly the social return to her investment at the margin. Therefore, there is a conflict over how to set the contracted quantity $\bar{q}$. For the contract breacher, $\bar{q}$ should be so high that q^* is always less than $\bar{q}$. In contrast, for the contract "enforcer," regions of breach subsidy where $q^* < \bar{q}$ should be balanced against regions of holdup tax where $q^* > \bar{q}$.

Proposition 5 below considers the following cost and valuation functions.

$$\text{(A2)} \quad V(I, q, \theta) = V_1(I) \cdot q + V_2(q, \theta),$$

$$C(S, q, \theta) = C_1(S) \cdot q.$$

PROPOSITION 5: *Suppose the parties expect the court to impose expectation damages. Given (A2) and any constant sharing parameter $\gamma \in (0, 1)$, there exists no contract $(\bar{q}, \bar{p}, T)$, such that the first-best investment levels I^* and S^* form a Nash equilibrium at date 2.*

PROOF:

See Appendix B.

The proof of Proposition 5 searches over all possible contracts and finds that none induces both parties to invest efficiently. If the contract price is chosen so that $\bar{p} \geq C_1(S^*)$, the buyer is always the breaching party and the seller sues. If the contract is set to balance the holdup tax and the breach subsidy for the seller, the buyer underinvests because he never gets a breach subsidy and is subject to a holdup tax whenever $q^* > \bar{q}$. The reverse problem obtains if $\bar{p} < C_1(S^*)$. This basic tension makes the expectation remedy ill-suited for bilateral investment problems. This conclusion is not limited to constant sharing rules, but extends to monotonic sharing rules.[19]

B. *Specific Performance*

When courts grant specific performance, the investment incentives of the buyer and the seller are more symmetric than under expectation damages. Under specific performance, the same contingencies encourage overinvestment for the buyer as for the seller, and correspondingly the same contingencies encourage underinvestment for both parties. This makes it possible to align both parties' investment incentives with a single quantity $\bar{q}$, provided the surplus sharing rule is constant and the parties' valuation functions satisfy a separability condition. The appropriate quantity is simply an unbiased estimate of the quantity to be traded ex post. Our possibility result requires the following separability conditions which replace (A1), and are a less restrictive version of (A2).

$$\text{(A3)} \quad V(I,q,\theta) = V_1(I) \cdot q + V_2(q,\theta) + V_3(I,\theta),$$

$$C(S,q,\theta) = C_1(S) \cdot q + C_2(q,\theta) + C_3(S,\theta).$$

Condition (A3) ensures that the cross-partial derivatives V_{Iq} and C_{Sq} are independent of q and θ. This condition would hold, for instance, if the investment saved some given amount of labor in the production of each unit, or if investment involved searching to procure an input at a lower linear price.[20] We may interpret the valuation and cost functions $V(I, q, \theta)$ and $C(S, q, \theta)$ implied by (A3) as second-order approximations to the parties' "true" valua-

[19] To be precise, Proposition 5 generalizes provided the sharing rule is strictly monotonic in the following sense. The function $\gamma(S, I, \bar{p}, \bar{q}, \theta)$ is differentiable in S and I, and $dRS(S, I, \bar{q}, \theta)/dI > 0$ implies $d[\gamma(\cdot)RS(\cdot)]/dI < dRS(\cdot)/dI$ and $d[(1 - \gamma(\cdot))RS(\cdot)]/dI < dRS(\cdot)/dI$. A parallel requirement must hold for the derivative with respect to S.

[20] We thank Bentley MacLeod for providing the latter interpretation.

tion functions, since joint second-order Taylor expansions satisfy (A3). In that sense, the following result provides an approximate solution to the bilateral investment problem, one that should satisfy parties who have limited ex ante information about their cost and valuations.

PROPOSITION 6: *Suppose the parties expect the courts to impose specific performance. Given (A3) and any constant sharing parameter* γ *suppose further that the parties choose a contract* $(\bar{q}^{SP}, \bar{p}^{SP}(\bar{q}^{SP}), T)$, *where*

$$\bar{q}^{\mathrm{SP}} = \int q^*(S^*, I^*, \theta)\, dF.$$

Then the first-best investment levels S^* *and* I^* *form a Nash equilibrium at date 2.*

PROOF:

Because $\bar{p}^{\mathrm{SP}}(\bar{q}^{\mathrm{SP}})$ satisfies (1), the seller always prefers to perform the contract rather than ignore the prior agreement $(\bar{q}, \bar{p})$. Thus the prior agreement is the relevant threat point to use to calculate the renegotiation surplus. Anticipating a γ share of the renegotiation surplus at date 4, and assuming that the buyer invests I^*, the seller chooses S to maximize $M(S, I^*; \bar{q})$,

$$M(\cdot) \equiv \bar{p}\cdot\bar{q} + \int [-C(S, \bar{q}, \theta) + \gamma\cdot RS(S, I^*, \bar{q}, \theta)]\, dF - S,$$

where

$$(19)\quad RS(S, I^*, \bar{q}, \theta) \equiv V(I^*, q^*, \theta) - C(S, q^*, \theta) - [V(I^*, \bar{q}, \theta) - C(S, \bar{q}, \theta)]$$

denotes the renegotiation surplus available at date 3. The derivative $M_S(\cdot)$ equals

$$\int [-(1-\gamma)\cdot C_S(S, \bar{q}, \theta) - \gamma\cdot C_S(S, q^*, \theta)]\, dF - 1.$$

Because of (A3), this expression simplifies to

$$(20)\quad -C_1'(S)\cdot\left[(1-\gamma)\bar{q} + \gamma\cdot\int q^*(S, I^*, \theta)\, dF\right] + \int \frac{\partial}{\partial S} C_3(S, \theta)\, dF - 1.$$

Since S^* and I^* are interior maximizers of $Z(S, I)$, it follows that

$$(21)\quad Z_S(S^*, I^*) = 0 = -C_1'(S^*) \int q^*(S^*, I^*, \theta)\, dF - \int \frac{\partial}{\partial S} C_3(S^*, \theta)\, dF - 1.$$

If $\bar{q}$ is chosen equal to $\bar{q}^{\mathrm{SP}} = \int q^*(S^*, I^*, \theta)\, dF$, expression (20) will be zero at $S = S^*$. To show that S^* is indeed the global maximizer of $M(\cdot, I^*; \bar{q}^{\mathrm{SP}})$, we note that the derivative $M_S(S, I^*; \bar{q}^{\mathrm{SP}})$ is greater than or equal to $Z_S(S, I^*)$ for $S < S^*$, while the opposite holds for $S > S^*$. (This follows from the fact that $\int q^*(S, I^*, \theta)\, dF$ is nondecreasing in S, which in turn follows from $C_{Sq} \leq 0$.) For any $S < S^*$ we thus find that

$$(22)\quad M(S^*, I^*; \bar{q}^{\mathrm{SP}}) - M(S, I^*; \bar{q}^{\mathrm{SP}}) \geq Z(S^*, I^*) - Z(S, I^*) > 0.$$

A symmetric argument shows that $M(S^*, I^*, \bar{q}^{\mathrm{SP}}) - M(S, I^*, \bar{q}^{\mathrm{SP}}) > 0$ for $S > S^*$. This establishes that S^* is a best reply against I^*. A parallel argument can be made for the buyer.

With additive separability of marginal cost and valuation, and a constant sharing rule, a single instrument $\bar{q}$ is enough to get both parties to invest efficiently. Regardless of the distribution of bargaining power, both are undercompensated at the margin for their investments in contingencies where it is efficient to trade more than the contract specifies; and both are overcompensated when it is efficient to trade less. The parties can align both of their incentives at once by setting $\bar{q}$ equal to the expected trading quantity following efficient investments.

IV. Relationship to the Literature

Prior literature on the use of fixed-price contracts to solve the holdup problem can be divided according to the assumptions made about renegotiation. Some papers allow the contract to specify the renegotiation process while others consider an exogenously given process. In contrast to our analysis, though, the renegotiation surplus is never shared in those models; one party always receives the entire surplus in equilibrium. Hart and Moore (1988), MacLeod and Malcomson (1993) and Nöldeke and Schmidt (1995) assume that the parties follow a bargaining procedure with an outcome given by some variant of the Outside Option Principle. By setting a high penalty for breach, one party's outside option always binds so that the other party receives the entire renegotiation surplus. Our analysis allows for other bargaining protocols (such as those considered in Appendix A) which result in surplus sharing.[21] Our work is also motivated by the concern that courts frequently will not enforce high penalties, and resort instead to standard legal remedies such as specific performance or expectation damages.

Chung (1991) and Aghion et al. (1994) take the view that the parties can design a renegotiation process, which becomes part of the contract. Their renegotiation processes also leave one party with the entire surplus. In Chung's (1991) model, the seller is simply given the "right" to make a take-it-or-leave-it offer.[22] For such an arrangement to be credible, the parties must believe that the status quo outcome $(\bar{q}, \bar{p})$ would be the final outcome if the buyer refused the seller's offer. Since this outcome would, however, be inefficient, we believe the buyer will anticipate the possibility of further negotiation and a corresponding share of the realized gains. Even after a court order of specific performance, the parties may rationally anticipate agreeing to a more efficient outcome. Generally, a court that orders production of 5 units, when 7 is efficient, will not stop parties from agreeing to trade the additional 2 units. (See Moore [1992] for a similar critique.)

Even if one believed that the court *might* stop such renegotiations, that is, might enforce the "game over" instructions of the mechanism, there is a knife-edge character to no-sharing results. A buyer would accept an offer to trade the efficient quantity at the same profit as trading $\bar{q}$ at price $\bar{p}$, only if the buyer places probability zero on profitable negotiation following a rejection.[23] It may be "safer" for the parties to adopt some iterative bargaining process, such as those considered in Appendix A, leaving both sides with a positive share of the available surplus.

Rogerson (1984) considers a model with constant surplus sharing and discrete trade, that is, $q \in \{0, 1\}$. He observes that without a contract (the $\bar{q} = 0$ case), holdups will cause underinvestment. On the other hand, with a contract to trade one unit, that is, $\bar{q} = 1$, overinvestment results. Our analysis indicates that the problem with such a contract is that efficient trade never exceeds $\bar{q}$, so there is no holdup tax to balance against the breach subsidy. If parties can write *enforceable* contracts to trade intermediate quantities $\bar{q}$ in the interval $(0, 1)$, they can induce efficient investment. Thus, a contract to trade half a table might be efficient even though it is only efficient ex post to trade a whole table or nothing.

If such contracts are not enforceable, or if they otherwise prefer, the parties might specify some contingencies where $\bar{q} = 1$, and others where $\bar{q} = 0$. For constant sharing rules, it makes no difference how well these contractual contingencies correspond to the true contingencies where trade is efficient; it only matters that the probability weight on those

[21] Another recent paper which adopts surplus sharing is Lars A. Stole and Jeffrey Zwiebel (1996).

[22] Aghion et al. (1994) use an iterative bargaining process. In equilibrium, though, one party captures the entire surplus. To keep their process on the equilibrium path, they use penalties that courts might refuse to enforce. Also, like Chung (1991) they do not allow any renegotiation after a specific performance order.

[23] Even then, Matthew Rabin's (1993) fairness arguments together with experimental evidence would suggest a rejection.

contingencies where $\bar{q} = 1$ be equal to $\bar{q}^{SP}$ or $\bar{q}^{ED}$. The contract could hinge on any verifiable event with appropriate probability.

V. Concluding Remarks

We have examined simple noncontingent contracts enforced under two legal regimes: expectation damages and specific performance. Under both regimes, simple noncontingent contracts can balance a breach subsidy against a holdup tax to provide a single investor with efficient investment incentives. Importantly, this is possible without renegotiation design and under a wide class of monotonic renegotiation processes. This suggests that specific performance and expectation damages both provide good protection for one party's investment. At the same time, our results cast doubt on the idea that vertical integration is prompted because of problems from holdups and opportunism in one-sided investment problems.[24]

Our conclusions are quite different for two investors. Under expectation damages, a contract which provides good incentives for one party provides poor incentives for the other party. Specific performance, in contrast, provides balanced incentives. Thus, our results suggest advantages of the specific performance remedy, and support recent trends to grant specific performance in more commercial contexts.

Expectation damages is inferior to specific performance in one other respect. It requires the court to observe valuations to calculate damages (or at least form an unbiased estimate of damages). Specific performance, on the other hand, requires a minimum of courts. They need only observe performance, which they must do anyway to recognize breach under a damage remedy.

Our results on two-sided investment problems also contribute to the theory of vertical integration. Our prediction of investment inefficiencies when the breach remedy is expectation damages suggests that in circumstances where courts refuse to grant specific performance, the two parties should be integrated to become divisions of a firm. To facilitate efficient interdivisional trade, headquarters could set up a system of negotiated transfer pricing governed by the specific performance remedy. The integrated firm would then be able to solve bilateral investment problems. This prediction is consistent with survey evidence on negotiated transfer pricing.[25] Furthermore, Michael J. Meurer's (1993) recent study finds that for disputes within the firm, ''compelled performance ...'' is the most likely remedy, but occasionally damages are paid by one party to another. Despite these potential advantages of vertical integration, a more complete theory will have to address the costs of integration as well, such as moral hazard problems with divisional managers.[26]

Appendix A

This appendix describes bargaining games that the parties may play after date 3 when the state θ becomes known. We treat specific performance first, then expectation damages. Since investments are sunk at date 3, the analysis applies to both one- and two-sided investment problems.

Specific Performance.—Suppose the date 1 contract calls for delivery of the $\bar{q}$ units at date 4, whereupon the buyer has to pay $\bar{p}\cdot\bar{q}$. We consider three iterative bargaining processes, which we view as potentially descriptive of bargaining when no commitments have been made to any particular renegotiation process.

In the simplest variant, the parties bargain with each other only between dates 3 and 4. There are N bargaining rounds between these dates. In each round, one party makes an offer for a contract $(\hat{q}, \hat{p}\cdot\hat{q})$ that would replace the existing contract. The other party can either accept or reject this offer. Rejection moves bargaining to the next round, while acceptance terminates the negotiations. We assume that any new contract also calls for delivery at date 4.

[24] For a helpful discussion of the relationship between holdups and vertical integration, see Patrick Bolton and Whinston (1993).

[25] See the survey by Price Waterhouse (1984).

[26] Edlin and Reichelstein (1995) consider these issues.

At date 4, the seller may deliver and would then be entitled to payment. If instead she breaches and does not deliver the quantity called for under the prevailing contract at date 4, then the buyer can sue to compel performance. For now, we assume the court order is enforced and no bargaining after date 4 is possible. Later, we discuss the impact of such bargaining.

We suppose that the parties take turns in making offers, that N is odd, and that the seller makes the first and last offers. Instead of discounting later agreements as Ariel Rubinstein (1982) does, we follow Roger B. Myerson (1991, Section 8.7) and introduce a small positive probability, ε, that the bargaining process terminates whenever an offer is rejected. This chance of breakdown may reflect the possibility that one party is irritated by the other's refusal, or that either party may need to attend to other matters and be unable to conduct further bargaining. Our assumption that the risk of breakdown is the same after the buyer rejects an offer as after the seller does implies that the two parties have roughly equal bargaining power.

If there is no agreement after N rounds, the seller will deliver $\bar{q}$ units at date 4. Delivery entitles the seller to the payment $\bar{p}\cdot\bar{q}$ and she could sue for the buyer's performance (payment) if the buyer does not pay. Inequality (1) ensures that the date 1 contract is more profitable than no trade.

We can now use backward induction to solve for the unique payoffs consistent with a subgame-perfect equilibrium. Consider bargaining round i. Let $W_b(i)$ denote the share of the surplus that the buyer can obtain if the parties have not reached an agreement in the first $(i-1)$ rounds of bargaining. Note that in the last round, the buyer will not receive any surplus in equilibrium, so $W_b(N) = 0$. In the penultimate round, however, the buyer can obtain an ε share of $RS(S, \bar{q}, \theta)$.[27] The seller is indifferent between accepting this offer and facing an ε probability of negotiation breakdown, so $W_b(N-1) = \varepsilon$. We find that in any even-numbered round $2\tilde{N}$, where $1 \le \tilde{N} \le (N-1)/2$, the share of the surplus attainable by the buyer is

$$\text{(i)} \quad W_b(2\tilde{N}) = \varepsilon + W_b(2\tilde{N}+1)\cdot(1-\varepsilon),$$

while in odd-numbered rounds

$$\text{(ii)} \quad W_b(2\tilde{N}-1) = (1-\varepsilon)\cdot W_b(2\tilde{N}).$$

Hence in any subgame-perfect equilibrium, the seller offers the buyer $W_b(2\tilde{N}+1)\cdot RS(S, \bar{q}, \theta)$ in round $2\tilde{N}+1$, and the buyer offers the seller $(1 - W_b(2\tilde{N}))\cdot RS(S, \bar{q}, \theta)$ in round $2\tilde{N}$. The unique subgame-perfect equilibrium outcome involves the buyer accepting the seller's first offer for $W_b(1)\cdot RS(S, \bar{q}, \theta)$. Solving equations (i) and (ii) recursively we obtain

$$\text{(iii)} \quad W_b(1) = \sum_{i=1}^{(N-1)/2} \varepsilon(1-\varepsilon)^{2\cdot i-1} = \frac{1-\varepsilon}{2-\varepsilon}[1-(1-\varepsilon)^{N-1}].$$

The sharing parameter γ equals $1 - W_b(1)$, and measures the seller's share of the renegotiation surplus. For any given (small) ε, $W_b(1)$ tends to $(1-\varepsilon)/(2-\varepsilon)$ as N gets large. Note that $1 - W_b(1)$ is therefore slightly larger than 0.5 for all ε and N, which reflects the seller's advantage from making the first and last offer.

The preceding bargaining game is unduly restrictive since there is no further negotiation after date 4. In Edlin and Reichelstein (1994), we consider a variant with an infinite number of rounds of bargaining following date 4. It turns out that for a sufficiently high contract price $\bar{p}$, the seller's share of the renegotiation surplus is $\gamma = 1 - W_b(1)$ if $q^* < \bar{q}$, and $\tilde{\gamma} = 1 - (1-\varepsilon)/(2-\varepsilon)$ if $q^* > \bar{q}$. Although this sharing rule is not monotonic, it does satisfy the weaker form of monotonicity, which, as we observed earlier, is sufficient for the proof of Proposition 1. Moreover, the sharing rule approaches a constant sharing rule as $N \to \infty$.

Both of the preceding court/bargaining games are restrictive because the seller loses all rights under the contract if she does not deliver at date 4. Often, the seller can deliver somewhat late without abandoning her con-

[27] For bilateral investment problems, the renegotiation surplus becomes $RS(S, I, \bar{q}, \theta)$, as defined in (19).

tractual rights. For this reason, Edlin and Reichelstein (1994) also consider a third variant of the game with a "grace" period. There, we explain that just as in the first two scenarios, the parties are bargaining over a renegotiation surplus defined by performing the contract, that is, over $RS(S, \bar{q}, \theta)$. The results thus accord with those above.

Expectation Damages.—The main text explained carefully the case where $q^* < \bar{q}$. For that case, no renegotiation is necessary since the buyer has an incentive to unilaterally announce an efficient breach and move the parties to the frontier. The renegotiation when $q^* > \bar{q}$ was not handled explicitly, however.

We describe here how the buyer and seller come to trade q^* when $q^* > \bar{q}$ and courts apply the expectation damages remedy. We consider a game where the buyer first chooses whether to announce an anticipatory breach. The seller then delivers some quantity q. If either party has breached, the other can then go to court and sue for damages. Finally, the parties may negotiate over any subsequent production in excess of q. These negotiations consist of alternating offers. If the parties have already traded a quantity q, they bargain over the remaining renegotiation surplus: $RS(S, q, \theta)$.

Since at this stage, there is no prior contract and the option of going to court is no longer available, the remaining bargaining game is standard, and there is a unique subgame-perfect equilibrium to this subgame. Let γ denote the seller's share of $RS(S, q, \theta)$ that results from this equilibrium.

We claim that the unique equilibrium involves neither party breaching and the two parties then splitting $RS(S, q, \theta)$ with the *buyer's payoff* being:

$$\text{(iv)} \quad V(\bar{q},\theta) - \bar{p}\cdot\bar{q} + (1-\gamma)\cdot RS(S,\bar{q},\theta)$$

and the *seller's payoff* being:

$$\text{(v)} \quad \bar{p}\cdot\bar{q} - C(S, \bar{q}, \theta) + \gamma\cdot RS(S, \bar{q}, \theta).$$

To see that the seller will perform if the buyer does not breach, suppose the seller delivers some quantity $q < \bar{q}$. Then the buyer may choose to sue. If he sues, his payoff will equal his expectancy, and if he chooses not to sue, it must be because his payoff already exceeds his expectancy. Thus, the buyer's payoff after any suit but before renegotiation will be at least $V(\bar{q}, \theta) - \bar{p}\cdot\bar{q}$. After renegotiation, the buyer's payoff will be at least the amount in (iv). Since for $q < \bar{q} < q^*$, $RS(S, q, \theta) > RS(S, \bar{q}, \theta)$, the buyer's payoff would be larger in the proposed equilibrium. Hence, the seller's payoff must therefore be less than in equilibrium. This prevents the seller from deviating.

Why doesn't the buyer breach? Similar reasoning applies. If the buyer breaches, announcing some $q < \bar{q}$, then after any lawsuit, but before renegotiation, the seller will receive at least her expectancy. Since the buyer's breach has increased the size of the renegotiation surplus, he has increased the seller's payoff. As before, this implies that his own payoff is reduced. This verifies the claim above.

APPENDIX B

PROOF OF PROPOSITION 5:

Case I: $\bar{p} \geq C_1(S^*)$. As argued in Section II, the seller will never find it profitable to breach the contract in this case. Furthermore, the analysis in Section II shows that in order for the seller to have an incentive to invest S^* (assuming the buyer invests I^*), the quantity $\bar{q}^{\mathrm{ED}}$ has to be such that for some contingencies θ, $\bar{q}^{\mathrm{ED}} < q^*(S^*, I^*, \theta)$, while for others $\bar{q}^{\mathrm{ED}} > q^*(S^*, I^*, \theta)$. (Recall that $q^*(S^*, I^*, \theta)$ has positive variance.) In order to balance the holdup tax against the breach subsidy, both sets of contingencies must have positive probability. To derive a contradiction, we show that in order for the buyer to have an incentive to choose I^*, it must be that $q^*(S^*, I^*, \theta) \leq \bar{q}$ for all θ except possibly a set of measure 0. Since the buyer will breach the contract when $q^* < \bar{q}$, and the seller will sue for damages, the buyer's ex post payoff becomes

$$\text{(i)} \quad V(q^*, I, \theta) - \bar{p}\cdot\bar{q} + [C(\bar{q}, S^*, \theta) - C(q^*, S^*, \theta)] \qquad \text{if } q^* < \bar{q}$$

and

$$V(\bar{q}, I, \theta) - \bar{p}\cdot\bar{q} + (1-\gamma)\cdot RS(S^*, I, \bar{q}, \theta) \text{ if } q^* > \bar{q},$$

with $RS(S^*, I, \bar{q}, \theta)$ as defined in (19). Taking the derivative of the buyer's expected payoff with respect to I, we obtain

$$\text{(ii)} \quad \int_{\{\theta | q^* < \bar{q}\}} V_1'(I)\cdot q^* \, dF + \int_{\{\theta | q^* > \bar{q}\}} \{V_1'(I)\cdot\bar{q} + (1-\gamma) \times [V_1'(I)\cdot(q^* - \bar{q})]\} \, dF.$$

Since I^* is optimal

$$\text{(iii)} \qquad \int V_1'(I^*)\cdot q^* \, dF = 1.$$

In order for I^* to maximize the seller's payoff, the expression in (ii) must equal 1 at I^*. Combining this fact with (iii), it follows that

$$\int_{\{\theta | q^* > \bar{q}\}} [\bar{q} + (1-\gamma)\cdot(q^* - \bar{q})] \, dF = \int_{\{\theta | q^* > \bar{q}\}} q^* \, dF.$$

This is equivalent to

$$-\gamma\cdot\int_{\{\theta | q^* > \bar{q}\}} (q^* - \bar{q}) \, dF = 0.$$

Therefore, if $\{\theta | q^*(S^*, I^*, \theta) > \bar{q}\}$ has positive probability, the buyer will not choose to invest I^*.

Case II: $\bar{p} < C_1(S^*)$. When $\bar{p} < C_1(S^*)$, the situation is reversed. The outline of the proof is that when the buyer chooses I^*, in order to induce the seller to choose S^*, the contract quantity $\bar{q}$ must be so high that $\{\theta | q^* > \bar{q}\}$ has probability zero. In contrast, when the seller chooses S^*, in order to induce the buyer to choose I^*, the contract must balance contingencies of breach subsidy ($q^* < \bar{q}$) against those of the holdup tax ($q^* > \bar{q}$).

We analyze in turn contingencies $q^* \geq \bar{q}$ and $q^* < \bar{q}$, assuming optimal investments I^* and S^* are chosen. When $q^* \geq \bar{q}$, the buyer and seller split the gains from modifying the contract. Their payoffs are

$$R^{\text{buyer}} \equiv V(\bar{q}, I^*, \theta) - \bar{p}\cdot\bar{q} + (1-\gamma)\cdot RS(S^*, I^*, \bar{q}, \theta)$$

$$R^{\text{seller}} \equiv \bar{p}\cdot\bar{q} - C(\bar{q}, S^*, \theta) + \gamma\cdot RS(S^*, I^*, \bar{q}, \theta).$$

When $q^* < \bar{q}$, the seller *will* want to breach some part of his obligations, and the buyer *might* want to breach.

Suppose the buyer announces an anticipatory breach, an intention to buy only $q^b < \bar{q}$. What will the seller do? The seller may contemplate bringing a court action for the buyer's breach on $\bar{q} - q^b$, but the seller is not damaged since $\bar{p} < C_1(S^*)$. Since the contract is divisible, the seller must still supply the q^b despite the buyer's partial breach. If the seller fails to deliver, the buyer may sue for damages. If the seller delivers $q < q^b$, the seller is entitled to

$$R^{\text{seller}} \equiv \bar{p}\cdot q - C_1(S^*)q - D,$$

and the buyer to

$$R^{\text{buyer}} \equiv V(q, I^*, \theta) - \bar{p}\cdot q + D,$$

where damages D are given by

$$D \equiv V(q^b, I^*, \theta) - \bar{p}\cdot q^b - V(q, I^*, \theta) + \bar{p}\cdot q.$$

Regardless of whether the seller decides to breach, the buyer's payoff when $q^* < \bar{q}$ becomes $V(q^b, I^*, \theta) - \bar{p}\cdot q^b$ if he breaches and $V(\bar{q}, I^*, \theta) - \bar{p}\cdot\bar{q}$ if he does not. If $V_q(\bar{q}, I^*, \theta) > \bar{p}$, the buyer does not breach; otherwise the buyer chooses q^b such that $V_q(q^b, I^*, \theta) = \bar{p}$. This implies $q^b > q^*$, since $\bar{p} < C_1(S^*)$ and $V(\cdot)$ is strictly concave.

The seller decides how much to breach by maximizing her payoff:

$$\max_q V(q, I^*, \theta) - C_1(S^*)q,$$

where q has to be less than $\bar{q}$, or less than q^b if there was an anticipatory breach by the buyer. The seller therefore chooses q such that $V_q(q, I^*, \theta) = C_1(S^*)$, which leads to the efficient quantity q^*.

In contingencies where $q^* \leq \bar{q}$, the seller's marginal return to investment given S^* and I^* is $C_1'(S^*)q^*$, exactly the same as the social return. In contrast, when $q^* > \bar{q}$, the seller's marginal return equals $C_1'(S^*)\cdot[\bar{q} + \gamma\cdot(q^* - \bar{q})]$. Therefore, since $\gamma \in (0, 1)$, the parties must choose $\bar{q}$ so that $q^*(S^*, I^*, \theta) \leq \bar{q}$ for all θ (except a null set) in order to get the seller to invest efficiently.

With such a $\bar{q}$, the buyer's payoff is always $V(q^b, I, \theta) - \bar{p}\cdot q^b$, where $q^b \leq \bar{q}$ is chosen by the buyer to maximize $V(q^b, I, \theta) - \bar{p}\cdot q^b$. The buyer's marginal return to investment at I^* becomes

$$\int V_1'(I^*)\cdot q^b \, dF.$$

Since $\bar{p} < C_1(S^*)$, $q^*(S^*, I^*, \theta) < q^b$, and so the buyer obtains a breach subsidy, a subsidy not balanced by any holdup tax. The buyer consequently overinvests, proving our claim that no contract provides both parties with the desired investment incentives.

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