NBER WORKING PAPER SERIES

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Working Paper No. 5007

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
February 1995

Earlier versions of this work were presented at seminars at Harvard University, Stanford University, Princeton University, the University of Chicago, Northwestern University, Yale University, the University of Southern California, the University of California, Berkeley, and Boston University. We are grateful to many participants of these seminars. We would particularly like to thank Ian Ayres, Tai-Yeong Chung, Richard Craswell, Paul Milgrom, Jonathan Paul, A. Mitchell Polinsky, William Rogerson, Robert Rosenthal, Klaus Schmidt, Jeffrey Zwiebel, Joseph Stiglitz, two anonymous referees and the co-editor Preston McAfee for their help. For financial assistance we thank the National Science Foundation (for a graduate fellowship and grant SES 920544) and the John M. Olin Program for Law and Economics at Stanford Law School. Eric Emch provided able research assistance.

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ABSTRACT

We consider a bilateral trading problem in which one or both parties makes relationship-specific investments before trade. Without adequate contractual protection, the prospect of later holdups discourages investment. We postulate that the parties can sign noncontingent contracts prior to investing, and can freely renegotiate them after uncertainty about the desirability of trade is resolved. We find that such contracts can induce one party to invest efficiently when either a breach remedy of *specific performance* or *expectation damages* is applied. Specific performance can also induce both parties to invest efficiently, provided a separability condition holds. In contrast, expectation damages is poorly suited to solve bilateral investment problems.

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1. INTRODUCTION

This paper brings together 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 delineates circumstances where contractually specified renegotiation processes are not necessary. It also provides support for recent trends toward applying specific performance in commercial contexts.[2] Finally, it refines the theory that vertical integration is driven by the need to make specific investments and the difficulties of writing complete contracts.

The so-called holdup problem has received considerable attention. Williamson [1975, 1985] and others have argued that holdups are common when one or both of two trading partners make relationship-specific investments, i.e., investments that enhance the value of trade but that are of little or no value outside the relationship.[3] 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 her relationship-specific investment. Consequently, this literature suggests that incomplete contracts lead to underinvestment in specific assets.[3,4]

[2]Although expectation damages is the more typical remedy, as the Official Comment to the Uniform Commercial Code §2-716 indicates, 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."

[3]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 (Klein, Crawford, and Alchian [1978]), and the "cheek-by-jowl" or "mine-mouth" locations of electrical power plants near coal mines (Joskow [1987]).

[4]This holdup literature spans industrial organization, labor, and comparative institutions (see, e.g., Williamson [1975, 1985], Klein, Crawford, and Alchian [1978], Hart and Moore [1988], and Grout [1984]). Holdups play a central role in recent attempts such as Grossman and Hart [1986] to broaden and deepen the investigation begun by Coase [1937] into the boundaries of the firm.

[5]We use the term "incomplete" the way economists are accustomed (e.g., 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 clearly specified — that important terms like price, quantity, time of delivery and quality are not in the contract.

The literature on legal remedies for breach of contract predicts the reverse. Most notably, Shavell [1980] and Rogerson [1984] observe that the prevailing remedies for breach of contract 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 damage 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, e.g., Polinsky [1989, p. 37]).

Our paper integrates this intuition with that from 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 identified by Rogerson and Shavell 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 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"; then, unilateral breach is not possible, since either party can insist that the contract be performed according to its terms.

In our model, parties sign a fixed-price contract prior to investing. Subsequently, the parties will have an incentive to renegotiate the contract when information about the value of trade is revealed. The fixed-price contract and the governing breach

This distinction is brought out well in Ayres and Gertner [1992].

remedy together frame renegotiation, determining the surplus over which the parties bargain. We study a wide class of *monotonic* 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, often implying that no fixed-price contract is efficient. On the other hand, if the court will enforce specific performance, then both parties can be given efficient incentives when a separability condition obtains.

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

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

The contracted quantity can be chosen so that *on average* the investor's marginal return from investment is equal to the social marginal 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, though the efficient contract involves a lower quantity under expectation damages since the breach subsidy is larger.

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.[6] Others imagine, as we do, that the parties sign a fixed-price contract which may be renegotiated.[7] Papers in this second camp are linked by the feature that in equilibrium one party receives the entire renegotiation surplus. In contrast, we investigate the consequences of sharing this renegotiation surplus. As section 5 discusses, sharing can occur if the parties cannot commit to the renegotiation processes considered in Chung [1991] and Aghion, Dewatripont, and Rey [1990,1994]. Surplus sharing may also result if the parties follow a bargaining process different from those in Hart and Moore [1988], MacLeod and Malcomson [1993] or Nöldeke and Schmidt [1994].

The remainder of this paper is organized as follows. Section 2 presents the unilateral investment model. Section 3 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 4 demonstrates that for bilateral investment problems the

[6] Rogerson [1992], Green and Laffont [1992], Hermalin and Katz [1993], and Konakayama, Mitsui, and Watanabe [1986].

[7] Chung [1991], Aghion, Dewatripont, and Rey [1990, 1994], MacLeod and Malcomson [1993], Nöldeke and Schmidt [1992], and Hart and Moore [1988]. Hart and Moore [1988] is probably better known for its formalization of the underinvestment from Williamson's holdup problem (proposition 4), than for its efficiency result (proposition 3).

specific performance remedy provides better incentives than expectation damages. Section 5 provides a more detailed comparison with the literature and Section 6 makes concluding comments.

2. THE UNILATERAL INVESTMENT MODEL

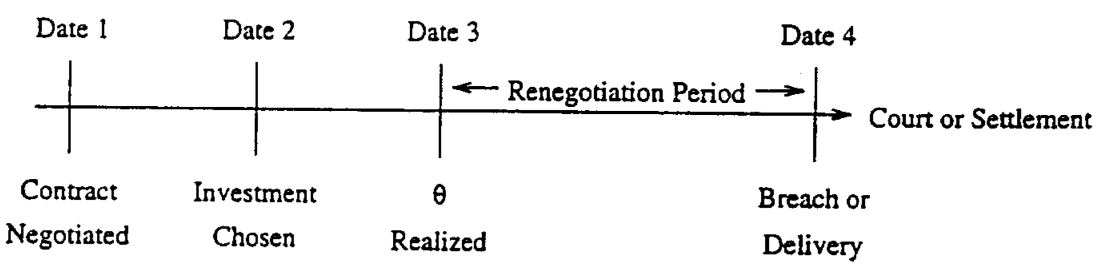
Our model has two risk-neutral parties who wish to trade some good. At date 1, they have the opportunity to write a fixed-price contract to exchange the good at date 4. Their main motive for the long-term contract is that the supplier, or seller, must decide at date 2 how much to invest in a relationship-specific asset that lowers the ex-post, or variable, 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 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 them 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 damage 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.
- $C(S, q, \theta)$: 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; the cross-partial derivative C_{qS} exists and satisfies $C_{qS} \leq 0$.

Time Line



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

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

Since the parties are risk-neutral, the socially optimal level of investment S^* solves the total surplus maximization problem, which we assume has a unique maximizer $S^* \in (0, S^{\max})$ given by

$$S^* = \underset{S \in [0, S^{\max}]}{\text{argmax}} \ Z(S), \quad \text{where} \quad Z(S) \equiv \int_{\Theta} (V(q^*, \theta) - C(S, q^*, \theta)) dF(\theta) - S$$

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, 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 may change 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 $\theta, S, \overline{q}$ and $\overline{p}$. 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 exogenous throughout the body of the paper, we examine several variants of an explicit renegotiation game in Appendix A. In these games, the bargaining process involves a sequence of alternating offers,

[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 costly or impossible (see, e.g. Barton [1972] or Goetz and Scott [1977]). For this sort of analysis, see also Hall and Lazear [1984].

much as in Rubinstein [1982] and Myerson [1991]. 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 $\frac{1}{2}$.

3. BALANCING HOLDUP TAX AGAINST BREACH SUBSIDY

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, the contract may itself specify a remedy. In a jurisdiction where parties can freely choose a remedy, the paper could be interpreted equally well 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.

3.1 Specific Performance

We analyze specific performance first because it is the remedy most familiar to economic theorists, even though it is commonly applied only 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 the party is already under such an order, can hold her in contempt of court.

[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.

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 [1984,50] ensures that suing is a credible threat because his contract price makes specific performance attractive to one party. It appears that 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, or sufficiently low so that the buyer will. Which they choose does not matter since, with a suitable up-front payment T, they may arbitrarily divide the ex-ante gains from trade. Specifically, for given $\bar{q}$, the parties may choose $\bar{p}$ so that

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

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:

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

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

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

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 $\overline{q}$ 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.

The 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, $\frac{dR^{\text{social}}}{dS}$ is given simply by $-C_S(S, q^*, \theta)$. This implies that the seller's marginal return to investment exceeds social returns by

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

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

$$\text{Breach Subsidy:} \quad \int_{\{\theta : q^* < \bar{q}\}} -(1-\gamma)[C_S(S, \bar{q}, \theta) - C_S(S, q^*, \theta)] dF. \tag{5}$$

This is the total amount by which the seller is overcompensated for her investment relative to the social return. The overcompensation leads us to call it a subsidy (just

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

why we call it a *breach* subsidy will become clearer under an expectation damage remedy). 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

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

Aggregating these contingencies together, we have what we term the holdup tax:

$$\text{Holdup Tax:} \qquad \int_{\{\theta | q^* > \bar{q}\}} -(1-\gamma)[C_S(S, q^*, \theta) - C_S(S, \bar{q}, \theta)]dF. \tag{7}$$

We call this quantity the "holdup tax" because it is the amount of the seller's return to marginal investment that the buyer takes (taxes) in the ex-post renegotiations. This tax naturally discourages the seller from investing.

FIGURE 1 – SPECIFIC PERFORMANCE

Figure 1 illustrates the holdup tax and breach subsidy under specific performance when the marginal cost of production is constant. In the breach region of low trade, if renegotiation were impossible, the benefits of production-cost savings from incremental investment would be captured by the seller-investor on all the contracted output. However, since renegotiation is possible, the seller — who gets a share γ of the renegotiation surplus — 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. It is important to observe that the holdup tax and breach subsidy are both continuous functions of $\bar{q}$.[11] Hence, the Intermediate Value Theorem ensures that a contract quantity $\bar{q}^{SP}$ exists such that the holdup tax equals the breach subsidy, where both tax and subsidy are evaluated at $S = S^*$. The first-order necessary conditions for a quantity $\bar{q}^{SP}$ to induce optimal investment S^* are that the holdup tax equals the breach subsidy at S^*:

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

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 such rules, each party's payoff is (weakly) increasing with the size of the surplus bargained over. In the context of our model, monotonicity requires that for any $\theta, \bar{q}, S$ and $\hat{S}$: $RS(S,\bar{q},\theta) > RS(\hat{S},\bar{q},\theta)$ implies

$$\begin{aligned} \gamma(S,\bar{q},\theta)\cdot RS(S,\bar{q},\theta) &\geq \gamma(\hat{S},\bar{q},\theta)\cdot RS(\hat{S},\bar{q},\theta) \\ (1-\gamma(S,\bar{q},\theta))\cdot RS(S,\bar{q},\theta) &\geq (1-\gamma(\hat{S},\bar{q},\theta))\cdot RS(\hat{S},\bar{q},\theta), \end{aligned} \tag{9}$$

where $RS(\cdot)$ is the renegotiation surplus defined in (3).

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 (6), minus the cost of the investment S. Hence, the seller's objective function at date 2 is to maximize:

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

[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.

Let

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

In the following proposition we will assume that:

(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 (A1) will be satisfied if $\bar{p}^{SP}(\cdot)$ is chosen to be some high 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. For 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: We show there exists a $\bar{q}^{SP}$ such that $\bar{S}(\bar{q}^{SP}) = S^*$. Since $Q^{\max}$ is the largest quantity the parties can trade, it suffices to show that

$$\bar{S}(0) \leq S^* \leq \bar{S}(Q^{\max}). \tag{11}$$

Given the continuity of $\bar{S}$, Assumption (A1) 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

[12] By Berge's Maximum Theorem, $\phi(\cdot)$ is upper-hemi-continuous, and hence, if $\phi(\cdot)$ is single valued it is a continuous function. In a related problem, Nöldeke and Schmidt [1994] derive sufficient conditions for the optimal investment level to be unique.

that

$$
\begin{aligned}
& M(S;0) - M(\hat{S};0) \\
= & \int [\gamma(S,0,\theta) \cdot RS(S,0,\theta) - \gamma(\hat{S},0,\theta) \cdot RS(\hat{S},0,\theta) - C(S,0,\theta) + C(\hat{S},0,\theta)]dF \\
\leq & \int [RS(S,0,\theta) - RS(\hat{S},0,\theta) - C(S,0,\theta) + C(\hat{S},0,\theta)]dF \\
= & \int [-C(S,q^*,\theta) + C(\hat{S},q^*,\theta)]dF \\
= & Z(S) - Z(\hat{S}). \qquad (12)
\end{aligned}
$$

The inequality follows from two observations. First, if $\overline{q} = 0$, then $RS(S,0,\theta) \geq RS(\hat{S},0,\theta)$ since $C_{Sq} \leq 0$. Second, the monotonicity of $\gamma(\cdot)$ implies that if $RS(S,\cdot) \geq RS(\hat{S},\cdot)$, then $(1-\gamma(S,\cdot)) \cdot RS(S,\cdot) \geq (1-\gamma(\hat{S},\cdot)) \cdot RS(\hat{S},\cdot)$.

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 of $S^* \leq \bar{S}(Q^{\max})$ 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.□

Proposition 1 implies that an efficient contract exists whenever the bargaining process follows an outside option principle (see Sutton [1986]). In MacLeod and Malcomson [1993] and Hart and Moore [1988], the price $\overline{p}$ 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 $\overline{q}^{SP}$ will depend on the sharing rule $\gamma(\cdot)$ and the function $\overline{p}^{SP}(\cdot)$. However, the quantity $\overline{q}^{SP}$ is invariant when $\gamma(\cdot)$ is a constant sharing rule (as derived in the Appendix for certain bargaining procedures). This property is suggested by equation (8) after dividing by $(1-\gamma)$. For a constant sharing rule we obtain the following result.

Proposition 2: *The same contractual quantity $\bar{q}^{SP}$ induces the seller to choose S^* for all values of γ under 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, even if the parties adopt different expectations of the subsequent division of ex-post surplus, the efficiency of the contract will be unaffected. Although they may disagree about the likely division of surplus, the parties will agree that the contract provides incentives for efficient investment.

3.2 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 it pays the damages given by the expectation formula. Expectation damages are calculated to make the injured party exactly as well off as if the contract were fully performed.

The analysis under a damage rule will in some circumstances differ depending upon whether the contract is viewed as "divisible" or "entire." We assume the court views the contract as divisible (perhaps because the contract so specifies). A divisible contract is legally equivalent to a large number of independent contracts for each of which the seller supplies one individual unit of the good and the buyer pays the same unit price.[13] Analyzing the breach of such a contract is particularly clean, so we focus on how the parties can write an efficient divisible contract. The formal analysis would be unchanged if we assumed instead 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. (Any costs incurred before the buyer can notify the seller should be included in the investment expenditure S.) The law recognizes these savings and so only entitles the seller to her *expectancy*.

If the seller continues to produce after being notified of the anticipated breach, the seller cannot recover her costs because she is obligated to *mitigate* damages.[14] The *expectation damage* formula requires that if the buyer breaches, he pays the seller an amount equal to the contract price, i.e., $\bar{p} \cdot \bar{q}$, less her cost savings from the avoided production. The resulting payment by the buyer becomes $\bar{p} \cdot \bar{q} - [C(S, \bar{q}, \theta) - C(S, q, \theta)]$.

[13] For discussion of divisible contracts, see Corbin [1960, §§694 - 699], or Farnsworth [1982, pp. 596 - 599]).

[14] See, e.g., *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."

Damages would be higher if the buyer breached later, refusing to accept full delivery at date 4 after the seller has incurred production costs $C(S, \bar{q}, \theta)$. Therefore, the buyer will notify the seller of any breach before unnecessary production 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 $C(S, \overline{q}, \theta) - C(S, q, \theta)$. Although this may be an optimistic view of courts, it lets us compare our results with previous authors, particularly Rogerson [1984] and Shavell [1980].

The seller can also breach the contract, but for her 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

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

Again, 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.

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 $\overline{q}$, the parties may choose $\overline{p}$ such that:

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

As before, let $\overline{p}^{ED}(\overline{q})$ denote a price the parties may choose to satisfy (1'), given a particular $\overline{q}$. 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 $\bar{p}^{ED}(\overline{q}) \cdot \bar{q} - C(S, \bar{q}, \theta)$. If she only produces $q < \bar{q}$, she receives $\bar{p}^{ED}(\overline{q}) \cdot q - C(S, q, \theta)$, and the buyer may sue for any damages he suffers from the breach. Even if the buyer does not sue, (1') implies that the seller's payoff is maximized at $\bar{p}^{ED}(\bar{q}) \cdot \bar{q} - C(\bar{q}, S, \theta)$. Thus, the seller will not want to breach the contract.

The Breach Subsidy: $q^*(\theta, S) < \bar{q}$

If efficient trade is low, as depicted by θ^2 in Figure 2, the buyer will not want to purchase all of $\bar{q}$. But, how much of his order will he cancel? Before the seller starts production, or at least before she produces more than q, the buyer will announce he will accept no more than some quantity q which solves

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

The amount $(\bar{p}^{ED}(\bar{q}) \cdot \bar{q} - C(S, \bar{q}, \theta))$ depends only upon the contract and 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 $q^*(\theta, S)$.[15] This is a well-known feature of the expectation damage remedy: one party will unilaterally breach a contract when breach is efficient, even when renegotiation is impossible (see Shavell [1980]). Since the efficient output can be reached unilaterally without renegotiating the contract, 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^*. In total, this just gives the seller the expectancy interest that the law protects:

$$\begin{aligned} R^{\text{seller}} &= \bar{p}^{ED}(\bar{q}) \cdot \bar{q} - C(S, \bar{q}, \theta) - (C(S, q^*, \theta) - C(S, q^*, \theta)) \\ &= \bar{p}^{ED}(\bar{q}) \cdot \bar{q} - C(S, \bar{q}, \theta). \end{aligned} \tag{14}$$

[15] 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 a].

Therefore, in a state θ where $q^* < \bar{q}$, 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:

$$\text{Breach subsidy:} \quad \int_{\{\theta:q^*<\bar{q}\}} -[C_S(S,\bar{q},\theta) - C_S(S,q^*,\theta)]dF. \tag{15}$$

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 first q^* 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 2.

[Figure 2]

Holdup Tax: $q^*(\theta, S) > \bar{q}$.

As before, we first consider a constant sharing rule γ to illustrate the holdup tax, though Proposition 3 below applies to any monotonic rule $\gamma(\cdot)$. When efficient trade q^* exceeds the contracted level of trade $\bar{q}$, the buyer won't breach, because expectation damages make it more profitable to buy $\bar{q}$, rather than any $q \leq \bar{q}$.[16] As before, the high unit price also makes it unattractive for the seller to breach. The seller and buyer split the value of the units to which they do not have contractual claims, i.e., the noncontracted units between $\bar{q}$ and q^*. The seller's ex-post return is

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

Like the situation under specific performance, the buyer is "holding up" the seller for

[16] A buyer contemplating breach solves:

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

Since it is efficient to trade $q^* > \bar{q}$ and since $V(q,\theta) - C(S,q,\theta)$ is concave in q, the buyer will fulfill the whole contract, buying $\bar{q}$.

a share $(1-\gamma)$ of the renegotiation surplus before agreeing to buy the extra units $q^{*}-\bar{q}$. Marginal social returns exceed the seller's returns by $-(1-\gamma)\ [C_S(S,q^{*},\theta)-C_S(S,\bar{q},\theta)]$. The total excess return becomes:

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

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

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

$$\tilde{R}^{\text{seller}}(S,\bar{q},\theta) \equiv \begin{cases} \bar{p}^{ED}(\bar{q})\cdot\bar{q}-C(S,\bar{q},\theta) & \text{if } q^{*}(S,\theta)\leq\bar{q} \\ \bar{p}^{ED}(\bar{q})\cdot\bar{q}-C(S,\bar{q},\theta)+\gamma(S,\bar{q},\theta)\cdot RS(S,\bar{q},\theta) & \text{if } q^{*}(S,\theta)>\bar{q}. \end{cases} \tag{19}$$

Let $\tilde{\phi}(\bar{q}) \equiv \underset{S\in[0,S^{\max}]}{\text{argmax}}\ \tilde{M}(S;\bar{q})$. 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 an expectation damage remedy. For 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 $\bar{q}=0$, i.e., $M(\cdot,0)\equiv\tilde{M}(\cdot,0)$. 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 $S>\hat{S}$,

$$\tilde{M}(S;Q^{max}) - \tilde{M}(\hat{S};Q^{max}) = \int[-C(S,Q^{max},\theta) + C(\hat{S},Q^{max},\theta)]dF$$
$$\geq \int[-C(S,q^{*},\theta) + C(\hat{S},q^{*},\theta)]dF = (Z(S) - Z(\hat{S}).\square$$

For the special case of a constant sharing rule, $\gamma(\cdot) = \gamma$, we observe that $\bar{q}^{ED}$ 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 $\tilde{M}_{Sq} > 0$. 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: For a constant sharing rule γ, $\bar{q}^{ED} < \bar{q}^{SP}$ *for* $\gamma > 0$, *and* $\bar{q}^{ED} = \bar{q}^{SP}$ *for* $\gamma = 0$.

Proof: Consider first $\gamma > 0$. Observe that $M_S(\cdot) < \tilde{M}_S(\cdot)$, and so a given $\bar{q}$ leads to weakly higher investment. Since $S^{*} \in (0, S^{\max})$, the seller would *strictly* overinvest under an expectation remedy with contract $\bar{q}^{SP}$ because if $M_S = 0$, then $\tilde{M}_S > 0$. The fact that $\bar{q}^{ED} < \bar{q}^{SP}$ follows by observing that $M_{Sq} > 0$ and so S is weakly increasing in $\bar{q}$. For $\gamma = 0$, $M(\cdot) \equiv \tilde{M}(\cdot)$, so $\bar{q}^{ED} = \bar{q}^{SP}$.$\square$

Finally, we note that the noncontingent contracts examined above are by no means unique. 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 [1993] 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.

4. BILATERAL INVESTMENT

This section extends our previous analysis to situations where the buyer can also make a relationship-specific investment to improve his valuation. At first glance, it may seem unlikely that the parties can find a contract giving them both efficient incentives at once, since they have only one contractual instrument, namely $\bar{q}$. We show below that for a particular class of problems, involving constant sharing rules, there is no fixed-price contract that provides efficient incentives for both parties, provided the breach remedy is expectation damages.

In contrast, we obtain a "possibility result" for the specific performance remedy given a separability condition for each party's valuation function, and given a constant surplus sharing rule. This result derives from the fact that 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.

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, and where $V(I,\cdot,\theta)$ is strictly concave in q. The unique efficient quantity to trade ex post becomes:

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

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 $[0, S^{\max}] \times [0, I^{\max}]$.

4.1 Expectation Damages

Unlike a specific performance remedy, the expectation damage 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. Below we show that even for a particular class of valuation functions, there will be no efficient fixed price contract when an expectation damage remedy is applied. We restrict attention to constant sharing rules where $\gamma(\cdot) \equiv \gamma$.

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 who winds up with the residual, receives exactly the social return to her investment at the margin — no breach subsidy. 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 for all contingencies q^* is 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 $q^* > \bar{q}$).

In Proposition 5, we consider the following cost and valuation functions:

(A2)
$$V(I,q,\theta) = V_1(I) \cdot q + V_2(q,\theta),$$
$$C(S,q,\theta) = C_1(S) \cdot q,$$

with $V_1'(\cdot) > 0$ and $C_1'(\cdot) < 0$, and show that no fixed-price contract provides both parties with efficient investment incentives under expectation damages.

Proposition 5: *Suppose the parties expect the court to impose expectation damages, and the valuation functions satisfy (A2). For any $\gamma \in (0,1)$, there does not exist a 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 to bilateral investment problems.

4.2 Specific Performance

When specific performance is granted it may be possible to simultaneously balance the holdup tax and breach subsidy for both parties at once. In fact it is possible whenever both the marginal valuation and marginal cost function are additively separable and the sharing rule is constant. This class is somewhat wider than that considered in Proposition 5. We require the following separability condition, which replaces (A1):

$$\text{(A3)} \qquad \begin{aligned} V(I,q,\theta) &= V_1(I)\cdot q + V_2(q,\theta), \\ C(S,q,\theta) &= C_1(S)\cdot q + C_2(q,\theta), \end{aligned}$$

with $V_1'(\cdot) > 0$ and $C_1'(\cdot) < 0$. (A3) ensures that the cross–partial derivatives V_{Iq} and C_{Sq} are independent of q and θ. Condition (A3) would hold for instance if the investment of extra capital saved some given amount of labor in the production of each unit, and if the wage rate is constant. 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" valuation functions, since joint second–order Taylor expansions satisfy (A3). In that sense, the following result provides an approximate solution to the bilateral investment problem.

Proposition 6: *Suppose the parties expect the courts to impose specific performance, and the valuation functions satisfy (A3). If the parties choose a contract* $(\bar{q}^{SP}, \bar{p}^{SP}(\bar{q}^{SP}), T)$, *where*

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

then the first-best investment levels S^* *and* I^* *form a Nash equilibrium at date 2 for any* $\gamma \in [0,1]$.

Proof: Because $\bar{p}^{SP}(\bar{q}^{SP})$ 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

$$RS(S, I^*, \bar{q}, \theta) \equiv V(I^*, q^*, \theta) - C(S, q^*, \theta) - [V(I^*, \bar{q}, \theta) - C(S, \bar{q}, \theta)] \tag{20}$$

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

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

Because of (A3), this expression simplifies to:

$$-C_1'(S) \cdot [(1-\gamma)\bar{q} + \gamma \cdot \int q^*(S, I^*, \theta)dF] - 1 \tag{21}$$

Since S^* and I^* maximize $Z(S, I)$, it follows that

$$Z_S(S^*, I^*) = 0 = -C_1'(S^*) \cdot \int q^*(S^*, I^*, \theta)dF - 1.$$

If $\bar{q}$ is chosen equal to $\bar{q}^{SP} = \int q^{*}(S^{*}, I^{*}, \theta)dF$, expression (21) will be zero at $S = S^{*}$. To show that S^{*} is indeed the global maximizer of $M(\cdot, I^{*}; \bar{q}^{SP})$, we note that the derivative $M_S(S, I^{*}; \bar{q}^{SP})$ 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 increasing in S, which in turn follows since $C_{Sq} \leq 0$.) For any $S < S^{*}$ we thus find that

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

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

With additive separability of marginal cost and valuation, 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. By setting $\bar{q}$ equal to the expected trading quantity following efficient investments, the parties can align both of their incentives at once.

5. 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; instead one party always receives the entire surplus in equilibrium. Hart and Moore [1988], MacLeod and Malcomson [1993] and Nöldeke and Schmidt [1994] assume that the parties follow a bargaining procedure with an outcome given by some variant of the

ensured that one party's outside option 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.[17] Our work is also motivated by the concern that courts frequently will not enforce high penalties, and instead resort to standard legal remedies such as specific performance or expectation damage.

Chung [1991] and Aghion, Dewatripont, and Rey [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.[18] 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, 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, i.e., might enforce the "game over" instructions of the mechanism, there is a knife-edge character to no-sharing results. A buyer would accept a take-it-or-leave-it 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.[19] It would be "safer"

[17] Consider,e.g., Stole and Zwiebel [1993].

[18] Aghion, Dewatripont, and Rey [1994] also 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.

[19] Even then, Rabin's [1993] fairness arguments together with experimental evidence would suggest

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, i.e., $q \in \{0, 1\}$. 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, i.e., $\bar{q} = 1$, 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 ex post it is only efficient 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 $\bar{q} = 0$. 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 contingencies where $\bar{q} = 1$ be equal to $\bar{q}^{SP}$ or $\overline{q}^{ED}$. The contract could hinge on any verifiable event with appropriate probability.

6. CONCLUSION

We have examined simple noncontingent contracts enforced under two legal regimes: expectation damages and specific performance. We explained how balancing a breach subsidy against a holdup tax will provide efficient investment incentives with simple contracts, and without renegotiation design. Under specific performance, the breach subsidy and holdup tax both grow proportionately with an investor's bargaining power. The optimal quantity is therefore independent of expected bargaining

a rejection.

power. The optimal quantity is merely an unbiased estimate of efficient trade under our separability condition. Therefore, such a quantity provides efficient incentives in bilateral investment problems as well.

In one investor problems, we found that expectation damages requires that a more conservative (lower) estimate of trade be put into the contract. This is because the breach subsidy is larger under expectation damages than under specific performance. We also found that expectation damages is poorly suited to solving bilateral investment problems.

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

One plausible test that courts might use to decide whether to grant specific performance would be to ask if the victim of breach reasonably relied upon the contract. If the victim of breach made important reliance decisions with value–enhancing consequences, then the investment problem was bilateral. This suggests that damages would be an "inadequate" remedy—inadequate to provide a similarly situated plaintiff with efficient ex-ante investment incentives. Our analysis supports recent trends to grant specific performance in more commercial contexts.

Finally, we note that our results have implications for the theory of the firm, in particular for the theory of vertical integration. Given our prediction of investment inefficiencies when both parties make investments and the breach remedy is expectation damages, it would be natural to make the two parties divisions of a firm. To facilitate trade between the divisions, 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 showing that negotiated transfer pricing is commonly used by multidivisional firms to account for intracompany transfers.[20] Furthermore, 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.[21]

APPENDIX A

In this appendix, we describe bargaining games that the parties may play after date 3 when the state θ becomes known. We do so first for specific performance and then for expectation damages. The analysis applies both to one- and two-sided investment problems since investments are sunk at date 3.

Specific Performance

Suppose the date 1 contract calls for delivery of the $\bar{q}$ units at date 4, whereupon the buyer has to pay $\bar{p} \cdot \bar{q}$. If the seller fails to deliver the $\bar{q}$ units, the buyer may go to court (immediately) and obtain a court order compelling the seller to fulfill her obligation. Once she has delivered $\bar{q}$ units, the seller can sue the buyer for payment.

We consider three variants of an iterative bargaining process. The first would suffice if we imagine that the parties commit to play these games. On the other hand, if we view them as loosely descriptive of bargaining when no commitments have been made, the second and third are increasingly realistic.

In the first (and 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 previous date 1

[20] See the survey by Price Waterhouse [1984].

[21] These issues are considered in Edlin and Reichelstein [1994 b].

contract. The other party can either accept or reject this offer. Rejection means that bargaining moves to the next round, while acceptance terminates the negotiations. We assume that any new contract also calls for delivery at date 4.

We suppose that the parties take turns in making offers, and, for concreteness, that N is odd and the seller makes the first and last offers. Instead of discounting later agreements as Rubinstein [1982] does, we follow Myerson [1991, Section 8.7] and introduce a small but positive probability, ϵ, that the bargaining process terminates whenever an offer is rejected. This chance of breakdown may reflect a number of factors, including the possibility that one party is irritated by the other's refusal. Alternatively, 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 $\overline{p} \cdot \bar{q}$ and she could sue for the buyer's performance (payment) if the buyer does not pay. The inequality in (1) ensures that the date 1 contract is more profitable than no trade. The seller may equivalently not perform if she anticipates being sued by the buyer. Because of the specific performance remedy, the resulting outcome will be the same.

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 $RS(S, \overline{q}, \theta)$,as defined in (2).[22] The seller is indifferent between accepting this offer and facing an ϵ probability of

[22] For bilateral investment problems, the renegotiation surplus would be $RS(S, I, \bar{q}, \theta)$, as defined in (20).

negotiation breakdown, so $W_b(N-1) = \epsilon$. We find that in any even-numbered round $2\tilde{N}$, where $1 \leq \tilde{N} \leq (N-1)/2$, the surplus attainable by the buyer is:

$$W_b(2\tilde{N}) = \epsilon + W_b(2\tilde{N}+1) \cdot (1-\epsilon), \tag{i}$$

while in odd-numbered rounds

$$W_b(2\tilde{N}-1) = (1-\epsilon) \cdot W_b(2\tilde{N}). \tag{ii}$$

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

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

The sharing parameter γ equals $1 - W_b(1)$, which measures the seller's share of the renegotiation surplus. For any given (small) ϵ, $W_b(1)$ tends to $\frac{1-\epsilon}{2-\epsilon}$ as N gets large. Note that $1 - W_b(1)$ is therefore slightly larger than .5 for all ϵ and N, which reflects the seller's advantage from making the first and last offer.

One could argue that the preceding bargaining game is unduly restrictive since there is no further negotiation after date 4. In Edlin and Reichelstein [1994 a], 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 $\overline{p}$, the seller's share of the renegotiation surplus is $\gamma = 1 - W_b(1)$ if $q^* < \overline{q}$, and $\tilde{\gamma} = 1 - \frac{1-\epsilon}{2-\epsilon}$ if $q^* > \overline{q}$. The sharing rule approaches a constant sharing rule as $N \to \infty$.

It could be argued that 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 contractual rights. The third variant of our game adds date 5 to represent the time by which the seller must deliver before her breach becomes material, discharging the buyer's obligations.

If the seller does not deliver by date 4, she is in breach and the buyer can sue for specific performance. (The point of the breach not yet being material is that if the buyer delivered somewhat late, he could still sue for payment.) We envision that if the seller did not deliver at date 4 and the buyer sued, the court would decree something like the following: "Deliver by date 5 or you will be in contempt of court, *unless the two of you agree to a better arrangement.*" Thus, nothing stops the parties from going to court to establish a status–quo point and then bargaining to a Pareto superior outcome. Just as in the scenarios described above, the parties would be bargaining over a renegotiation surplus defined by performing the contract, i.e., over $RS(S,\overline{q},\theta)$. The results thus accord with those above.

Expectation Damages

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

We describe here how the buyer and seller come to trade q^* when $q^* > \overline{q}$, and when courts apply the expectation damage 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 involved, the remaining bargaining game is standard. Regardless of whether discounting or the possibility of breakdown drives the parties to settle on the efficient trade and some division of surplus, there is a unique subgame perfect equilibrium to this subgame. Let γ denote the seller's share of RS that results from this equilibrium.

We claim that the unique equilibrium involves neither party breaching and the two parties then splitting RS with the following payoffs: The parties' payoffs are:

$$\text{Buyer's payoff} = V(\overline{q},\theta) - \overline{p}\cdot\overline{q} + (1-\gamma)\cdot RS(S,\overline{q},\theta) \qquad (iv)$$

$$\text{Seller's payoff} = \overline{p}\cdot\overline{q} - C(S,\overline{q},\theta) + \gamma\cdot RS(S,\overline{q},\theta) \qquad (v)$$

To see that the seller will perform if the buyer does not breach, suppose the seller delivers some quantity $q < \overline{q}$. 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 $V(\overline{q},\theta) - \overline{p}\cdot\overline{q}$. After renegotiation, the buyer's payoff will be at least the amount in (iv). Since for $q < \overline{q} < q^*$, $RS(S,q,\theta) > RS(S,\overline{q},\theta)$ the buyer's payoff would be larger in the proposed equilibrium (this would be true for any monotonic sharing rule). Since renegotiation is a zero-sum game, 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 $q < \overline{q}$, 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 will have increased the seller's payoff and thereby decreased his own. This verifies the claim above.

APPENDIX B

Proof of Proposition 5:

Case I: $\bar{p} \geq C_1(S^*)$

As argued in Section 3, the seller will never find it profitable to breach the contract in this case. Furthermore, the analysis in Proposition 3 shows that in order for the seller to have an incentive to invest S^* (assuming the buyer invests I^*), the quantity $\bar{q}^{\text{ED}}$ has to be such that for some contingencies θ, $\bar{q}^{\text{ED}} < q^*(S^*, I^*, \theta)$, while for others $\bar{q}^{\text{ED}} > q^*(S^*, I^*, \theta)$. 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 payoff becomes:

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

and

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

with $RS(S^*, I, \bar{q}, \theta)$ as defined in (20). Taking the derivative of the buyer's expected payoff with respect to I, we obtain

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

Since I^* is optimal

$$\int V_1'(I^*) q^* dF = 1. \qquad (iii)$$

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

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

This is equivalent to:

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

implying that $\{\theta | q^* > \bar{q}\}$ must have probability zero when $\gamma \neq 0$. This establishes the desired contradiction.

Case II: $\bar{p} < C_1(S^*)$

When $\bar{p} < C_1(S^*)$, the situation is reversed. Given that 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:

$$\begin{aligned} R^{\text{buyer}} &\equiv V(\bar{q}, I^*, \theta) - \bar{p} \cdot \bar{q} + (1-\gamma) \cdot RS(S^*, I^*, \bar{q}, \theta) \\ R^{\text{seller}} &\equiv \bar{p} \cdot \bar{q} - C(\bar{q}, S^*, \theta) + \gamma \cdot RS(S^*, I^*, \bar{q}, \theta). \end{aligned}$$

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 only to buy $q^b < \bar{q}$. What will the seller do? The seller may contemplate bringing a court action for the buyer's breach on $\bar{q} - q^b$, but this would be senseless because the seller has no damages given the low price $\bar{p} < C_1(S^*)$. 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 concaving.

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 $q^* < \bar{q}$, 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 $C_1'(S^*)[\bar{q} + \gamma(q^* - \bar{q})]$. (Absent negotiations, the buyer would not breach and the seller would deliver $\bar{q}$.) Therefore, for $\gamma \in (0, 1)$, the parties must choose $\bar{q}$ so that $q^*(S^*, I^*, \theta) < \bar{q}$ 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 $V(q^b, I, \theta) - \bar{p} \cdot q^b$, as shown above. The buyer's marginal return to investment at I^* becomes

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

Since $q^*(S^*, I^*, \theta) < q^b$, 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 incentive. □

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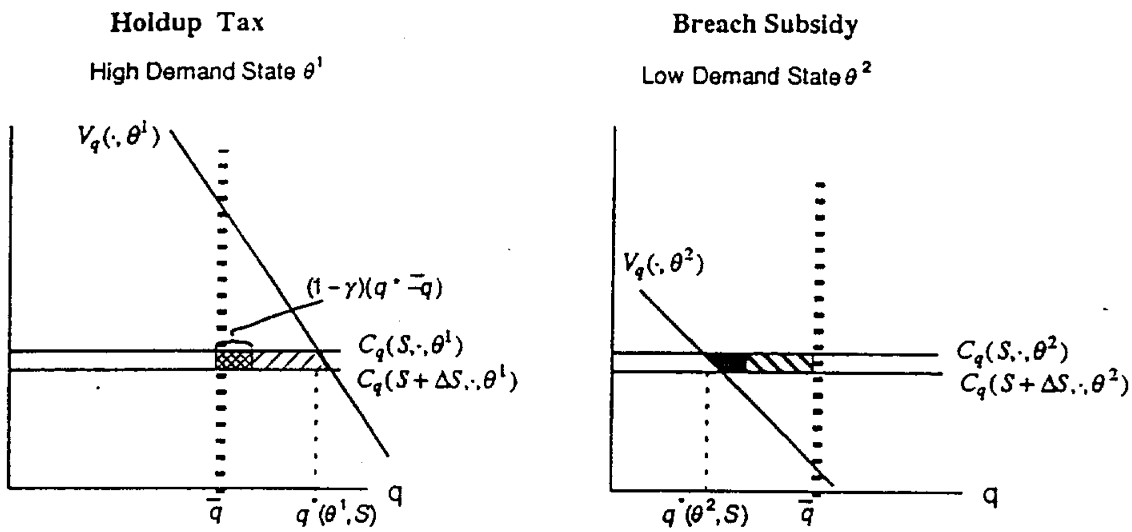
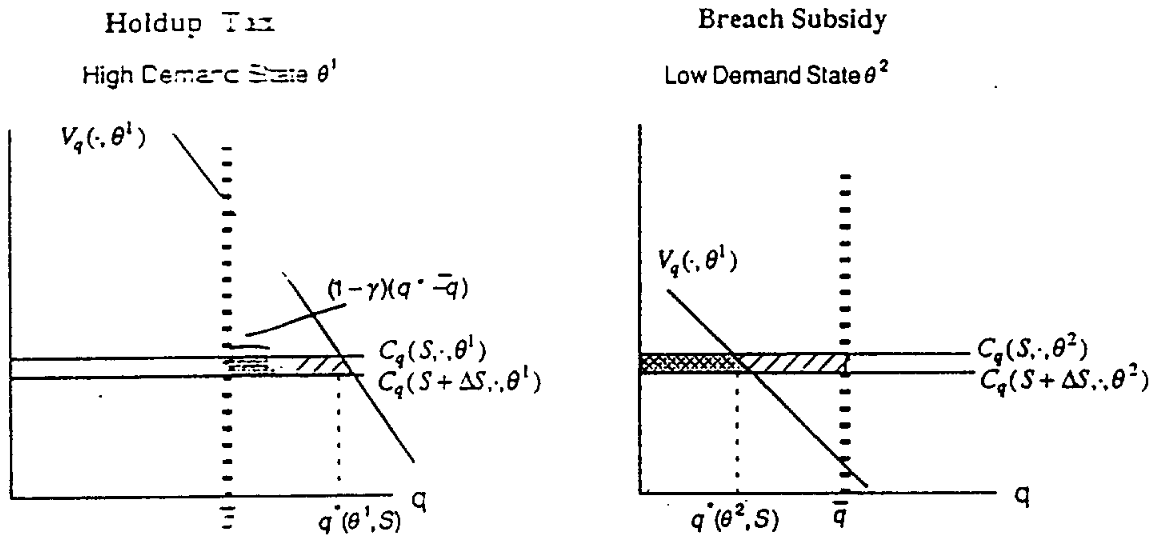
Figure 1



Difference between seller's investment return and social return in the linear cost case.

High Demand State θ^1		
	$(\Delta S)[q^* - \bar{q}]C_q$	Contribution of ΔS to surplus gained from renegotiation
	$(1-\gamma)(\Delta S)[q^* - \bar{q}]C_q$	Holdup tax on investment ΔS (share of added surplus accruing to buyer)
Low Demand State θ^2		
	$(\Delta S)[\bar{q} - q^*]C_q$	Reduction in surplus gained from renegotiation caused by investment ΔS
	$(1-\gamma)(\Delta S)[\bar{q} - q^*]C_q$	Breach subsidy to investment ΔS (share of reduction borne by buyer and not seller)

Figure 2



Difference between seller's investment return and social return in the linear cost case.

Low Demand State θ^2	
$(\Delta S)\bar{q}C_q$	Seller's return to investment ΔS because of contract $\bar{q}$
$(\Delta S)[\bar{q}-q^*]C_q$	Breach subsidy to investment ΔS (seller's return in excess of social returns)
High Demand State θ^1	
$(\Delta S)[q^*-\bar{q}]C_q$	Contribution of ΔS to surplus gained from renegotiation
$(1-\gamma)(\Delta S)[q^*-\bar{q}]C_q$	Holdup tax on investment ΔS (share of added surplus accruing to buyer)