Renegotiation and the efficiency of investments

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In a long-term relationship between two parties, one party’s threat of a unilateral violation of an initial contract may induce a renegotiation of the contract. As a renegotiation may result in one party capturing some of the return from the other’s investments, this possibility may lead to underinvestment. I show that if there is uncertainty associated with the outcome of a renegotiation, and if players are risk averse, there will be an interval for the initial contract so that it is not renegotiated. By an appropriate choice of the initial contract, underinvestment can thus be avoided.

1. Introduction

- When two or more agents cooperate to create an economic surplus, it is difficult to ensure that they are faced with the appropriate incentives. Agents maximize their own individual payoff, but this may not involve maximization of the joint surplus. This idea has been discussed in various settings in a large number of articles. Williamson (1979) and Klein, Crawford, and Alchian (1978) consider investments in relation-specific assets in an incomplete-contracts framework. After the investments are undertaken, opportunistic behavior of one party may induce a renegotiation of the initial contract involving a sharing of the joint surplus. The risk of a surplus-sharing renegotiation will lead to underinvestment, as the agents do not reap the full marginal return of their investments. In the literature, this phenomenon is often referred to as a holdup problem.

In recent years a considerable literature has explored various ways to overcome the holdup problem. Different suggestions have been made, depending on the assumptions made about the economic situation that is considered. The present article considers the same economic situation as that of Grout (1984) and MacLeod and Malcomson (1993). Two parties trade over a flow of goods. Both players make relation-specific self-investments, i.e., investments that affect a player’s own gains from trade but with no direct externalities on the gains of trade for other players. There is an initial contract, which prevails unless it is renegotiated by mutual consent. Yet either player may unilaterally violate the contract by disrupting trade as a means of persuading the other party to accept a renegotiation (Grout considered union bargaining, assuming that only the firm invests, while only the union might disrupt trade; other possible interpretations

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are provided below). The possibility that a renegotiation results in a sharing of the surplus induces players to invest less than optimally. As emphasised by Grout and MacLeod and Malcomson, in this setting the players set investments efficiently if they are certain that there will be no renegotiation (in other settings, renegotiation need not be a hindrance to efficiency).

In the present article I draw attention to a novel aspect that may prevent a renegotiation and thus ensure efficient investments. I consider a situation where there is ex ante uncertainty about the outcome of a possible renegotiation, due to stochastic disagreement points in the renegotiation, and where players are risk averse. Under risk aversion, it is well known that the expected utility from trade is less than the utility from trade with the expected price. Consequently, undertaking the risky action of violating the initial contract, thus inducing a renegotiation, involves a reduction in the total expected utility of the players.

To explain the effects on the possibility of a renegotiation, it is easier to first consider the same model without ex ante uncertainty as to the renegotiation outcome. Both parties may threaten not to trade, as a means of renegotiating the initial contract. If either player disrupts trade, there is a renegotiation with the outcome given by the Nash bargaining solution, where the no-trade payoffs are the disagreement points. It turns out that the initial contract is always renegotiated, as one of the players will always credibly threaten not to trade. If the Nash bargaining outcome is above the price of the initial contract, the seller will threaten to stop trade; if it is below the initial price, the buyer will threaten to stop trade.

However, the combination of uncertain renegotiation outcome and risk aversion changes this. It creates an interval for the initial contract, so that if the initial price is within this interval, threats of disrupting trade will not be credible and there will be no renegotiation. If the initial contract is outside the interval, the disadvantaged player will credibly threaten to disrupt trade, and the price will be renegotiated to the nearest endpoint of the interval.¹

To ensure efficiency the players must thus try to set the initial price so that it falls within the interval where it is not renegotiated. If the future gains from trade are fairly foreseeable, even a simple contract saying that if trade takes place, the price is \( x \) dollars, may in fact lead to efficient investments. This result is in the spirit of MacLeod and Malcomson (1993), but the criterion for which circumstances will lead to efficient investments is very different from theirs.

There are two possible interpretations of my assumption that either player may unilaterally violate the contract as a means of inducing a renegotiation. One interpretation, following Hart and Moore (1988) and MacLeod and Malcomson (1993), is that in case no trade takes place, a court cannot verify why (i.e., which party chose not to trade). Thus, if one party violates the contract by disrupting trade, the other party cannot verify this for a court and is thus unable to sue for damages or demand a specific performance. This may be a plausible assumption in an employment setting; as argued by Malcomson (1997), it may not in practice be easy to verify whether an employee chose to stay away from work or was turned away by the employer.

An alternative interpretation is that it may well be verifiable which party chose not to trade, but the courts will not enforce any penalty provisions. This is the motivation of Grout (1984); the Trade Union Immunity Laws in the United Kingdom prevent an employer from suing a trade union to recover any losses during an industrial dispute, even if the dispute violates a previous agreement. This interpretation is also

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¹ The feature that there is an interval for the initial contract where it is not renegotiated was derived in Holden (1994a), based on an assumption of fixed costs of a disruption of trade and no risk aversion.
of some relevance for renewals of wage contracts. First, investments often have a return that lasts over several wage contract periods. Second, although the contract may be of limited duration, it need not be irrelevant for the following contract period. In many countries, labor market regulations or agreements between the social partners state that the conditions of the expired contract prevail until the contract is renegotiated by mutual consent. (This is the case in Austria, France, Norway, Spain, and Sweden; see the country chapters in Blanpain (1985). Even in the United States, a related but weaker feature exists; the employer is bound by law to observe the old union contract until a bargaining impasse is reached; see Gold (1989).) Yet the parties may threaten to disrupt trade (strike or lockout) as a means of obtaining a favorable new agreement, thus obtaining a share of the return from the other party’s investment. The prediction of my model, that there exists an interval where the contract is not renegotiated, may thus explain the empirical regularity that contract renewals are often bunched at zero, i.e., at constant money wages (Jacoby and Mitchell, 1990).

The assumption that either player may unilaterally violate the contract is in contrast to the assumption of Chung (1991) and Aghion, Dewatripont, and Rey (1994) that courts can enforce a level of trade that is specified in the contract (“specific performance contracts”; see also Nöldeke and Schmidt (1995)). Under specific performance contracts, renegotiation is not necessarily inconsistent with the efficiency of investments.

The importance of uncertainty as to the renegotiation outcome is emphasized in the literature on private information bargaining (see the survey in Kennan and Wilson (1993)). However, this literature aims at explaining strikes, while the feature that uncertainty may prevent renegotiation has not, as far as I know, been explored before. To keep the exposition simple, and consistent with a common assumption in the holdup literature, I assume that there is symmetric information, so that there is no scope for signalling or screening in the renegotiation process.

The idea that uncertainty as to the renegotiation outcome may prevent a renegotiation has a counterpart in the literature on the effect of arbitration schemes on bargaining behavior. As discussed by Farber and Katz (1979), an increase in the uncertainty as to the decision of an arbitrator may raise the likelihood that the negotiators reach an agreement without arbitration, if negotiators are risk averse.

The article is organized as follows. Section 2 presents the basic model and the analysis of the renegotiation game. Section 3 discusses the efficiency of investments. Section 4 concludes. All proofs are in the Appendix.

2. The model

- The formal model is designed to capture some of the essential parts of long-term relationships. First, the parties may undertake investments that only affect their own gain from trade (self-investments). If the good is labor, the firm (the buyer) may invest in capital equipment that increases productivity but has negligible impact on the utility of the employee. The employee (the seller) may incur costs by relocating closer to his workplace to save travel costs. Second, at the time of investment there is uncertainty about each party’s future gains from trade. Third, the parties may disrupt trade (a strike or lockout) as a means of enforcing a renegotiation of the initial contract. In the real world, players may also enforce a renegotiation by threatening to leave the partner permanently (the outside-options alternative). As shown by Hart and Moore (1988) and MacLeod and Malcolmson (1993), this possibility may also involve holdup inefficiency. If included in the present article, however, outside options yield standard results (as in,
e.g., MacLeod and Malcomson (1993)) without affecting my novel results. To make the exposition shorter and more transparent, I thus neglect outside options.

The issue of interest is how the parties should design the initial contract so that it ensures investments are chosen optimally. As noted in the Introduction, in the present setting efficiency of investments essentially requires that the initial contract not be renegotiated. This is difficult, however, due to a specific feature of the situation I consider that has been previously adopted by, among others, Hart and Moore (1988) and MacLeod and Malcomson (1993), namely that courts can only verify whether or not trade has occurred, not which party was responsible for any breakdown of trade. As observed in the Introduction, Grout’s (1984) assumption that one party may violate the contract without subsequent penalty provisions has the same implications in this setting.\footnotemark[2]\footnotemark[3]

The timing of events in the formal model is as follows. At stage 0, a buyer $b$ and a seller $s$ negotiate the price $p^0$ over the supply of a flow of a good. At stage I, each agent chooses a level of investment, $i^b \geq 0$ for the buyer and $i^s \geq 0$ for the seller. At stage II, there is realization of a random variable $\theta \in \Theta$, which determines the value of trade between the two parties. Stages 0, I, and II take place within negligible time, while stage III has an infinite horizon. At stage III, trade may take place, and the parties may also renegotiate the initial contract. Either party may unilaterally choose not to trade, and potentially a disruption of trade may last forever, so that no trade ever takes place. Figure 1 shows the timing of events.

The state in stage III is defined by $\sigma = (i^b, i^s, \theta) \in \Sigma$, where $\Sigma$ denotes the set of states. If trade takes place, the flow payoffs to the buyer and the seller in monetary terms are $u^b(i^b, \theta) - p - i^b$ and $u^s(i^s, \theta) + p - i^s$, respectively, where $p$ is the prevailing contract (equal to $p^0$ unless both parties have agreed upon a new contract); for simplicity the investments are measured so that their flow cost is unity. It is assumed that $u^b > 0$ and $u^s < 0$. Furthermore, $u^b$ and $u^s$ are bounded, differentiable, and strictly concave in $i^b$ and $i^s$, respectively, where $\partial u^b(0, \theta)/\partial i^b > 1$ and $\partial u^s(0, \theta)/\partial i^s > 1$ (so that for both players, the efficient level of investment is strictly positive). Both players are risk averse, so that their utility is a monotone strictly concave transformation of the payoff in monetary terms, i.e., that $U^b = U(u^b - p - i^b)$ and $U^s = U(u^s + p - i^s)$, where the first and second derivatives satisfy $U' > 0$ and $U'' < 0$. The parties’ monetary payoffs during a possible disruption of trade are functions of a stochastic variable $\alpha \in A$, $b(\alpha) - i^b$ for the buyer and $s(\alpha) - i^s$ for the seller. $\alpha$ is unknown before trade is disrupted (but with a commonly known distribution), but it is realized as soon as trade is disrupted.\footnotemark[4] In a wage-bargaining context, $\alpha$ may for instance be an indicator for the individual workers’ support for the strike. Alternatively, $\alpha$ may reflect whether

\footnotetext[2]{A potentially important difference between the two alternative interpretations is that the former allows for breach payments as long as they do not depend on which player violates the contract (as this is not verifiable), while in the latter breach payments are not enforceable. However, within this model breach payments that are independent of which player violates the contract would not affect the main result; see also MacLeod and Malcomson (1993).}

\footnotetext[3]{Grout refers to his model as one with nonbinding contract, not using the vocabulary of a literature that has evolved after his article was published. However, a more specific description, in accordance with U.K. laws, would be the one in the main text; trade will not be enforced by a court (due to trade union immunity laws), but if trade takes place, a court will enforce the payment specified in the contract. Moreover, a contract prevails until it is renegotiated by mutual consent.}

\footnotetext[4]{It is assumed that for all $\alpha \in A$, there exists a $p$ such that

$$U(u^b - p - i^b) + U(u^s + p - i^s) > U(b(\alpha) - i^b) + U(s(\alpha) - i^s),$$

which ensures that the players always reach an agreement in a renegotiation.
the firm loses customers to its competitors during a strike or the customers just postpone their purchases.

The crucial issue of the analysis is the modelling of a possible disruption of trade. To obtain a satisfactory analysis of this aspect, the model must be designed so that it gives an adequate representation of the strategic considerations of the players (see Rubinstein, 1991). It seems reasonable that if a player is not satisfied with the initial contract, he will consider a disruption of trade so as to enforce a renegotiation. However, a threat of disrupting trade will only be credible if the player actually would benefit from carrying it out, that is, the player must obtain a higher payoff from disrupting trade, thus enforcing a new agreement, than by trading under the initial contract. If the player obtains higher payoff by trading under the initial contract, a threat of disrupting trade will not be credible, so it will not induce a renegotiation of the contract. To capture these considerations, the model must be designed so that a player is only allowed to disrupt trade after having rejected an offer by the opponent. 5

The formal specification of stage III is as follows (see Figure 2). First, the buyer makes an offer (denoted $p^b$) which the seller may accept or reject. Acceptance ends the renegotiation process, and trade takes place under the new contract. If the seller rejects the offer, he then decides whether he will disrupt trade to enforce a renegotiation. If he decides to disrupt trade, a renegotiation process takes place, possibly leading to trade under a new contract. If the seller decides to trade, he has the opportunity to offer a new contract (denoted $p^s$), which the buyer may accept or reject. Acceptance ends the renegotiation process, and trade takes place under the new contract. If the offer is rejected, the buyer decides whether he will disrupt trade, inducing a renegotiation, or trade under the initial contract. 6

Consider first the subgame that takes place if one of the players has chosen not to trade under the initial contract. $\alpha$ is immediately realized, so there is complete information. I assume that this leads to an immediate agreement on a new contract, given by the Nash bargaining solution.

$$p(\alpha, \sigma) = \arg \max [U(u^b - p - i^b) - U(b(\alpha) - i^b)][U(u^s + p - i^s) - U(s(\alpha) - i^s)].$$ (1)

Note that the disagreement points are set equal to the players' flow utilities during a delay in reaching an agreement. This follows Binmore, Rubinstein, and Wolinsky

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5 The same considerations lie behind the outside option principle of Binmore, Shaked, and Sutton (1989). An intuitive explanation of this feature is that when a player is about to leave the negotiating room to disrupt trade (e.g., to give orders to initiate a strike), the opponent will have time to give a counteroffer (see the discussion in Shaked, 1994).

6 Note that although the game is not symmetric, the outcome will be symmetric in the sense that if the positions of the buyer and seller are reversed, the outcome will not be altered.
(1986), based on an interpretation of the Nash bargaining solution as the subgame-perfect equilibrium (SPE) outcome of the limit case of the Rubinstein (1982) perfect-information, alternating-offers model, where the period length converges to zero. There is a unique price that solves (1), given by the first-order condition

\[
\phi(p; \alpha, \sigma) \equiv -U'(u^b - p - i^b)[U(u^t + p - i^t) - U(s(\alpha) - i^t)] \\
+ U'(u^t + p - i^t)[U(u^b - p - i^b) - U(b(\alpha) - i^b)] = 0, \quad (2)
\]

where the second-order condition

\[
\frac{\partial \phi}{\partial p} < 0 \quad (3)
\]

is fulfilled by the concavity of \(U\). Let \(p^{e}(\sigma) = E_a[p(\alpha, \sigma)]\) denote the expected outcome of the bargaining conditional on \(\sigma\).

Consider now the buyer’s choice of whether to refuse to trade under the initial contract, thus disrupting trade. If he refuses to trade under the initial contract, there will be a renegotiation, with the outcome depending on the realization of \(\alpha\). The expected utility of the buyer is \(E_a[U(u^b - p(\alpha, \sigma) - i^b)]\). On the other hand, if there is trade under the initial contract, the buyer obtains utility \(U(u^b - p^0 - i^b)\). The buyer will refuse to trade under the initial contract only if this gives him higher expected utility than trade under the initial agreement. There exists a critical value for the initial price, denoted \(p_{b0}\), which makes the buyer indifferent between the two alternatives. \(p_{b0}(\sigma)\) is defined by the equation

\[
E_a[U(u^b - p(\alpha, \sigma) - i^b)] = U(u^b - p_{b0}(\sigma) - i^b). \quad (4)
\]

That is, \(p_{b0}\) is the highest initial price that the buyer would agree to pay rather than disrupt trade. Because of the concavity of \(U(\cdot)\), the expected utility of the buyer in case of a renegotiation will be lower than his utility if trade were to take place under the expected outcome of a renegotiation, that is, \(E_a[U(u^b - p(\alpha, \sigma) - i^b)] < U(u^b - p^{e}(\sigma) - i^b)\). This implies that \(p_{b0}(\sigma) > p^{e}(\sigma)\) for all \(\sigma \in \Sigma\). To use a well-known vocabulary, \(p_{b0}\) is the
certainty equivalent to the risky project of disrupting trade, while \( p^{ba} - p^E \) is the risk premium. Under standard assumptions, the more risk averse the buyer, the greater the risk premium. Furthermore, the more uncertainty associated with the outcome of the renegotiation, the greater the risk premium (see Gravelle and Rees, 1992).

Correspondingly, we may define a critical value for the initial price, denoted \( p^{aa} \), that makes the seller indifferent between refusing to trade under the initial contract and trading under the initial contract. \( p^{aa}(\sigma) \) is defined by the equation

\[
E_a[U(u^s + p(\alpha, \sigma) - i^s)] = U(u^s + p^{aa}(\sigma) - i^s).
\]  

(5)

\( p^{aa} \) is the lowest initial price that the seller would accept rather than disrupt trade. The risk aversion of the seller (the concavity of \( U(\cdot) \)) ensures that \( p^{aa}(\sigma) < p^E(\sigma) \) for all \( \sigma \in \Sigma \). It follows that \( p^{ba}(\sigma) > p^{aa}(\sigma) \) for all \( \sigma \in \Sigma \).

The outcome of the bargaining can be described as follows. If the initial price is within the interval \([p^{aa}, p^{ba}]\), any threats of disrupting trade are noncredible, and there is no renegotiation of the initial contract (case (iii) in Proposition 1 below). The reason is that the risk associated with a disruption of trade implies that for both players the expected utility from violating the contract is lower than the utility from trading under the initial contract. But if the initial price is outside this interval, a disruption of trade gives higher payoff to one of the players than does trade under the initial contract. In this case (cases (i) and (ii) in Proposition 1), the player who is disadvantaged by the initial contract may credibly threaten to refuse to trade under the existing contract. He will not succeed in demanding a contract that gives him a higher payoff than he would have gotten if trade were disrupted, as this will be rejected by the opponent. Rather, the opponent will concede to a new price that gives the threatening player the payoff that he would have gotten if trade were disrupted. Thus, in equilibrium, the threats will not be carried out—there will be no disruption of trade. However, the costs that are avoided by trade not being disrupted (that is, the costs associated with the uncertainty as to the outcome of a renegotiation) will be captured by the opponent.

**Proposition 1.** For any initial contract \( p^0 \), the unique limit equilibrium price \( p^*(\sigma, p^0) \) and the unique limit equilibrium flow utilities \( \bar{U}^s(\sigma, p^0) \) and \( \bar{U}^b(\sigma, p^0) \) are given by

(i) If \( p^0 < p^{aa}(\sigma) \),

\[
p^*(\sigma, p^0) = p^{aa}, \quad \bar{U}^s(\sigma, p^0) = U(u^s + p^{aa} - i^s), \quad \bar{U}^b(\sigma, p^0) = U(u^b - p^{aa} - i^b).
\]

(ii) If \( p^0 > p^{ba}(\sigma) \),

\[
p^*(\sigma, p^0) = p^{ba}, \quad \bar{U}^s(\sigma, p^0) = U(u^s + p^{ba} - i^s), \quad \bar{U}^b(\sigma, p^0) = U(u^b - p^{ba} - i^b).
\]

(iii) If \( p^0 \in [p^{aa}, p^{ba}] \),

\[
p^*(\sigma, p^0) = p^0, \quad \bar{U}^s(\sigma, p^0) = U(u^s + p^0 - i^s), \quad \bar{U}^b(\sigma, p^0) = U(u^b - p^0 - i^b).
\]

Note that the size of the interval for the initial price where there is no renegotiation is increasing in the uncertainty associated with a renegotiation and in the degree of risk aversion of the players. An immediate implication is that if there is no uncertainty as to the outcome of the bargaining, then \( p^{ba} = p^E = p^{aa} \), that is, the interval for the initial contract where there is no renegotiation vanishes, and one of the players will always credibly threaten to disrupt trade, thus enforcing a renegotiation of the contract. Clearly, this result also obtains if both players are risk neutral. (This conclusion is discussed in the concluding remarks below.) Note also that as \( p^{ba} \) and \( p^{aa} \) are stochastic, depending
on $\theta$ as well as on the levels of investment, risk-neutral players cannot trivially avoid a renegotiation by setting $p^0 = p^{bo} = p^{so}$.

Before proceeding to the analysis of the investment decision, let me make a remark on the modelling of the renegotiation process. In contrast to the standard approach in applications of bargaining theory (e.g., Grout, 1984, or Layard, Nickell, and Jackman, 1991), I use a model where players explicitly must choose to disrupt trade. This seems an important extension, as continued trade under the old contract is clearly an option. However, if trade is disrupted, the renegotiation process is modelled in the standard fashion, by the use of the Nash bargaining solution. On the interpretation of the Nash bargaining solution as the limit case of the Rubinstein (1982) infinite-horizon alternating-offers model, this involves an implicit assumption that if trade is disrupted, it cannot be resumed until a new agreement is reached. The effect of this assumption is to avoid the multiplicity of equilibria that prevails in the Rubinstein model if one allows players in each period to decide whether to trade in that period; see Haller and Holden (1990) and Fernandez and Glazer (1991). In this case there are both SPE outcomes with a renegotiation of the initial contract and SPE outcomes with no renegotiation. This multiplicity is problematic in an analysis of the efficiency of investments.

The assumption that once trade is disrupted, a new agreement is needed before trade can be resumed may seem strong.\footnote{A real-world counterpart obtains in Denmark, where the Main Agreement between the employees’ and employers’ associations, LO and DA, explicitly states that a collective agreement is no longer valid if either of the parties has disrupted trade (strike or lockout), which is referred to as a “releasing conflict” (Jacobsen, 1985).} However, the results of Holden (1994b) suggest that a weaker assumption may suffice. Here it is shown that the Rubinstein outcome (i.e., a renegotiation) is the unique SPE outcome in the Haller and Holden (1990) model if one adopts the assumption that players are able to commit to disrupt trade for two periods unless an agreement is reached before that. This also holds when the period length converges to zero.

3. Efficiency of investments

In this section I apply the results of Proposition 1 to study the circumstances under which it is possible to ensure an efficient level of investment by an appropriate choice of the contract price $p^0$. I neglect the question of how the surplus is shared between the parties. Note that the choice of $p^0$ need not affect the division of the surplus, as any partition of the expected surplus is possible with suitable choice of upfront payments from one player to the other at stage 0.

The crucial issue for the efficiency of investments is that if the contract is renegotiated, the new price will be affected by the levels of investment. In Appendix B I show that the renegotiated price is an increasing function of the buyer’s level of investment (which increases his gain from trade) and a decreasing function of the seller’s level of investment (which decreases his costs of providing the good).

I define the efficient levels of investment as the levels of investment that maximize each of the players’ expected utilities, for a given price level $p^0$:\footnote{As there are no direct externalities, the expected utility of one player is independent of the level of investment of the other; as long as the price is kept constant. Thus, these levels of investment are Pareto optimal. However, they may depend on the price $p^0$.}

$$\max_{i^b} E_o[U(u^b(i^b, \theta) - p^0 - i^b)]; \quad \max_{i^s} E_o[U(u^s(i^s, \theta) + p^0 - i^s)]. \quad (6)$$

The first-order conditions are

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\[ E_\theta[D(U'(-\delta w(i^j, \theta)/\delta i^j - 1))] = 0, \quad j \in \{b, s\}. \quad (7) \]

(I denote the solutions \( i^{bs} \) and \( i^{sr} \).) However, the players choose the level of investment that maximizes their own expected surplus at stage I, where they take into consideration that the realized price may depend on the levels of investment. That is, the investment of player \( j \) is given by

\[ i^j = \operatorname{arg\ max} \{E_\theta[D(U(\sigma, p^0))]\}, \quad (8) \]

where \( U(\sigma, p^0) \) is given from Proposition 1. Thus, if there is a positive probability that there is a renegotiation of the contract, then the buyer will set a lower level of investment than the efficient level, as the higher the buyer’s investment, the higher the renegotiated price. Likewise, the seller will invest less than the efficient level. However, if both players are certain that the initial contract will not be renegotiated, then (7) is the first-order condition to (8), so the players will set the efficient level of investment. This is indeed the standard result in the literature. To obtain efficiency, the contract must be designed so that no renegotiation will occur.

As observed by Joskow (1988) and MacLeod and Malcomson (1993), avoiding a renegotiation and thus inducing efficient levels of investment is made easier if there are some verifiable events that the contract can be conditioned on. To analyze this formally, let \( \Omega \) be a partition of \( \Theta \) (that is, if the events \( u, v \in \Omega \) and \( u \neq v \), then \( u \cap v = \phi \) and \( \bigcup_{u \in \Omega} u = \Omega \)) and assume that it is verifiable which of the events \( \Omega \) takes place. Thus, a contract can be written where the price varies according to the verifiable events \( \omega \in \Omega \) i.e., \( p^0 = p^{ba}(\omega) \), while the price is the same for all states of nature within the event \( \omega \) (which reflects that complete contracting is not possible).

Proposition 1 shows that to ensure that the buyer cannot credibly threaten to disrupt trade to renegotiate the contract, we must have \( p^0 \leq p^{bs} \). To ensure that the seller cannot credibly threaten to disrupt trade, we must have \( p^0 \geq p^{ba} \). Consider the following assumption.

**Assumption 1.** \( \sup[p^{sa}(\sigma)_{\theta \in \omega}, i^b = i^{bs}, i^s = 0] < \inf[p^{ba}(\sigma)_{\theta \in \omega}, i^b = 0, i^s = i^{sr}] \), for \( \omega \in \Omega \).

When Assumption 1 holds, a contract \( p^0(\omega) \) can be written that satisfies

\[ \sup[p^{sa}(\sigma)_{\theta \in \omega}, i^b = i^{bs}, i^s = 0] < p^0(\omega) \]

\[ < \inf[p^{ba}(\sigma)_{\theta \in \omega}, i^b = 0, i^s = i^{sr}], \quad \text{for } \omega \in \Omega. \quad (9) \]

The intuition is that whatever exogenous event happens, neither of the players can enforce a renegotiation of the initial contract, even if he deviates from the equilibrium path by not investing. This condition ensures that we always have \( p^0 \in [p^{sa}, p^{ba}] \); threats of disrupting trade are never credible. This can be summarized in the following proposition.

**Proposition 2.** Assuming that Assumption 1 holds, a contract specifying a price \( p^0(\omega) \) that satisfies (9) results in efficient investments.

Recall that the size of the interval \([p^{sa}, p^{ba}]\) is equal to the size of the costs associated with an uncertain renegotiation outcome under risk aversion. Thus, the larger these costs, the easier it is to avoid a renegotiation, and the more likely it is that efficiency can be ensured. In contrast, uncertainty in the gains from trade, which does not derive from a verifiable event, will induce *ex ante* uncertainty in \( p^{sa} \) and \( p^{ba} \) even conditional
on $\omega$, and thus it will be more difficult to find an initial price scheme $p^0(\omega)$ that lies within the interval. Such uncertainty has the consequence that it is more difficult to avoid a renegotiation, and hence also more difficult to obtain an efficient level of investment. If there is little uncertainty in the gains from trade, a contingent contract may not be necessary. In this case a contract of the simplest sort, a fixed price that can only be renegotiated by mutual consent, will induce efficiency.

An example that corresponds with the results of Proposition 2 is the sale of natural gas from the North Sea to mainland Europe, where sellers invest in the search for and extraction of the gas and the buyers invest in the network for distribution. The contracts governing the sale of natural gas from the North Sea contain several characteristics that work to avoid the possibility of renegotiation that would involve one of the parties obtaining a share of the return of the other party’s investment. The gas price is often indexed to the price of oil-related products (this corresponds to the price depending on a verifiable event $\omega$).\textsuperscript{9}

4. Concluding remarks

In a long-term relationship between two players, efficient levels of investment can only be achieved if it can be ensured that both players obtain the full marginal return on their investment. As previously shown by Grout (1984) and MacLeod and Malcolmson (1993), this requires that players can be prevented from unilaterally disrupting trade as a means of inducing a renegotiation of the initial contract. I argue that if players are risk averse, uncertainty as to the outcome of a contract renegotiation may have such a preventive effect. More precisely, by analyzing a formal bargaining model with stochastic disagreement points, I show that there is an interval for the price of the initial contract such that if it is within this interval, it will not be renegotiated. In this case, both players have higher expected utility by trading under the existing contract than by undertaking the risky action of disrupting trade to induce a contract renegotiation. The length of the interval is increasing in the uncertainty associated with the renegotiation outcome and in the degree of risk aversion of the players, while the position of the interval depends on the relative gains of trade for the players. Efficiency of investment requires that the gains from trade of the players are sufficiently foreseeable when the initial contract is written, so that it is possible to ensure that the initial price falls within the interval where it is not renegotiated.

The model has several empirical predictions. First, it suggests that actual wages and prices may be rigidly given by an initial contract, even in situations where either party may unilaterally disrupt trade as a means of inducing a renegotiation of the contract. The rigidity of the initial contract may prevail in spite of fluctuations over time in the parties’ gains from trade. This prediction is consistent with evidence from Bils (1985) that wages are much more procyclical for individuals who are moving between employers or in and out of the work force (and thus negotiate an initial contract) than for individuals who remain with the same employer (and thus have an initial contract that can be renegotiated). It is also consistent with the observation that empirical distributions of nominal wage changes at contract renewal often have a spike at zero, i.e., constant money wages (Jacob and Mitchell, 1990).\textsuperscript{10}

\textsuperscript{9} Some verifiable events cannot, however, be foreseen. Thus, the contracts often involve a clause allowing for a renegotiation if substantial economic change has taken place, like changes in environmental regulations or the introduction of (or changes in) taxes/tariffs (Statoil, 1995). In such renegotiations, the contracts may state that a revision of the price may only reflect the economic change that has taken place.

\textsuperscript{10} Contract renewals involve an additional aspect, that players in negotiating the contract for one period take into consideration the effect on subsequent contract periods. This is neglected here but is analyzed formally in a related model in Holden (1997).
this rigidity is in contrast to the continuous renegotiation of wages that is often assumed in the macro-matching literature (e.g., Mortensen and Pissarides, 1994, or Bertola and Caballero, 1994). It is also in contrast to the implications of some of the previous work in the holdup literature. If one generalizes Grout’s (1984) model by allowing both parties to disrupt trade, the result would be that the initial contract is always renegotiated (as in my model without uncertainty associated with the outcome of a renegotiation).

Second, my model suggests that an initial contract may be renegotiated if there are unforeseen changes in the parties’ relative gains from trade that are sufficiently large to outweigh the rigidity arising from an uncertain renegotiation outcome under risk aversion. An implication appears to be that a contract is less likely to be renegotiated the more uncertain the outcome of a renegotiation, and the more risk averse the players. These hypotheses may be difficult to evaluate empirically, but in principle they are testable. In fact, there is empirical support for the related idea that uncertainty as to the decision of an arbitrator increases the probability that the parties reach an agreement themselves. Based on data for over 300 Wisconsin teacher contract negotiation cases, Babcock and Taylor (1996) show that the greater the uncertainty about the arbitrator, the lower the probability of an impasse.

The model of MacLeod and Malcomson (1993) also explains rigidity of wages and prices provided by contracts in situations where unilateral disruption of trade is possible. Yet the source of the rigidity is different from that of the present article. In MacLeod and Malcomson’s model, a player may credibly threaten to disrupt trade, thus inducing a renegotiation of the initial contract, only if he has lower flow payoff when trading under the initial contract than when violating the contract by disrupting trade. The result is derived in a noncooperative bargaining model with a finite and known number of bargaining periods, and the proof (which is a straightforward application of the backward induction principle) relies on the finite-horizon assumption: In the final bargaining period, it is clearly optimal to trade if this gives higher payoff on a single-period basis and there is no future to be affected. Thus, in the next-to-last period both parties will know that trade will take place in the last period, so trade will be optimal in this period also, etc.

The finite-horizon model is regarded with skepticism in the literature; see the well-known textbooks by Fudenberg and Tirole (1991) and Osborne and Rubinstein (1990). However, the infinite-horizon version of MacLeod and Malcomson’s model exhibits the same multiplicity of equilibria as that analyzed by Haller and Holden (1990) and Fernandez and Glazer (1991); see MacLeod and Malcomson (1995). MacLeod and Malcomson (1995) show that if one requires SPE outcomes of the infinite-horizon model to be Pareto efficient (according to the concept of strong renegotiation-proofness), then one obtains the same results as in the finite-horizon model. Yet it seems problematic to adopt a convention that assumes away costly conflicts (by requiring Pareto efficiency) in an analysis of whether threats of initiating a costly conflict are credible, because the result essentially follows directly from the assumption.

To compare the models, it is illustrative to consider a specific example, namely wage bargaining. In my model, employers and employees may be reluctant to stop trade (lockout or strike) if the outcome of the ensuing renegotiation is highly uncertain. Yet a player may credibly threaten to disrupt trade, thus inducing a renegotiation, if a renegotiation involves higher expected utility than does trade under the existing contract. In MacLeod and Malcomson’s model, a strike threat is not credible if workers have a higher flow payoff while working under the prevailing contract than during a strike. One implication is that strike threats are unlikely to be credible; after all, the
workers have voluntarily worked under the initial contract before the renegotiation started, and they are unlikely to have a higher payoff during a strike than they would have obtained elsewhere in the labor market. Another implication is that a rise in the employer’s gain from trade will not enable a worker to renegotiate to a higher wage, as long as the worker still gains from the original contract. In contrast to the latter implication, in my model a renegotiation involving higher wages may be the result of a rise in the employer’s gain from trade or of a decrease in the worker’s gain from trade. These differences between the models are potentially testable empirically.

In the real world, there are also aspects other than uncertainty about the renegotiation outcome under risk aversion that prevent players from unilaterally violating a contract to induce a renegotiation (still restricting attention to situations where courts cannot enforce trade; see the Introduction). The most obvious is that a violation of the contract may actually involve a costly disruption of trade. This aspect does not prevent a renegotiation in my model, because if a disruption of trade took place, there would be an immediate agreement on a new contract so that the costs associated with the disruption of trade would be negligible. To prevent a renegotiation induced by a unilateral violation of the contract, a disruption of trade must involve nonnegligible costs to the players. This can be captured in formal models, either by assuming exogenously that a disruption of trade involves nonnegligible costs, for example by a minimum length of the disruption (see Holden 1994a, 1994b), or by using a model where there is a nonnegligible probability that a disruption of trade of nonnegligible duration takes place in equilibrium (a model with private information, or possibly a model with complete information but a multiplicity of equilibria; see Haller and Holden (1990) and Fernandez and Glazer (1991)).

Private information is neglected in the present model, to simplify the modelling and to focus on the main issue of the article. However, I conjecture that under the realistic assumption that both players also have some private information on their costs of a disruption of trade, the basic results would not be changed. Rather, there would be additional uncertainty as to the renegotiation outcome, and the length of the interval with no renegotiation would increase. If private information induced a nonnegligible probability that a costly disruption took place in equilibrium, such an interval might exist even if players were risk neutral. The risk of a costly disruption might make both players prefer to trade under the initial contract.

Other aspects that may preclude unilateral violation of a contract in real-life situations include adverse effects on future cooperation between the players (Klein, Crawford, and Alchian, 1978), adverse effects on the player’s reputation, or the notion that the player may incur “ethical” costs by undertaking opportunistic behavior.

Appendix A

- **Proof of Proposition 1.**

  *Case (i) \( p^\sigma(\sigma) > p^\theta \).* The equilibrium path is that the buyer offers \( p^\sigma \), which is immediately accepted by the seller. The seller will not accept a lower price, because then he would be better off by disrupting trade, obtaining a payoff \( U(w^e + p^\sigma - i) \). If the seller tries to obtain higher payoff by rejecting the buyer’s offer, then to choose to trade and demand a higher price, it will be rejected by the buyer and trade will take place under the initial contract. The buyer will clearly propose \( p^\sigma \); both a higher and a lower offer will give him lower payoff.

  *Case (ii) \( p^\sigma(\sigma) < p^\theta \).* There are two alternative equilibrium paths, leading to the same outcome. One path is that the buyer offers \( p^\theta \) and the seller accepts it. The other path is that the buyer offers a higher price, which the seller rejects. The seller then chooses trade and offers \( p^\sigma \), which the buyer accepts. The buyer will not accept a higher price, because then he would be better off by disrupting trade, obtaining a payoff \( U(w^e - p^\sigma - i) \). The buyer cannot obtain a higher payoff: trade under the initial contract gives lower payoff and disrupting trade gives the same payoff.

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Case (iii). The equilibrium path is that any offers \( p \neq p^0 \) will be rejected, and both players will choose to trade. Thus, trade will take place under the initial agreement. Any deviation clearly hurts the deviating player. \( Q.E.D. \)

Appendix B

The relationship between the levels of investment and the negotiated price is found by implicit differentiation of the first-order condition (2) of the Nash bargaining solution,

\[
\frac{\partial \phi}{\partial i^b} + \frac{\partial \phi}{\partial p} \frac{\partial p}{\partial i^b} = 0.
\]  
(B1)

Thus,

\[
\frac{\partial p}{\partial i^b} = -\frac{\partial \phi}{\partial \phi} > 0,
\]  
(B2)

as \( \partial \phi/\partial p < 0 \) from the second-order condition (3) and

\[
\frac{\partial \phi}{\partial i^b} = -U'(u^b - p - i^b) \left( \frac{\partial u^b}{\partial p} - 1 \right) [U(u^b + p - i^b) - U(s(\alpha) - i^b)]
\]

\[+ U'(u^b - p - i^b) \left( \frac{\partial u^b}{\partial p} - 1 \right) U'(u^b + p - i^b) + U'(b(\alpha) - i^b) U'(u^b + p - i^b) > 0.
\]  
(B3)

(Optimal investment will always satisfy \( \partial \phi/\partial i^b - 1 \geq 0 \), so the two first terms in (B3) are nonnegative, while the last term is strictly positive.) In the same way, it can be seen that increased investment by the seller leads to a lower price.

References


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