

Wage Bargaining with Time-Varying Threats

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Abstract

We study wage bargaining in which the union is uncertain about the firm's willingness to pay and threat payoffs vary over time. Strike payoffs change over time as replacement workers are hired, as strikers find temporary jobs, and as inventories or strike funds run out. We find that bargaining outcomes are substantially altered if threat payoffs vary. If dispute costs increase in the long-run, then dispute durations are longer, settlement rates are lower, and wages decline more slowly during the short-run (and may even increase). The settlement wage is largely determined from the long-run threat, rather than the short-run threat.

I. Introduction

With the exception of Hart (1989), studies of bargaining with private information assume that threat payoffs are constant over time.¹ Yet an important feature of many bargaining settings is the variability of threat payoffs. For example, in labor contract negotiations, threat payoffs change over time as replacement workers are hired and trained, as strikers find temporary jobs, as inventories or strike funds are depleted, and as public assistance to strikers is triggered by passing waiting periods for benefits. In this paper, we examine the consequences of these threat changes on the bargaining outcome. In particular, we focus on their impact on strike durations and the pattern of wage concessions during the strike.

We analyze these issues using a model of wage bargaining with a two-phase threat, in which the short-run threat payoffs differ from the long-run threat payoffs. Our main result is that bargaining outcomes are substantially altered by time-varying threats. This is especially true for dispute durations, settlement rates, and the relationship between wages and dispute duration. If dispute costs increase in the long-run, then dispute durations are longer, settlement rates are lower, and wages decline more slowly with time (and may even increase). In addition, we show that the settlement wage is largely determined from the long-run threat, rather than the short-run threat. Hence, focusing solely on observed short-run threats may be misleading.

Allowing time-varying threats also helps explain empirical results. The theory provides an explanation for why cooling off periods lengthen disputes (Gunderson and Melino 1990), why settlement rates are lower during periods of eligibility for unemployment insurance (Kennan 1980b), why strike durations are longer during business downturns (Kennan 1985, Harrison and Stewart 1989), and why wages might not decrease with strike durations (Card 1990).

Moreover, the theory can help explain the actions firms and unions take to influence threat payoffs. A firm may stockpile a 30-day inventory before a strike deadline, it may negotiate a mutual aid pact with competitors, or it may make plans for hiring replacement workers. A union may arrange for the payment of strike benefits from the national union or lobby for strike aid from other sources. The consequences and motivations for these actions can be evaluated with the theory presented here.

Section 2 develops a model of wage bargaining with a two-phase threat. In Section 3, we look at the implications of a strike threat in which the short-run strike costs differ from the long-run strike costs.

Finally, Section 4 describes how policy changes can influence the threat payoffs over time, and how these changes affect dispute activity. Proofs are in the Appendix.

II. A Model of Wage Bargaining with a Two-Phase Threat

A union and firm are bargaining over the wage to be paid during a contract of duration T . The union's reservation wage is common knowledge. The value-added of the work force after settlement is v . It is common knowledge that v is a random variable with distribution F and positive density f on the interval $[l, h]$. However, only the firm knows the realization of v .

We consider a threat that consists of two phases indexed by $\theta \in \{1, 2\}$: a short-run phase and a long-run phase with differing payoffs. During the phase θ , the union receives a payoff of x_θ and the firm receives a payoff of $y_\theta(v) = a_\theta v - b_\theta$, where $a_\theta < 1$. The dispute cost $1 - a_\theta$ represents the fraction of v that is lost during a dispute. We define $c_\theta = (b_\theta - x_\theta)/(1 - a_\theta)$ to be the *relative payment difference* during the threat θ : what the firm pays less what the union gets divided by the dispute cost. Then the inefficiency from dispute is $(1 - a_\theta)v + b_\theta - x_\theta = (1 - a_\theta)(v + c_\theta)$. We assume that the inefficiency is positive for all $v \in [l, h]$, which implies $c_\theta > -l$.

The threat remains in the first phase until time $\tau \in [0, T]$ and then switches to the second phase after τ . In practice, the transition time τ may be endogenous (a firm's decision about when to hire replacement workers) or exogenous (a waiting period before eligibility for unemployment insurance benefits). In either case, we assume that τ is known before bargaining begins. Given τ , the union makes an initial wage offer. The parties then alternate making wage offers until an agreement is reached. As in Admati and Perry (1987), the parties' response to an offer can occur at any time after the minimum time between offers has passed. We consider the limiting case as the minimum time between offers goes to zero.

An outcome of the bargaining, denoted $\langle t, w, \tau \rangle$, specifies the time of agreement $t \in [0, T]$, the contract wage w at the time of agreement, and the transition time $\tau \in [0, T]$, as shown in Figure 1 for the case with $t > \tau$. The discounted fraction of the pie remaining at time t is defined as

$$d(t) = \frac{e^{-rt} - e^{-rT}}{1 - e^{-rT}},$$

and $\delta = d(\tau)$. Given the outcome $\langle t, w, \tau \rangle$, each side's payoffs are the present value of the payoff flows over $[0, T]$. Hence, the union's payoff is

$$U(t, w, \tau) = \begin{cases} (1 - d(t))x_1 + d(t)w & \text{if } t \leq \tau \\ (1 - \mathbf{d})x_1 + (\mathbf{d} - d(t))x_2 + d(t)w & \text{if } t > \tau, \end{cases}$$

and the firm's payoff is

$$V(t, w, \tau) = \begin{cases} (1 - d(t))(a_1 v - b_1) + d(t)(v - w) & \text{if } t \leq \tau \\ (1 - \mathbf{d})(a_1 v - b_1) + (\mathbf{d} - d(t))(a_2 v - b_2) + d(t)(v - w) & \text{if } t > \tau. \end{cases}$$

A. Full-Information Bargaining with a Two-Phase Threat

A key feature of the signaling equilibrium we analyze is that after a revealing offer is made by the firm the parties settle at the full-information wage—the wage they would settle at if the revealed information were common knowledge. A first step, then, in extending the signaling model is to determine the full-information wage when the bargainers face a two-phase threat with a transition at time τ . This wage is found by backward induction as in Ståhl (1972) and Rubinstein (1982). To eliminate the importance of who moves first or last, we take the limit as the time between offers goes to zero.

Proposition 1. *Suppose the value v is common knowledge and the bargaining has reached time $t < \tau$ without a settlement. In the limit as the time between offers goes to zero, the full-information wage at time t with a firm v is*

$$w(t, v) = (1 - \mathbf{g}(t))w_1(v) + \mathbf{g}(t)w_2(v), \quad \text{where}$$

$$\mathbf{g}(t) = \frac{e^{-rt} - e^{-rT}}{e^{-rt} - e^{-rT}} \quad w_q(v) = x_q + \frac{1}{2}(1 - a_q)(v + c_q) \quad \mathbf{q} \in \{1, 2\}.$$

The full-information wage from a sequence of threats is a weighted average of the full-information wages for each threat where the weights are given by the fraction of remaining time spent in each threat, assuming that a settlement is never reached.

An implication of Proposition 1 is that observed bargaining outcomes depend critically on potentially unobserved threats. For example, in labor contract negotiations the settlement wage in the early days of a strike will be a weighted average of the full-information wages under the short-run and long-run threats. If the time until the shift in the strike threat is short relative to the contract length, the settlement wage is largely determined by the long-run threat. To illustrate, suppose the interest rate is 10%, the contract duration is three years, and the shift occurs after a strike of 30 days. Then at the outset of bargaining, the long-run threat is given 97% of the weight in determining the settlement wage. Even if the strike never reaches the long-run phase, the settlement wage is largely based on the long-run threat. It is the phase not reached that determines the settlement. Empirical models of wage settlements, then, are misspecified if they only control for determinants of the current threat payoffs.

B. The Signaling Equilibrium with a Two-Phase Threat

In the signaling equilibrium with constant threat payoffs (Cramton and Tracy 1992), the union makes an initial offer $w(m)$, which is acceptable if the firm's value v exceeds some cutoff level m . The equilibrium with one-sided uncertainty and a two-phase threat is closely related. As a result of the union's initial offer $w(m)$, there are three possibilities depending on the firm's value v : if $v \geq m$, the firm immediately accepts the initial offer; if $v \in [v_\tau, m)$, the firm makes a counteroffer before the transition is reached ($t \leq \tau$); and if $v < v_\tau$, the firm makes a counteroffer after the transition ($t > \tau$).

1. The Firm's Duration Decision

The next proposition considers the firm's optimization problem in response to an initial offer of $w(m)$ by the union.

Proposition 2. *Suppose the union makes an initial offer of $w(m) = (1 - \mathbf{d})w_1(m) + \mathbf{d}w_2(m)$, where $\mathbf{d} = (e^{-rt} - e^{-rT}) / (1 - e^{-rT})$. In the subgame that follows, in the limit as the time between offers goes to zero, there is a perfect Bayesian equilibrium with the following form. If $v \geq m$, the firm immediately accepts the offer. If*

$v_t \neq v < m$, where

$$v_t = m - (1 - d)(m + c_1) / a \quad \text{and} \quad a = 1 + d \frac{a_1 - a_2}{1 - a_1},$$

the second phase is not reached; the firm waits until

$$D(v) = a \frac{m - v}{m + c_1}$$

of the contract has passed before offering

$$w(v) = (1 - g(v))w_1(v) + g(v)w_2(v), \quad \text{where} \quad g(v) = \frac{d}{1 - D(v)}.$$

If $v < v_t$ the second phase is reached; the firm waits until

$$D(v) = 1 - d \frac{v + c_2}{v_t + c_2}$$

of the contract has passed before making the offer $w_2(v)$. The firm's counteroffer is accepted immediately by the union.

Proposition 2 tells us how dispute duration and settlement rates are influenced by changes in threat payoffs over time. Consider the screening model of strikes studied by Hart (1989). Hart analyzes the case, where the strike cost is initially small but then jumps upward when a “crunch point” is reached (say the firm runs out of inventory). In this case, $a_1 > a_2$, so $\alpha > 1$, and the dispute duration is higher (the settlement rate is lower) than when the strike efficiency stays constant at a_1 (so $\alpha = 1$). This is consistent with Hart's conclusion for the screening model: disputes are lengthened by higher long-run dispute costs. In contrast, if we assume that strike costs are lower in the second phase ($a_1 < a_2$), because the firm is able to hire replacement workers, then $\alpha < 1$ and strike duration is reduced.

Interestingly, wages can increase with time during the first phase of a two-phase threat, provided $w_1(v) < w_2(v)$. At first glance, this may seem at odds with incentive compatibility. Intuition suggests that a firm that is supposed to settle at a higher wage after a period of delay would prefer to settle at a lower wage without any delay. Incentive compatibility requires that the total wage bill, $b_1 D(v) + w(v)(1 - D(v))$, decline with v . However, a firm with a lower v can settle at a higher wage provided the higher wage is paid for a shorter time (i.e., the dispute is sufficiently long) and the short-run threat is sufficiently attractive. This may arise if the firm can draw on inventories in the short-run. The firm may prefer to reduce inventories with a short strike, even if it means settling at a slightly higher wage. Increasing strike costs during a dispute, then, provides an explanation for the absence of a negative relationship between wages and strike durations.

In a study of Canadian strikes, Card (1990) found no compelling evidence of a negative relationship between wages and strike duration. Rather, Card found a small positive relationship for short strikes and a small negative relationship for long strikes. Our model provides one explanation. If long-run strike

costs are higher than short-run strike costs, then wages can increase in the short-run and then decrease in the long-run. Whether strike costs tend to increase during a strike is an open question. Some evidence is found in a survey we conducted of major U.S. strikes in the 1980s. A majority of firms and unions responded that strike costs would increase if the strike were to continue.

2. The Union's Initial Offer

Given the behavior specified in Proposition 2, we can determine the union's optimal initial offer $w(m)$.

Proposition 3. *The union's initial offer $w(m) = (1 - \mathbf{d})w_1(m) + \mathbf{d}w_2(m)$ is chosen so m maximizes $U(m)$ defined as follows. If $v_t \leq l$, then*

$$U(m) = w(m)(1 - F(m)) + \int_{\ell}^m I_1(v) dF(v), \quad \text{where}$$

$$I_1(v) = (1 - \mathbf{d})x_1 + \mathbf{d}x_2 + \frac{1}{2}\mathbf{d}(1 - a_2)(c_2 - c_1) + \frac{1}{2}[1 - a_1 + \mathbf{d}(a_1 - a_2)] \frac{(v + c_1)^2}{m + c_1}.$$

If $v_t > l$, then

$$U(m) = w(m)(1 - F(m)) + \int_{v_t}^m I_1(v) dF(v) + \int_{\ell}^{v_t} I_2(v) dF(v), \quad \text{where}$$

$$I_2(v) = (1 - \mathbf{d})x_1 + \mathbf{d}x_2 + \frac{1}{2}\mathbf{d}(1 - a_2) \frac{(v + c_2)^2}{v_t + c_2}.$$

Proposition 3 simplifies if $c_1 = c_2$, as shown below.

Proposition 4. *Suppose $c_1 = c_2 = c$. The union's initial offer is $w(m) = (1 - \mathbf{d})w_1(m) + \mathbf{d}w_2(m)$, where m maximizes*

$$(M) \quad (m + c)(1 - F(m)) + \int_{\ell}^m \frac{(v + c)^2}{m + c} dF(v).$$

The union's expected payoff is

$$U(\mathbf{d}) = (1 - \mathbf{d})U_1 + \mathbf{d}U_2, \quad \text{where} \quad U_q = x_q + (1 - a_q)(m + c)(1 - F(m)).$$

Consider a union deciding between two possible threats $\theta \in \{1, 2\}$. The union may decide to use threat θ exclusively. Alternatively, it may decide to mix the threats by using threat 1 from 0 to τ and then adopt threat 2 from τ to T . Proposition 4 says that such a mixture does not benefit the union. If $c_1 = c_2$, then the expected payoff to the union from a sequence of threats is simply the weighted-sum of the expected payoffs from the individual threats, with weights equal to the fraction of time spent in each threat. Hence, the union will prefer to adopt the threat with the higher expected utility and stick with it.²

C. An Example with Uniform Uncertainty

If v is uniformly distributed, we can calculate the union's initial offer from Proposition 3.

Proposition 5. *Suppose v is uniformly distributed on $[l, h]$. The union's initial offer $w(m) = (1 - d)w_1(m) + dw_2(m)$ is chosen as follows. Define*

$$\mathbf{a} = 1 + \mathbf{d} \frac{a_1 - a_2}{1 - a_1} \quad \mathbf{b} = \frac{1}{2}[1 - a_1 + \mathbf{d}(a_1 - a_2)] \quad \mathbf{g} = \frac{1}{2}\mathbf{d}(1 - a_2)(c_2 - c_1)$$

$$x_t = (1 - \mathbf{d})x_1 + x_2 \quad v_t = m - (1 - \mathbf{d})(m + c_1) / \mathbf{a}.$$

If $v_t \leq l$, then $m = m(c_1)$, where

$$m(c_1) = -c_1 + \frac{1}{4}[k + (h + c_1)(1 + (h + c_1) / k)], \quad \text{and}$$

$$k = \left[4\sqrt{(\ell + c_1)^3((h + c_1)^3 + 4(\ell + c_1)^3)} + (h + c_1)^3 + 8(\ell + c_1)^3 \right]^{1/3},$$

and the union's expected payoff is

$$U(m) = x_t + \mathbf{g} + 2\mathbf{b}(m + c_1) \frac{h - m}{h - \ell}.$$

If $v_t > l$, then m is chosen to maximize

$$U(m) = x_t + \mathbf{g} + \mathbf{b}(m + c_1) \frac{h - m}{h - \ell} - \mathbf{g} \frac{v_t - \ell}{h - \ell} \\ + \frac{\mathbf{b}}{3} \frac{(m + c_1)^3 - (v_t + c_1)^3}{(m + c_1)(h - \ell)} + \frac{\mathbf{d}}{6} (1 - a_2) \frac{(v_t + c_2)^3 - (\ell + c_2)^3}{(v_t + c_2)(h - \ell)}.$$

The first and second derivatives of $U(m)$ with respect to m are easily computed. Hence, we can use Newton's method to calculate the optimal m if $v_t > l$. Once the optimal m is determined, straightforward calculations yield formulas for dispute durations, hazard rates, and wage changes. These are presented in the Appendix.

Proposition 5 is used to determine the equilibrium outcome under specific threats, so that we can evaluate the sensitivity of the bargaining outcome to changes in the threat payoffs. For this purpose, we need to establish benchmark levels for the model parameters. Throughout the remainder of the paper, the benchmark model will be as in Cramton and Tracy (1993): $r = 10\%$, $T = 2.7$ years, $a_i = 75\%$, $b_i = x_i = 0.35$, and v is uniformly distributed on 1 ± 0.07 . The parameters in this benchmark have been set so the equilibrium outcome is consistent with many of the descriptive statistics in our sample of union contract negotiations.³

III. Implications of a Two-Phase Strike Threat

We now turn to a strike threat with payoffs that change after a particular point from short-run levels to long-run levels. Two possibilities are considered: high long-run strike costs and low long-run strike costs.

High Long-run Strike Costs. Hart (1989) studies a strike threat with low costs in the short-run, but high costs in the long-run after a crunch point is reached. A motivation for costs to take this form is that, at the time the strike begins, the firm has a stock of inventory to satisfy customer demand. As the strike continues, inventories are depleted and eventually run out. At the point inventories are exhausted, customers shift to alternative suppliers and the cost of the strike to the firm becomes much higher. Hart's main point is that in a screening model of bargaining with private information the presence of a crunch point at which strike costs escalate can lead to much longer strike durations. Hence, even when the time between offers is short, the screening model may be consistent with long strikes.

We saw in Proposition 2 that Hart's result extends to the signaling equilibrium. With high long-run strike costs as a result of a crunch point, strike duration is longer than without the crunch. To gauge the size of this effect, Table 1 shows how the bargaining outcome changes in the benchmark model as the short-run and long-run strike costs vary from 5% to 75%, assuming a short-run of either 30 days ($\tau = 30$) or 60 days ($\tau = 60$). We assume the firm's wage payment changes in proportion to a_i . Thus, as a_i varies, the firm's wage payment b_i in phase i of the strike is adjusted so $b_i/a_i = b_j/a_j$ where $j \neq i$. The motivation for this is that the firm must spend proportionally more on labor to raise production during the strike. For example, by hiring twice as many replacement workers, the firm may double production.

Strike durations, settlement rates, and wage declines are affected by changes in either the short-run or long-run strike cost. If strikes involve little cost in the short-run, then strike durations are long, and the settlement rate and wage decline are low in the short-run. With a short-run of 30 days as the short-run strike cost increases from 5% to 75%, the mean strike duration falls from 42 to 17 days, the short-run settlement rate rises from 6.6% to 20.9% per week, the long-run settlement rate rises from 15.6% to 96.7% per week, the short-run wage decline rises from 0.5% to 9.1% per 100 days, and the long-run wage decline falls from 3.1% to 3.0% per 100 days. In contrast, if strikes involve little cost in the long-run, then strike durations are short, and the settlement rate and wage decline are high in the short-run. With a short-run of 30 days as the long-run strike cost increases from 5% to 75%, the mean strike duration rises from 7 to 61 days, the short-run settlement rate falls from 49.7% to 3.7% per week, and the short-run wage decline falls from 4.6% to -0.1% per 100 days.

Hart's crunch point is illustrated by a high long-run strike cost, as found in the last row of Table 1b. In this case, the long-run strike cost is 75%, compared with a short-run cost of 25%. This increase in the strike cost after a short-run of 30 days has the effect of increasing the mean strike duration from 32 to 61 days, reducing the short-run settlement rate from 11.0% to 3.7% per week, reducing the short-run wage decline from 3.0% to -0.1% per 100 days, and increasing the long-run wage decline from 3.0% to 5.1% per 100 days. Note that wages actually increase slightly during the first phase.

An alternative to the firm building inventory before a potential strike is for the firm's customers to build inventory. Customers may be in a better position to store inventory and strikers may be able to disrupt the delivery of the firm's inventory during a strike. Whether inventory is stored by the firm or its customers, the outcome on the bargaining is the same: short-run strike costs are reduced.

That strikes are longer when the long-run costs of a strike increase may seem counter-intuitive. The

joint cost hypothesis (Kennan 1980a, and Reder and Neumann 1980) predicts just the opposite. The correct intuition stems from understanding that strike duration is determined from the firm's incentive compatibility condition. In equilibrium, a firm waits until the marginal benefit of waiting (a lower wage) balances the marginal cost of waiting (additional dispute costs). The increase in long-run strike costs effectively magnifies the pie that the parties are bargaining over, which is the inefficiency associated with the dispute. This implies a greater dispersion of wage settlements between the high v firms and the low v firms. Hence, the incentive for signaling a low v increases with the long-run strike cost, but the strike cost in the short-run is constant, so duration must increase to balance the costs and benefits of waiting to signal a low v .

Empirical studies have found that strikes are more frequent (Vroman 1989; Gunderson, Kervin, and Reid 1986) and shorter (Kennan 1985; Harrison and Stewart 1987) in good times. Our model may provide an explanation. Suppose, as a result of production smoothing, inventories are greater in bad times than in good times.⁴ Then strike durations should increase in bad times, because of low short-run strike costs. Strike incidence should fall in bad times, because striking is less likely to be the union's preferred threat, due to larger inventories and higher unemployment in bad times (Cramton and Tracy 1991).

Low Long-run Strike Costs. Strike costs may decrease over time as the firm hires and trains replacement workers. Initially, the strikers may be in picket lines and production may stop, but as the strike continues, the strikers may find temporary jobs and the firm may hire replacement workers to restore production. Tables 1a and 1b show that a larger strike cost in the short-run leads to a shorter strike duration, and a higher settlement rate and wage decline in the short-run. For example, if the strike cost decreases from 25% to 5% after a short-run of 30 days, the mean strike duration falls from 32 days to 7 days, the short-run settlement rate increases from 11.0% to 49.7% per week, and the short-run wage decline increases from 3.0% to 4.6% per 100 days. With high short-run strike costs, the firm has an incentive to settle early – the short-run strike costs are high but wages are falling slowly because the long-run strike costs are low.

IV. The Effect of Policy Changes on Dispute Activity

Government policies can induce shifts in the threat payoffs during a dispute. For example, a striker's eligibility for UI or other government benefits may depend on the length of the strike. Our two-phase threat model is useful in evaluating such policies.

The Timing of Unemployment Insurance and Other Benefits. In New York (Rhode Island), strikers become eligible for unemployment benefits after a strike has lasted eight (seven) weeks. We wish to evaluate the effect of such a policy on the bargaining outcome. The payment of UI benefits increases the union's payoff during a strike. It also may increase the firm's wage payment during a strike if UI benefits are experience rated.⁵

Table 2 shows how the bargaining outcome is affected by changes in the union's short-run and long-run strike payoff, assuming a short-run of either 30 or 60 days. Parameters are set at the benchmark levels with the exception that v is uniform on 1 ± 0.10 , rather than 1 ± 0.07 , so not all firm types settle before the 60 day short-run ends. Increasing the union's long-run strike payoff has the effect of increasing strike duration, decreasing the long-run settlement rate, decreasing both the short-run and long-run wage decline, and increasing the union's share of the gains. For example, suppose that eligibility for UI benefits begins after 60 days, which approximates the policies in New York and Rhode Island, and that UI benefits increase the union's long-run strike payoff from 0.35 to 0.45 without increasing the firm's wage bill (i.e., no experience rating, so $b_1 = b_2$). Then strike duration increases from 46 to 50 days, the long-run

settlement rate decreases from 21.8% to 12.4% per week, and the short-run wage decline decreases from 3.1% to 1.7% per 100 days. Roughly the same outcomes result when UI benefits are 50% experience rated (the firm pays one-half of the UI benefit, so $b_2 = b_1 + \frac{1}{2}(x_2 - x_1)$). However, if UI benefits are 100% experience rated, then there is no effect of UI benefits on dispute settlement rates, but a large positive effect on wages.

The short-run settlement rate is lower than the long-run settlement rate, because of a lack of heterogeneity over the amount of uncertainty. Without heterogeneity, the settlement rate increases exponentially over time; with heterogeneity, the settlement rate can decline over time. Hence, when we introduce heterogeneity over the amount of uncertainty so that the settlement rate is flat in the benchmark case, then the drop in the long-run settlement rate caused by UI benefits implies that the settlement rate will be higher before the benefits begin. Kennan (1980b) finds that the settlement rate in New York is higher during the first eight weeks of a strike.

One may wonder why New York and Rhode Island chose to delay access to UI benefits for strikers. One explanation is that the delayed access represents a compromise between labor and the legislature. Labor is most interested in the wage gains that come from access to UI benefits. The legislature is concerned with the cost of the program. Delaying access serves both goals: wage gains are achieved without large increases in UI payments, since most strikes end before the UI trigger is reached.

The effect of union strike funds on the bargaining outcome can be evaluated similarly. Paying strikers from a strike fund has the effect of raising the union's payoff during a strike, assuming the strike funds are coming from a national fund that is only partially charged back to the local union. If workers receive payments from a strike fund during the early days of a strike, then strike duration increases, and the short-run settlement decreases, as shown in Table 2a. For example, suppose the strike fund payment raises the union's short-run strike payoff from 0.35 to 0.45 for the first 60 days of the strike. Then the strike duration increases from 46 to 66 days and the short-run settlement rate decreases from 7.7% to 4.5%. The strike fund increases the union's share of the gains, because of the higher wage settlements. Total bargaining costs increase, because of the longer durations.

Conciliation and Cooling Off Periods. Collective bargaining often takes place in the shadow of established rules for conciliation and cooling off. In the U.S., contracts negotiated under the Railway Labor Act involve mandatory mediation and cooling off periods, which result in much longer dispute durations (Cramton and Tracy 1992). In Canada, a cooling off period follows the conclusion of the conciliation process. No strike or lockout may take place until both steps are completed. Although conciliation may have additional effects, both conciliation and cooling off periods force a period of delay on the parties before a strike can begin. Hence, conciliation and cooling off periods are analogous to an exogenous strike deadline after the expiration date.

Our basic model applies if we associate the conciliation and cooling off periods with the first phase of the strike threat. In this case, we have a threat with a small inefficiency in the short-run and a high inefficiency in the long-run. From the prior section, this implies that dispute durations are increased by the cooling off period, since the settlement rate in the cooling off period is much less than the settlement rate once a strike has begun. Strike incidence falls, since some would-be strikes settle during the cooling off period. Although the cooling off period restricts the union's ability to call a strike, for cooling off periods that are short relative to the contract length, this constraint has little effect on the union's payoff. The delayed strike threat remains effective, since both parties anticipate its use after the cooling off period. Hence, the negotiated wage is based largely on the strike threat, even if a settlement is reached

during the cooling off period.

Gunderson and Melino (1990) investigate the effects of conciliation and cooling off periods in Canada. They find that conciliation is associated with lower strike incidence (the effect is significant when conciliation boards are involved). Both conciliation and cooling off periods are associated with slightly longer strike durations conditional on a strike taking place. In particular, each additional day of imposed delay increases the conditional strike duration by one-half day.⁶ Hence, dispute durations increase as a result of conciliation and cooling off periods.

V. Conclusion

Bargaining threats in real situations rarely have the simple stationary structure assumed in the bargaining models. This paper determines how changes in the threats during negotiations may influence the bargaining outcome. Changes in the threat payoffs can be due to actions the bargainers take, such as hiring and training replacement workers during a long strike or calling a strike after a period of delay. Changes in the threat payoffs also can be exogenously imposed, such as the payment of UI benefits to strikers if a strike has lasted sufficiently long. In either case, the bargaining outcome is not just a function of the current threat, but depends critically on how the threat changes over time.

The analysis of time-varying threats provides new insights into how empirical estimation of the model should proceed. First, the equilibrium wage is predominantly based on the long-run threat payoffs, rather than the short-run payoffs that are observed in the early days of a dispute. In addition, dispute durations and the relationship between dispute durations and wages are sensitive to how threat payoffs change over time. If dispute costs increase over time, then dispute durations are longer and wages decline more slowly. As a consequence, micro wage equations should include long-run estimates of the economic and policy variables used in the estimation. Similarly, the settlement rate depends on current and future values of the variables used in the estimation.

Appendix

Proof of Proposition 1. The threat is in phase 1 from t to τ and phase 2 from τ to T . If negotiations reach time τ , the outcome is simply the full-information wage under the phase 2 threat $w_2(v)$, but payoffs are discounted by $\gamma = \gamma(t)$. Now break the time period from t to τ into $2n + 1$ half-periods as shown in Figure 2. In each half-period, one party makes an offer and the other accepts or rejects. The discount factor associated with each half-period of delay is $\lambda = \gamma^{1/(2n+1)}$. With this finite horizon, we can determine the optimal offers before time τ by backward induction. For an offer to be a best response it must be that the offer makes the other player indifferent between accepting or countering with her best offer. Since at τ the union gets w_2 , in the last period before τ , the firm makes the offer $w^0 = (1 - \lambda)x_1 + \lambda w_2$, which makes the union indifferent between accepting or rejecting. Suppose with $n - 1$ periods to go the firm offers w^{n-1} to the union. To make the firm indifferent between accepting and rejecting, the union's prior offer $w^{n-1/2}$ must be such that

$$v - w^{n-1/2} = (1 - I)(a_1 v - b_1) + I(v - w^{n-1}), \quad \text{or}$$

$$w^{n-1/2} = (1 - I)(1 - a_1)v + b_1 + I w^{n-1}.$$

Hence, to make the union indifferent, the firm's offer w^n with n periods remaining must be

$$\begin{aligned}
w^n &= (1 - \mathbf{I})x_1 + \mathbf{I}w^{n-1/2} = (1 - \mathbf{I})(x_1 + \mathbf{I}b_1 + \mathbf{I}(1 - a_1)v) + \mathbf{I}^2w^{n-1} \\
&= (1 - \mathbf{I})((1 + \mathbf{I})x_1 + \mathbf{I}(1 - a_1)(v + c_1)) + \mathbf{I}^2w^{n-1}.
\end{aligned}$$

This recursive definition of w^n can be solved to yield

$$\begin{aligned}
w^n &= x_1(1 - \mathbf{I}^{2n+1}) + (1 - a_1)(v + c_1)(1 - \mathbf{I}) \sum_{i=1}^n \mathbf{I}^{2i-1} + \mathbf{I}^{2n+1}w_2 \\
&= x_1(1 - \mathbf{I}) + (1 - a_1)(v + c_1)(\mathbf{I} - \mathbf{g}) \frac{1}{1 + \mathbf{I}} + \mathbf{g}w_2.
\end{aligned}$$

Taking the limit as the number of offers goes to infinity results in

$$\lim_{n \rightarrow \infty} w^n = (1 - \mathbf{g})w_1 + \mathbf{g}w_2, \quad \text{where } w_q = x_q + \frac{1}{2}(1 - a_q)(v + c_q).$$

Proof Sketch of Proposition 2. Only a sketch of the proof, focusing on the equilibrium path, is given here. Off-the-equilibrium-path behavior that supports this equilibrium path can be constructed as in Cramton (1992).

Suppose the union makes an initial offer $w(m)$ that is accepted by the firm if $v \geq m$. We wish to determine how long a firm with $v < m$ must wait before making a revealing counteroffer. If $t \geq \tau$, the analysis is the same as the single-threat analysis in Cramton and Tracy (1992). Hence if v_τ is the type that makes a revealing offer at time τ , then $v < v_\tau$ wait until

$$D(v) = 1 - \mathbf{d} \frac{v + c_2}{v_t + c_2}$$

of the contract period has passed before making an offer. If $t < \tau$, the analysis is complicated by the fact that the settlement wage is a continuously changing linear combination of the first-phase wage and the second-phase wage. From Proposition 1,

$$w(v(t)) = (1 - \mathbf{g}(t))w_1(v) + \mathbf{g}(t)w_2(v), \quad \text{where}$$

$$\mathbf{g}(t) = \frac{e^{-rt} - e^{-rT}}{e^{-rt} - e^{-rT}} \quad w_q(v) = x_q + \frac{1}{2}(1 - a_q)(v + c_q).$$

The time t at which firm $v(t)$ makes a revealing offer is chosen to maximize its utility:

$$\max_t y(v)(1 - d(t)) + (v - w(v(t)))d(t).$$

Define $D(t) = 1 - d(t)$ to be the fraction of the contract spent in dispute and let $\Delta = 1 - \delta$. We can then

restate the firm's optimization problem in terms of D :

$$y(v) = a_1 v - b_1 w(v) D + (v - w(v))(1 - D) \quad \text{where} \quad w(v) = \frac{w_1(v)}{1 - D} + \frac{w_2(v)}{1 - D}.$$

Taking the derivative with respect to D yields the first-order condition

$$y(v) - v + w(v) - w'(v)(1 - D) = 0.$$

This is a separable differential equation, which given the initial condition $v(0) = m$, has the solution

$$v(D) = m + (m + c_1)D / \alpha, \quad \text{where} \quad \alpha = \frac{a - a_1}{1 - a}.$$

Inverting $v(D)$ yields

$$D(v) = \frac{v - m}{m + c_1} \frac{1 - a}{a - a_1}.$$

Since the firm's preferences satisfy the single crossing property, a necessary and sufficient condition for $D(v)$ to solve the firm's optimization problem is that $v'(D) < 0$. Inspection of the differential equation reveals that $v'(D) < 0$ if and only if $(m + c_1)/\alpha > 0$, which is true so long as $\alpha > 0$, since $c_1 > -1$. But $\alpha > 0$ if and only if $1 - a_1 > \delta(a_2 - a_1)$, which is always true since $\delta < 1$ and $a_2 < 1$. Hence, $D(v)$ solves the firm's optimization problem. The formula for v_τ follows since $v_\tau = v(\delta)$.

Proof of Proposition 3. We wish to determine the union's expected payoff $U(m)$ from making the initial offer $w(m)$, given the behavior from Proposition 2. Let $d_1(v) = d(v) = 1 - D(v)$ be the discount factor for a firm v that settles before the strike deadline, so

The settlement wage $w(v)$ for a firm $v \geq v_\tau$ is a linear combination of the first-phase wage and the second-phase wage weighted by duration:

$$w(v) = (1 - \mathbf{d}) \frac{w_1(v)}{m + c_1} + \mathbf{d} w_2(v).$$

Let $d_2(v)$ be the discount factor for a firm $v < v_\tau$ that settles after the transition to the second phase:

$$d_2(v) = 1 - \frac{v - m}{m + c_2} \frac{1 - a}{a - a_1}.$$

We can now state the union's expected payoff $U(m)$ as a function of m . There are two cases to consider. In the first, all firm types settle before the transition at τ : $1 \geq v_\tau$. In the second, some firm types settle after the transition time: $1 < v_\tau$. If $1 \geq v_\tau$, then for $v \in [1, m]$, the union receives x_1 for the fraction $1 - d_1(v)$ and receives $w(v)$ for $d_1(v)$; hence,

Otherwise, if $1 < v_\tau$, then for $v \in [v_\tau, m]$, the union receives x_1 for $1 - d_1(v)$ and receives $w(v)$ for $d_1(v)$, and for $v \in [1, v_\tau]$, the union receives x_1 for $1 - \delta$, x_2 for $\delta - \mathbf{d}$, and $w_2(v)$ for \mathbf{d} . Thus,

Substituting the formulas for $d_1(v)$, $d_2(v)$, and $w(v)$ and simplifying yields

$$U(m) = w(m)(1 - F(m)) + \int_{v_\tau}^m I_1(v) dF(v) + \int_{\ell}^1 I_2(v) dF(v), \quad \text{where}$$

$$I_2(v) = (1 - \mathbf{d})x_1 + \mathbf{d}x_2 + d_2(v)(w_2(v) - x_2).$$

$$I_1(v) = (1-d)x_1 + dx_2 + \frac{1}{2}d(1-a_2)(c_2 - c_1) + \frac{1}{2}[1-a_1 + d(a_1 - a_2)] \frac{(v+c_1)^2}{m+c_1}.$$

$$I_2(v) = (1-d)x_1 + dx_2 + \frac{1}{2}d(1-a_2) \frac{(v+c_2)^2}{v_t + c_2}.$$

Proof of Proposition 4. When $c_1 = c_2 = c$, then $I_1(v) = I_2(v) = I(v)$, where

$$I(v) = (1-d)x_1 + dx_2 + \frac{1}{2}[1-a_1 + d(a_1 - a_2)] \frac{(v+c)^2}{m+c}.$$

Therefore, the expressions for $U(m)$ are the same if $v_t \leq 1$ or if $v_t > 1$. Moreover, since $w(m)$ simplifies to

$$w(m) = (1-d)x_1 + dx_2 + \frac{1}{2}[1-a_1 + d(a_1 - a_2)](m+c),$$

$U(m)$ simplifies to

$$U(m) = (1-d)x_1 + dx_2 + \frac{1}{2}[1-a_1 + d(a_1 - a_2)] \left[(m+c)(1-F(m)) + \int_{\ell}^m \frac{(v+c)^2}{m+c} dF(v) \right].$$

It follows that $U(m)$ is maximized by maximizing expression (M). The first-order condition for the optimal m , which must be satisfied since there is an interior optimum, is

$$(m+c)(1-F(m)) = \int_{\ell}^m \frac{(v+c)^2}{m+c} dF(v).$$

Substituting this first-order condition into the expression for $U(m)$ yields the union's expected payoff as a function of δ :

$$U(d) = (1-d)U_1 + dU_2, \quad \text{where} \quad U_q = x_q + (1-a_q)(m+c)(1-F(m))$$

and m maximizes (M).

Proof of Proposition 5. The proof follows directly from substituting $F(v) = (v-1)/(h-1)$ into the expressions of Proposition 3 and then simplifying.

Formulas for the Example with Uniform Uncertainty

Dispute durations follow from Proposition 2. If $v \geq v_t$, then the dispute duration is found by solving for t in the formula

$$t(v) = t_1(v) = \frac{1}{r} \log \left[\frac{m-v}{m+c_1} \frac{1-m e^{-j}}{1-m e^{-c_1 T}} \right], \quad \text{where } j = e^{-rT}.$$

If $v < v_t$, then duration is found by solving for t in the formula

$$t(v) = t_2(v) = \frac{1}{r} \log \left[j + \frac{1-e^{-rt}}{1-e^{-jt}} \frac{v-c_2}{v_t+c_2} \right].$$

Define

$$k_1 = \frac{m+c_1}{a(1-j)} \quad k_2 = \frac{v_t+c_2}{d(1-j)}.$$

If $v_t \leq 1$, then the expected duration is

$$\bar{t} = \int_{\ell}^m t_1(v) \frac{dv}{m-\ell} = \frac{1}{r} \left[1 + \left(\frac{k_1}{m-\ell} - 1 \right) \log \left[1 - \frac{(m-\ell)}{k_1} \right] \right].$$

If $v_t > 1$, then the expected duration is

$$\begin{aligned} \bar{t} &= \int_{v_t}^m t_1(v) \frac{dv}{m-\ell} + \int_{\ell}^{v_t} t_2(v) \frac{dv}{m-\ell} \\ &= \frac{1}{r} \left[1 - \frac{1}{m-\ell} (k_3 + (jk_2 + v_t + c_2) \log[j + d(1-j)]) \right], \quad \text{where} \\ k_3 &= (m - v_t - k_1) \log \left[1 - \frac{m - v_t}{k_1} \right] - (jk_2 + \ell + c_2) \log \left[j + \frac{\ell + c_2}{k_2} \right]. \end{aligned}$$

The settlement rate during a dispute is

$$\begin{aligned} R(t) &= \frac{-v'(t)}{v(t) - \ell'}, \\ v' &= -r \left(v - m + \frac{m+c_1}{a(1-j)} \right) \quad \text{if } v \geq v_t \\ w_2'(v) &= -r \left(\frac{w_2'(v)}{v w_2(v)} + \frac{j(v_t + c_2)}{d(1-j)} (1 - a_2) v' \right). \end{aligned}$$

where v' follows from the formulas for $D(v)$:

The percentage wage decline during the second phase of the threat ($v < v_t$) is

The percentage wage decline during the first phase ($v \geq v_\tau$) is

$$\mathbf{w}_1(v) = -\frac{w'(v)}{w(v)} \quad \text{where}$$

$$w'(v) = v' \left[\frac{1}{2}(1-a_1) \left(1 - \frac{\mathbf{d}}{d_1(v)} \right) + \frac{1}{2} \frac{\mathbf{d}}{d_1(v)} (1-a_2) + \mathbf{d}\mathbf{a} \frac{w_1(v) - w_2(v)}{d_1(v)^2(m+c_1)} \right]$$

$$w(v) = \left(1 - \frac{\mathbf{d}}{d_1(v)} \right) w_1(v) + \frac{\mathbf{d}}{d_1(v)} w_2(v)$$

$$d_1(v) = 1 - \mathbf{a} \frac{m-v}{m+c_1}$$

$$w_q(v) = x_q + \frac{1}{2}(1-a_q)(v+c_q)$$

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Footnotes

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¹See Kennan and Wilson (1989, 1993) for surveys.

²We are assuming that the union can commit to any threat path. At a minimum, the threat path should be sequentially rational: the union should never want to deviate from the path, given the firm's strategy. Fernandez and Glazer (1991) and Haller and Holden (1990) consider a full-information game in which the union selects the threat each period. They show that every threat path is sequentially rational, which results in multiple perfect equilibria. Allowing the union to commit to a threat path amounts to letting the union pick an equilibrium from among the set of perfect equilibria. At least with full information, the union's threat choice is sequentially rational.

³The sample includes 5,002 contracts with large bargaining units in the U.S. from 1970 to 1989. See Cramton and Tracy (1992), McConnell (1989), and Tracy (1986) for a detailed description of this data.

⁴This is a heroic assumption in light of the macro empirical evidence that inventories are procyclic (Blinder and Maccini 1991). Micro-level data, however, indicates that there is tremendous heterogeneity in inventory behavior — some plants are production smoothers while others are production bunchers (Schuh 1992). Given this heterogeneity, it is difficult to draw conclusions from aggregate data.

⁵These payments may be large. In the 1971 strike at New York Telephone, strikers received \$49 million in UI benefits (roughly 50% of their regular wages) of which \$40 million was paid by the firm (New York Telephone Co. v. New York State Department of Labor, 440 U.S. 519).

⁶This is consistent with our model when we allow heterogeneity in the amount of uncertainty among bargaining pairs.

Figure 1

A Bargaining Outcome

Time:	0	τ	t	T
Fraction Remaining:	1	δ	$d(t)$	0
State:	Phase 1	Phase 2	Agreement	
Union Payoff:	x_1	x_2	w	
Firm Payoff:	$a_1v - b_1$	$a_2v - b_2$	$v - w$	

Figure 2

Bargaining from t to T with a Threat Transition at $\tau > t$

Time	t	Phase 1	τ	Phase 2	T
Firm's Offer	w^n	w^{n-1}		w^0	
Union's Offer	$w^{n-1/2}$	w_2			

Table 1a
Bargaining Outcome as a Function of the Short-run Strike Cost ($1 - a_1$)

SR Strike Cost (%) $1 - a_1$	Duration (days)		SR Settlement Rate (%)		LR Settlement Rate (%)		SR Wage Decline (%)		LR Wage Decline (%)	
	$\tau=30$	$\tau=60$	$\tau=30$	$\tau=60$	$\tau=30$	$\tau=60$	$\tau=30$	$\tau=60$	$\tau=30$	$\tau=60$
5	42	48	6.6	6.8	15.6	27.0	0.5	0.6	3.1	3.1
15	37	39	8.8	9.0	17.7	46.7	1.8	1.8	3.1	3.1
25	32	32	<i>11.0</i>	<i>11.0</i>	<i>20.6</i>	<i>167.2</i>	<i>3.0</i>	<i>3.0</i>	<i>3.0</i>	<i>3.0</i>
35	28	27	13.1	12.9	24.5	NA	4.3	4.2	3.0	NA
45	24	24	15.1	14.7	30.2	NA	5.5	5.4	3.0	NA
55	21	21	17.1	16.5	39.2	NA	6.7	6.6	3.0	NA
65	19	19	19.0	18.2	55.9	NA	7.9	7.7	3.0	NA
75	17	18	20.9	19.8	96.7	NA	9.1	8.9	3.0	NA

Table 1b
Bargaining Outcome as a Function of the Long-run Strike Cost ($1 - a_2$)

LR Strike Cost (%) $1 - a_2$	Duration (days)		SR Settlement Rate (%)		LR Settlement Rate (%)		SR Wage Decline (%)		LR Wage Decline (%)	
	$\tau=30$	$\tau=60$	$\tau=30$	$\tau=60$	$\tau=30$	$\tau=60$	$\tau=30$	$\tau=60$	$\tau=30$	$\tau=60$
5	7	7	49.7	52.2	NA	NA	4.6	4.5	NA	NA
15	20	20	17.9	17.6	60.6	NA	3.8	3.8	2.5	NA
25	32	32	<i>11.0</i>	<i>11.0</i>	<i>20.6</i>	<i>167.2</i>	<i>3.0</i>	<i>3.0</i>	<i>3.0</i>	<i>3.0</i>
35	41	43	7.9	8.0	14.3	29.7	2.3	2.3	3.5	3.5
45	48	53	6.2	6.3	11.8	18.8	1.6	1.7	4.0	4.0
55	53	60	5.1	5.2	10.4	14.7	1.0	1.1	4.4	4.4
65	57	66	4.3	4.4	9.6	12.6	0.4	0.5	4.7	4.8
75	61	71	3.7	3.8	9.0	11.3	-0.1	0.0	5.1	5.1

NOTE.— As a_i varies, $b_i = a_i b_j / a_j$ where $j \neq i$. Other parameters are set at benchmark levels: $r = 10\%$, $T = 2.7$ years, $a_j = 75\%$, $b_j = 0.35$, $x_1 = x_2 = 0.35$, and v is uniform on 1 ± 0.07 . Benchmark in *italics*. Duration = mean duration (days). SR Settlement Rate = initial settlement rate during phase 1 (% / week). LR Settlement Rate = initial settlement rate during phase 2 (% / week). SR Wage Decline = median wage decline during phase 1 (% / 100 days). LR Wage Decline = median wage decline during phase 2 (% / 100 days). NA = not applicable because all firm types settle before phase 2 is reached.

Table 2a
Bargaining Outcome as a Function of the Union's Short-run Strike Payoff (x_1)

SR Strike Payoff x_1	Duration (days)		SR Settlement Rate (%)		LR Settlement Rate (%)		SR Wage Decline (%)		LR Wage Decline (%)	
	$\tau=30$	$\tau=60$	$\tau=30$	$\tau=60$	$\tau=30$	$\tau=60$	$\tau=30$	$\tau=60$	$\tau=30$	$\tau=60$
0.45	57	66	4.6	4.5	9.5	12.4	3.0	3.0	3.1	3.1
0.4	51	55	6.1	6.1	10.3	15.8	3.0	3.0	3.1	3.1
0.35	46	46	7.7	7.7	<i>11.3</i>	<i>21.8</i>	<i>3.0</i>	<i>3.1</i>	<i>3.1</i>	<i>3.0</i>
0.3	41	38	9.3	9.3	12.6	35.7	3.0	3.1	3.0	3.0
0.25	36	32	10.9	10.9	14.1	101.0	3.0	3.1	3.0	3.0

Table 2b
Bargaining Outcome as a Function of the Union's Long-run Strike Payoff (x_2)

LR Strike Payoff x_2	Duration (days)		SR Settlement Rate (%)		LR Settlement Rate (%)		SR Wage Decline (%)		LR Wage Decline (%)	
	$\tau=30$	$\tau=60$	$\tau=30$	$\tau=60$	$\tau=30$	$\tau=60$	$\tau=30$	$\tau=60$	$\tau=30$	$\tau=60$
0.45	62	50	7.6	7.7	6.5	12.4	1.7	1.7	1.6	1.6
0.4	52	48	7.6	7.7	8.9	17.1	2.3	2.3	2.3	2.3
0.35	46	46	7.7	7.7	<i>11.3</i>	<i>21.8</i>	<i>3.0</i>	<i>3.1</i>	<i>3.1</i>	<i>3.0</i>
0.3	42	45	7.7	7.7	13.8	26.6	3.8	3.9	3.9	3.9
0.25	40	44	7.7	7.7	16.2	31.3	4.7	4.7	4.8	4.9

NOTE.— v is uniform on 1 ± 0.10 . Other parameters are set at benchmark levels: $r = 10\%$, $T = 2.7$ years, as x_i varies, $x_j = 0.35$, $a_1 = a_2 = 75\%$, and $b_1 = b_2 = 0.35$. Benchmark in *italics*.

Duration = mean duration (days). SR Settlement Rate = initial settlement rate during phase 1 (% / week). LR Settlement Rate = initial settlement rate during phase 2 (% / week). SR Wage Decline = median wage decline during phase 1 (% / 100 days). LR Wage Decline = median wage decline during phase 2 (% / 100 days).