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BARGAINING AND STRIKES

Oliver Hart*

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massachusetts
institute of
technology

50 memorial drive
cambridge, mass. 02139

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ABSTRACT

A recent literature has shown that asymmetric information about a firm's profitability does not by itself explain strikes of substantial length if the firm and workers can bargain very frequently without commitment. In this paper we show that substantial strikes are possible if (a) there is a small (but not insignificant) delay between offers; and (b) a strike-bound firm may experience a decline in profitability, with the probability of decline increasing with the length of the strike. A brief discussion of the ability of the theory to explain the data on strikes is included.
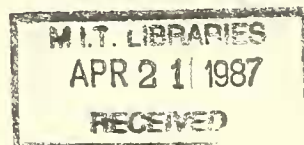
1. Introduction:

Strikes are generally regarded as an important economic phenomenon, and yet good theoretical explanations of them are hard to come by. The difficulty is to understand why rational parties should resort to a wasteful mechanism as a way of distributing the gains from trade. Why couldn't both parties be made better off by moving to the final distribution of surplus immediately (or if it's uncertain to its certainty equivalent) and sharing the benefits from increased production?

The key to this puzzle would appear to be asymmetric information between firms and unions, and in the last few years a number of papers have developed dynamic models of bargaining in which firms have better information about their profitability than workers (see, e.g., Fudenberg-Levine-Tirole (1985), Sobel-Takahashi (1983), Cramton (1984), Grossman-Perry (1985)). In such models delay to agreement is a screening device. Profitable firms lose more from a strike than unprofitable firms and hence will settle early for high wages, while unprofitable firms will be prepared to delay agreement until wages fall. The reason that the parties cannot do better by avoiding the strike and sharing the gains from increased production is that there is no way for an unprofitable firm to "prove" that it's unprofitable except by going through a costly strike.

While these asymmetric information bargaining models seem at first sight to provide a good basis for a theory of strikes, their adequacy has recently been challenged in a provocative paper by Gul-Sonnenschein-Wilson (1985) (see also Gul-Sonnenschein (1985)). GSW claim that delay is obtained in these models only by assuming that there are significant intervals between bargaining times. GSW argue that if, as seems reasonable, the parties can bargain frequently, the equilibrium amount of delay to agreement will be very small.

The reason for this is essentially that given (as is assumed in this literature) that the parties cannot commit themselves to future bargaining strategies, once the profitable firms have settled early, it will not be in the interest of the workers and remaining firms to drag out the bargaining -- instead they will quickly reach an agreement at a lower price. Anticipating this early reduction in price, however, the profitable firms will prefer to wait and the use of delay as a screening mechanism breaks down. As a consequence, equilibrium has the property that all firms settle "quickly" at a "low" price and there are essentially no strikes. (This result is closely related to the Coase conjecture for a durable good monopolist, formalizations of which can be found in Bulow (1982) and Stokey (1982); note that, if as is commonly assumed, the union makes all the offers, the union would like to commit itself not to bargain frequently. Such commitment is assumed to be impossible, however.)

The GSW observation has consequences far beyond the theory of strikes. Any theory which tries to explain inefficiency as a consequence of screening is potentially at risk. For example, take the Rothschild-Stiglitz-Wilson model of insurance (Rothschild-Stiglitz (1976), Wilson (1977)). There, in a separating equilibrium, low risk customers distinguish themselves from high risk customers by buying partial insurance at a low premium; while high risk customers buy full insurance at a high premium. In a dynamic context, however, as soon as the low risk customers have revealed themselves, it will be in an insurance company's interest to increase their coverage to full insurance, with the premium remaining relatively low. Anticipating this, however, the high risk types will wait to buy full insurance on favorable firms, and the separating equilibrium breaks down.

The same problem arises in "hidden information" principal-agent models where managers of bad firms signal that fact by producing low output or

employing few workers.[1] In a dynamic context this will not be an equilibrium
-- if there are frequent possibilities for recontracting -- since as soon as
the manager has started to produce low output, thus revealing that his firm is
bad, it will be in the interest of the manager and the principal to
renegotiate their contract so that production is at an efficient level for a
bad firm.[2] As a result, the optimal contract will have the property that
there will be essentially no ex-post productive inefficiency. This is, of
course, bad in ex-ante terms since it reduces the amount of risk sharing
between the manager and the principal.

In this paper, we suggest a way round the GSW difficulty.[3] Our approach
contains two ingredients. The first is the idea that in many union-firm
negotiations it is reasonable to suppose at least a limited delay between
offers. One reason for this has to do with the transaction cost of making
offers. Typically, an offer must be discussed and agreed to by several top
union officials or top executives of the firm. Meetings of such individuals
may be difficult to arrange and it may therefore be quite credible that after
one offer has been made, a new offer will not be forthcoming for a certain
period of time, a matter of days, perhaps.[4] (In fact the union and firm may
choose an involved decision-making procedure -- for example, one that requires
that offers be approved by several layers of the hierarchy -- precisely with
this purpose in mind.)

Delay may also be present for technological reasons. Suppose that
production is organized in discrete units, e.g. by the day. If an offer is
rejected at 9 p.m., then even if a new offer is made and agreed to quite
quickly, the next day's production may be lost. Given this, the incentive of
a party whose offer has just been rejected to come back rapidly with a better
offer is much reduced; the party may as well wait until close to 9 p.m. the
next day. In other words, even if bargaining can in principle occur very

frequently, the existence of production deadlines can cause <u>effective</u> intervals between bargaining of some magnitude.

For both these reasons, we believe that in the union-firm context it is realistic to assume a limited delay between offers (it is difficult to come up with a number, but, at a very rough guess, one to three days doesn't seem implausible), rather than to suppose bargaining by the second as in GSW.

One may ask whether a delay of one-three days between offers is enough by itself to reverse the GSW result and explain the magnitude of strike activity observed in practice. We will argue in Section 2 that the answer to this is probably no: strikes are still likely to be too short. This motivates the inclusion of a second feature in our model. This is the idea that the cost of a strike amounts to more than just the loss of current production. A long strike will also quite likely depress a firm's future profitability, e.g. because the firm loses ground to competitors. We formalize this by supposing that a strike-bound firm's future profitability decays (stochastically) over time. Moreover, we assume that this decay becomes more severe after a certain point, e.g. because the firm faces a "crunch" when it runs out of inventories. Under these conditions, we show that it may pay the union (who, we shall suppose, makes all the offers) to drag out the bargaining until close to the crunch in order to obtain greater leverage over the firm. As a consequence, we find that strikes of considerable duration can occur in equilibrium.

The paper is organized as follows. After presenting the basic model in Section 2, we introduce decay in Section 3. Sections 2 and 3 also contain a brief discussion of the ability of the theory we present to explain the data on strikes. Finally, Section 4 contains concluding remarks.

2. A Model with Limited Delay Between Offers

We have argued that it seems reasonable to suppose at least some interval between offers in union-firm bargaining. We shall refer to this interval as a "day" -- and will interpret it as such in our empirical discussion -- but, as we have noted, in some circumstances the period may more realistically be interpreted as two or three days. In other respects, the model we consider in this section is identical to that in GSW, which in turn is based on that in Sobel-Takahashi (1983) and Fudenberg-Levine-Tirole (1985).

Consider a union bargaining with a firm. Starting on day one, the union makes one offer a day, which the firm can accept or reject. The firm is supposed not to be able to make offers. The union's offers are to sell a permanent flow of labor (a fixed amount, one unit per day, say) at the daily price of w. The firm's profitability from using this labor, v, is a random variable, the realization of which is known to the firm but not to the union. The union is supposed to know the probability distribution of v, however. The firm's profitability in the absence of labor is zero. The union has no outside opportunities, and its objective function is taken to be the net present value of future wages.

The union and firm discount future profit and wages at the common daily discount factor, δ, $0 < \delta < 1$ (given an annual interest rate of 10%, $\delta \cong$ .99974). We write the firm's daily profitability as s, where $v = (s/(1-\delta))$. To simplify matters, we analyze the special case where s can take on only two values, s_H with probability π_H and s_L with probability π_L ($s_H > s_L > 0$, π_H, $\pi_L > 0$, $\pi_H + \pi_L = 1$). The firm and union are supposed to be risk neutral.

If the union could commit itself, it is well known that its optimal strategy would be to make a single take it or leave it offer, w^*. If (1) $\pi_H s_H$

$> s_L$, the optimal $w^* = s_H$, which means that a high firm accepts the offer and a low firm rejects it, while if (2) $\pi_H s_H < s_L$, the optimal $w^* = s_L$ and both types of firms accept. Following most of the literature, however, we shall be interested in the case where commitment is impossible. This does not affect the solution in Case 2, but it does alter the Case 1 solution, since it will be in the union's interest to make a second offer to a low firm, and this will be anticipated by a high firm. In what follows, we analyze a perfect Bayesian equilibrium for this case. For the application of this equilibrium concept to the present context, see Fudenberg-Levine-Tirole (1985).

A simple way to calculate the perfect Bayesian equilibrium is as follows. Given that s is bounded away from zero, it is known that bargaining will end in finite time. Furthermore the union's last offer must be s_L since if it were higher a low firm would remain and bargaining would continue; while it never pays the union to make offers below s_L. We therefore consider the consequences of bargaining extending for one period, two periods, etc., and find which case is payoff maximizing for the union.

We shall find that it simplifies the description of equilibrium considerably if we imagine that the union is bargaining with many firms rather than just one, and talk loosely about the fraction or number of high or low firms acting in a particular way rather than the probability of a particular firm acting in that way. The reader should realize, however, that this is an expository device and that the equilibrium we derive should be interpreted as a mixed strategy one applying to a single firm.

(A) Bargaining Ends in One Period

This case is extremely simple. The first and last price is s_L, and so the union's payoff (in daily terms) is

$$V_1 = s_L \ . \tag{2.1}$$

(B) Bargaining Ends in Two Periods

Now the second price is s_L, and a low firm waits for this. The union will find it optimal to choose the first price so that high firms are just indifferent between accepting this and waiting for s_L in the second period. That is,

$$s_H - w_1 = \delta(s_H - s_L), \qquad (2.2)$$

which yields

$$w_1 = (1-\delta) s_H + \delta s_L . \qquad (2.3)$$

Note that any higher price would result in no firms accepting in the first period, a situation clearly inferior to (A). On the other hand, the union would simply be giving money away if it charged a lower price.

It is easy to see that the union benefits if all high firms accept w_1 rather than waiting and since the high firms are indifferent we suppose that they follow the union's wishes.

The union's payoff from the two period strategy is therefore

$$V_2 = \pi_H w_1 + \delta \pi_L s_L = \pi_H s_H (1-\delta) + \delta s_L . \qquad (2.4)$$

We see that

$$V_2 > V_1 <=> \pi_H s_H > s_L , \qquad (2.5)$$

which we can rewrite as

$$V_2 > V_1 \iff \pi_L < 1 - \frac{s_L}{s_H} \equiv \rho_2 \; . \qquad (2.6)$$

Note that since we are in Case (1), this condition is automatically satisfied.

(C) Bargaining Ends in Three Periods

In this case, $w_3 = s_L$ and all low firms wait until the third day to accept. By the same argument as above, the first and second prices, w_1 and w_2, must be such that high firms are indifferent between accepting these prices and waiting until period 3 for the price s_L. That is,

$$s_H - w_2 = \delta(s_H - s_L), \text{ which yields } w_2 = (1-\delta)s_H + \delta s_L, \qquad (2.7)$$

and

$$s_H - w_1 = \delta^2(s_H - s_L), \text{ which yields } w_1 = (1-\delta^2)s_H + \delta^2 s_L. \quad (2.8)$$

The union makes most profit if all the high firms accept w_1. However, this is not perfect, since if there are no high firms left when period 2 comes along, the union will, of course, end the bargaining then with an offer of s_L. That is, we will be in Case (B) rather than Case (C). Therefore, for it to be credible that the bargaining will extend for three periods, enough high firms must be left over to the second period to make the union want to continue for two more periods. We know from (2.6) that this will be the case as long as, in period 2, the ratio of high firms to low firms is greater than or equal to $(1-\rho_2)/\rho_2$. (Only the ratio matters. Multiplying the number of high and low firms by a constant doesn't affect the relative ranking of the 2 period solution to the one period one.) In other words, at least $\pi_L(1-\rho_2) \, \rho_2$ high

firms must be left over to period 2. The union's payoff is maximized by having <u>exactly</u> this number left over, which means that $(\pi_H - \frac{\pi_L(1-\rho_2)}{\rho_2})$ accept the first offer, w_1. It follows that the union's three period payoff is

$$V_3 = (\pi_H - \frac{\pi_L(1-\rho_2)}{\rho_2})\, w_1 + \delta\pi_L \frac{(1-\rho_2)}{\rho_2}\, w_2 + \delta^2\pi_L\, w_3$$

$$= (1-\frac{\pi_L}{\rho_2})\,((1-\delta^2)s_H + \delta^2 s_L) + \delta(\frac{\pi_L}{\rho_2} - \frac{\pi_L}{\rho_1})\,((1-\delta)s_H + \delta s_L)$$

$$+ \delta^2\, \pi_L s_L\ , \qquad\qquad (2.9)$$

where $\rho_1 \equiv 1$.

Straightforward manipulation yields

$$V_3 > V_2 <=> \pi_L < \frac{\delta(s_H - s_L)}{s_H(\frac{1}{\rho_2} - \frac{1}{\rho_1}(1-\delta))} \equiv \rho_3\ . \qquad (2.10)$$

As one might expect, it only pays the union to continue for three periods rather than two if there are relatively few low firms or if their relative profitability (s_H/s_L) is large (ρ_3 is increasing in (s_H/s_L)). It is easy to show that $\rho_3 < \rho_2$, and hence if the three period solution is better for the union than the two period solution, then it is also better than the one period solution (by (2.6)).

As noted, we have talked loosely about the "number" of high firms that accept w_1 or w_2, whereas, since there is only one firm, we really mean the probability that a high firm does this. That is, the equilibrium that we have

computed should be interpreted as a mixed strategy one, with $\nu = (\pi_H - (\pi_L(1-\rho_2)/\rho_2))/\pi_H$ being the probability that the high firm accepts w_1 and $(1-\nu)$ being the probability that it accepts w_2.

(D) Bargaining Ends in n periods

It is straightforward to extend the above argument by iteration to the case where bargaining ends in n periods. Suppose that we have obtained $V_1, \ldots, V_{n-1}$ and $\rho_1, \ldots, \rho_{n-1}$, with $\rho_1 > \rho_2 > \ldots > \rho_{n-1}$ (above we have done this for $n = 4$). To obtain V_n and ρ_n, we proceed as follows. First, as above, the final price $w_n = s_L$, while w_k, $k=1,\ldots,n-1$, will be such that a high firm is indifferent between accepting w_k in period k and waiting until s_L in period n. This yields

$$w_k = (1-\delta^{n-k})s_H + \delta^{n-k}s_L \ , \quad k=1,\ldots,n-1. \tag{2.11}$$

Secondly, it follows from the definition of ρ_{n-1} that for it to be credible that bargaining will extend a further $(n-1)$ periods after the first period

has passed, it is necessary that (*) at least $\dfrac{\pi_L(1-\rho_{n-1})}{\rho_{n-1}}$ high firms are left

over to period 2. Note that if this number is left over, not only is $V_{n-1} \geq V_{n-2}$, but also $V_{n-1} \geq V_k$ for all $k < n-2$, since $\rho_{n-1} < \rho_{n-2} < \rho_{n-3} \cdots < \rho_1$. Hence (*) is also a sufficient condition that bargaining extends a further $(n-1)$ periods. As above, the union's payoff is maximized by having <u>exactly</u>

$\dfrac{\pi_L(1-\rho_{n-1})}{\rho_{n-1}}$ high firms left over.

The same argument shows that $\pi_L \frac{(1-\rho_{n-2})}{\rho_{n-2}}$ high firms must be left over to period 3 (so that bargaining continues a further $(n-2)$ periods), $\pi_L \frac{(1-\rho_{n-3})}{\rho_{n-3}}$

to period 4 (so that bargaining continues a further $(n-3)$ periods), etc. Hence

$$
\begin{aligned}
V_n &= \left(\pi_H - \pi_L \frac{(1-\rho_{n-1})}{\rho_{n-1}}\right) w_1 + \delta\left(\pi_L \frac{(1-\rho_{n-1})}{\rho_{n-1}} - \pi_L \frac{(1-\rho_{n-2})}{\rho_{n-2}}\right) w_2 \\
&\quad + \ldots + \delta^{n-2}\left(\pi_L \frac{(1-\rho_2)}{\rho_2} - \pi_L \frac{(1-\rho_1)}{\rho_1}\right) w_{n-1} + \delta^{n-1} \pi_L w_n \\[2mm]
&= \left(1 - \frac{\pi_L}{\rho_{n-1}}\right) w_1 + \delta\left(\frac{\pi_L}{\rho_{n-1}} - \frac{\pi_L}{\rho_{n-2}}\right) w_2 + \ldots + \delta^{n-2}\left(\frac{\pi_L}{\rho_2} - \frac{\pi_L}{\rho_1}\right) w_{n-1} \\[2mm]
&\quad + \delta^{n-1} \pi_L w_n .
\end{aligned}
\tag{2.12}
$$

Straightforward manipulation yields

$$
V_n > V_{n-1} \iff \pi_L < \frac{\delta^{n-2}(s_H - s_L)}{s_H \left(\frac{1}{\rho_{n-1}} - \frac{(1-\delta)}{\rho_{n-2}} - \delta\frac{(1-\delta)}{\rho_{n-3}} - \delta^2\frac{(1-\delta)}{\rho_{n-4}} - -\delta^{n-3}\frac{(1-\delta)}{\rho_1}\right)} \equiv \rho_n .
\tag{2.13}
$$

Moreover, it is easy to check that $\rho_n < \rho_{n-1}$.

We have seen how to compute V_n and ρ_n for all n. Once we know the sequence $\rho_1 > \rho_2 > \ldots$, it is easy to determine the maximizer of V_n, i.e. how

many periods of bargaining m is optimal for the union. Simply find the m such that

$$(**) \quad \rho_{m+1} < \pi_L < \rho_m \ .$$

(Note that the ρ_n's do not depend on π_H, π_L.) For since the ρ_n are decreasing in n, it follows from (**) that $\pi_L < \rho_k$ for all $k \leq m$ and $\pi_L > \rho_k$ for all $k \geq m+1$. Hence, by the definition of ρ_k, $V_m > V_{m-1} > \ldots > V_1$ and $V_m > V_{m+1} > V_{m+2} \ldots$. In other words, $V_m = \max_k V_k$. This establishes

Proposition 1: It is optimal for the union to choose the m period solution, where (**) $\rho_{m+1} < \pi_L < \rho_m$.[5,6]

It is important to realize that m stands for the maximum length of bargaining rather than the actual length. The latter, of course, depends on the realization of s (but note that a low firm waits until day m to settle).

The next proposition tells us how m varies with the discount factor, δ. It also shows that $\rho_n \rightarrow 0$ as $n \rightarrow \infty$, which implies that there is a finite solution to (**).

Proposition 2: ρ_n is increasing in δ for each n. In particular $\rho_n(\delta) \leq \rho_n(1) = (1 - (s_L/s_H))^n$, from which it follows that $\lim_{n \rightarrow \infty} \rho_n = 0$.

Proof: Differentiating (2.13) and rearranging terms yields

$$\frac{d\rho_n}{d\delta} \propto \sum_{k=2}^{n-1} (n-k)\delta^{k-2} \left[\frac{1}{\rho_{n-k-1}} - \frac{1}{\rho_{n-k}} \right] \ ,$$

which is positive since $\rho_{n-k-1} < \rho_{n-k}$. The rest of the Proposition follows directly.   Q.E.D.

Since ρ_n is increasing in δ, higher δ's lead to higher m's satisfying (**), i.e. to more bargaining. In particular, Proposition 2 implies that the greatest potential amount of bargaining, $\bar{m}$, which occurs in the limit $\delta \to 1$, is given by the solution to

$$(1 - (s_L/s_H))^{m+1} < \pi_L < (1 - (s_L/s_H))^m, \qquad (2.14)$$

and hence is finite. Note that this provides a simple proof of the Gul-Sonnenschein-Wilson result for the two point distribution. GSW consider the limit as the interval between successive bargaining periods tends to zero. Among other things, this causes $\delta \to 1$. Now simply interpret what we have called a day as a very short period, Δt, e.g. a second or a microsecond ... Then total bargaining time $\leq \bar{m} \Delta t$, which tends to zero as $\Delta t \to 0$.

Given (2.14), it is straightforward to obtain upper bounds on the length of bargaining for a two point distribution. These bounds will in fact be very close to actual maximum bargaining times, given an annual interest rate of 10% and a corresponding $\delta \overset{\sim}{_{=}} .99974$, which is so close to 1. It is clear from the second inequality in (2.14) that $\bar{m}$ will be very small unless either π_L is very small or (s_H/s_L) is quite large. For example, if $s_H = 2s_L$, we require $\pi_L < .031$ to get 5 days of bargaining and $\pi_L < .001$ to get 10 days. If $s_H = 3s_L$, these conditions are relaxed to $\pi_L < .132$ and $\pi_L < .017$ respectively. On the other hand, if we fix $\pi_L = 1/2$, then values of (s_H/s_L) equal to 5, 15, 25 yield, respectively, 3, 9, and 17 days of bargaining.

Of course, 3, 9 or 17 days maximum of bargaining is actually very little. In practice, strikes can last up to a year, and, although this is rare, strikes of three or four months are not uncommon. Hard data on strikes

are not readily available, but those that do exist (see Farber (1978) or Kennan (1985)) suggest that the mean length of a strike conditional on there being a strike is of the order of 40 days (another piece of evidence worth noting is that about 15% of contract negotiations lead to a strike).

Clearly, to get strikes which can last three or four months with a two point distribution would require either an extremely low value of π_L or a very large value of (s_H/s_L). Large values of (s_H/s_L) do not seem very plausible, however. It's one thing to suppose that there's an asymmetry of information between the firm and union about the firm's profitability, but it's quite another to assume that it's enormous.[7]

On the other hand, while a low value of π_L is consistent with long _maximum_ times of bargaining, it does not by itself imply a substantial _expected_ duration of bargaining, of the order of 40 days say. To see this, note that the logic behind (2.12) implies that the expected duration of a strike, conditional on a strike occurring (i.e. on bargaining extending for more than one day), D, satisfies:

$$D = A/B, \tag{2.15}$$

where

$$A = \sum_{i=1}^{m-2} (i-1) \left[\frac{\pi_L(1-\rho_{m-i})}{\rho_{m-i}} - \frac{\pi_L(1-\rho_{m-i-1})}{\rho_{m-i-1}} \right] - \pi_L m \quad, \tag{2.16}$$

$$B = 1 - \left[\frac{\pi_H - \pi_L(1-\rho_{m-1})}{\rho_{m-1}} \right] = \frac{\pi_L}{\rho_{m-1}} \quad, \tag{2.17}$$

and m is maximum bargaining time. Using the approximation $\rho_m = (1-(s_L/s_H))^m$,

defining $y = (s_H/(s_H-s_L))$, and simplifying, we obtain

$$D \sim 2 + \frac{1}{y^{m-2}} + \frac{\frac{1}{y}(1 - (\frac{1}{y})^{m-3})}{1 - \frac{1}{y}}$$

$$< 2 + \frac{1}{y-1} = 1 + \frac{s_H}{s_L} \qquad (2.18)$$

It follows that D cannot be of the order of 40, even if π_L is small, unless s_H/s_L is very large.

In interpreting these results, one should bear in mind that they have all been obtained for the case of a two point distribution, which may not be typical.[8] Unfortunately, analyzing more general distributions is not easy. It should be noted, however, that in their study of the uniform distribution, Grossman-Perry (1985) have obtained somewhat longer bargaining times. If s is uniformly distributed on $[s_L, s_H]$, where $s_L > 0$, they find that with $(s_H/s_L) = 25$, bargaining lasts a maximum of 22 days (in contrast to our finding of 17 days). Interestingly, they find that more bargaining occurs when the firm can make alternating offers (so that there is now one offer every half day) -- in this case bargaining lasts for 33 days.

Returning to the two point case, we should note that there is one interpretation of the model under which a high value of (s_H/s_L) does seem reasonable. Suppose that the workers have a disutility of effort R. Then the net profit in this activity is $(s - R)$, and the relevant ratio of high profitability to low profitability is $(s_H - R)/(s_L - R)$ rather than (s_H/s_L). This ratio can, of course, be very large if s_L is close to R. Hence very large values of $\bar{m}$, and large expected lengths of strike, are possible in this case. (Analogously, in the uniform case, if the support of s is $[R, \bar{s}]$,

potential delay is unbounded and expected delay in the stationary equilibrium = 61 days if the annual interest rate is 10% -- see Grossman-Perry (1985).)

There are several difficulties with this interpretation of the model, however. First, if the firm's net profitability can be very close to zero, we would expect it in practice to be negative reasonably often, which means that we should see a significant fraction of strikes leading to closure of the firm. This appears to be a very rare phenomenon. Secondly, if R represents outside earning opportunities rather than the utility of leisure, it is plausible to suppose that R is only realized when bargaining ceases, e.g. the workers may have to move to other locations to earn R. But then, with the two point distribution, there are only two possibilities. Either the workers would find it profitable to continue bargaining with a firm known to be low or they wouldn't. In the first case, the opportunity cost is irrelevant (it's never earned), while in the second the full commitment solution involving no bargaining delay can be implemented. In both cases, delay will be small. (This argument is very dependent on the two point assumption and may well not generalize.)

Finally, even if we interpret R as a disutility of labor and take $(s_L - R)$ to be low, so that the model can explain delay, it doesn't seem consistent with significant variation in accepted wages as a function of strike length. In fact explaining such variation will be a problem even once we move away from the two point distribution case. To see this, note that in equilibrium (with the union making all the offers), the most profitable firm, s_H, will be prepared to accept the first offer, w_1. This firm always has the option, however, of waiting until period n and accepting w_n. Hence

$$s_H - w_1 \geq \bar{\delta}^n (s_H - w_n) \qquad (2.19)$$

which implies, since $w_n \geq s_L$ (the lowest conceivable profitability), that

$$\frac{w_1 - w_n}{w_n} \leq (s_H - 1) \frac{(1 - \delta^n)}{s_L}. \qquad (2.20)$$

(Note that it is s_H, s_L, not $(s_H - R)$, $(s_L - R)$, which appear in the formula.) With $\delta = .99974$, (2.20) tells us that wage variation is at most 10% a year if $s_H = 2s_L$, and at most 20% a year if $s_H = 3s_L$, both fairly small amounts. To put it another way, to explain the 140% annual wage decline revealed by Farber's raw data, we require $(s_H/s_L) \geq 15$, which seems implausibly large.

As a counterweight to this observation, it should be noted that, once other explanatory variables for wages, e.g. firm size, are included, it appears that the residual wage variation implied by the data is much smaller. Fudenberg-Levine-Ruud (1984) find that wages decline with strike length at about 9% a year, while some authors even find that wages increase with strike length (see Kennan (1985))! Of course, if the latter is the case, it may be necessary to ditch the standard bargaining model entirely and replace it with one where the workers have private information.

It is clearly premature to draw any firm conclusions about the standard bargaining model. However, the above remarks do suggest that it may be difficult for this model to explain the observed data on strikes, particularly the delay to agreement. This motivates the study of alternative models; one such is described in the next section.

3. A Model with Decay

The bargaining model discussed in the last section, along with much of the bargaining literature following Rubinstein's paper (1982), supposes that a profitable opportunity which is not taken today will continue to be available tomorrow and that the only cost of delay is that the identical income stream will start one period later. This is a strong assumption. In many circumstances, it seems likely that a firm which experiences a long strike will find its profitability significantly reduced when the strike ends. There are several reasons for this. First, the firm may lose ground to competitors, and some of this loss may be permanent. For example, customers who cannot obtain supplies from this firm may switch to another firm, and to the extent that switching is costly (there may be lock-in effects), this may not easily be reversed. This effect is also important for new customers who are choosing a long-run supplier for the first time. Secondly, competitors may be able to get ahead on vital investments and innovations, which may put this firm in an unfavorable position in the future. An example of this is where the environment is imperfectly competitive and some other firm can make a pre-emptive move during the strike that puts it at a strategic advantage. Thirdly, the firm's machinery may depreciate more rapidly than usual during a strike due to lack of use or lack of maintenance. Finally, even if the firm can in principle carry out some of the above-named activities while the workers are on strike, e.g. innovation or maintenance, it may find it harder to finance these activities given the reduction in its cash flow (some imperfection in the capital market is required for this last argument).

It also seems likely that the decay of productive opportunities is not uniform over time. A short strike may impose very little cost on a firm, while a long strike may be much more serious. This is presumably because in the short-term the firm can supply customers out of inventory, and ground lost

in investment and innovation activity can be made up later. After a while, however, inventories run out and the firm may find that it has fallen irreversibly behind its competitors. In fact it may be reasonable to suppose that the profitability of a firm facing a strike depreciates sharply after a while, with the firm facing a "crunch" at a certain point.[9]

We will assume the existence of a crunch in what follows. It is convenient to model decay in productive opportunities by supposing that each period there is some probability that a firm facing a strike experiences disaster and becomes valueless before the next period; and that with one minus this probability the firm remains completely intact. (One can imagine that disaster occurs when a competitor takes a key long-term contract away from the firm or beats the firm in a crucial marketing decision.) This disaster-no disaster decay assumption is crude, but it turns out to be easier to handle analytically than the case of deterministic shrinkage in the firm's profitability. We suspect that our results are not particularly sensitive to the exact formalization used.

It is important to emphasize that we suppose that only firms experiencing a strike are in danger of losing their value. A firm that reaches agreement with the union and operates continuously thereafter is supposed to maintain its profitability forever at s.

We assume that the probability of a strike-bound firm surviving until day t (i.e. maintaining its value to that day), given that it has already survived to day (t - 1), is a constant λ if $t \leq T$; and another constant $\eta < \lambda$ if $t > T$. Here λ is taken to be very close to 1, but η may be significantly below 1. In other words the firm experiences a crunch at date T, with survival being less likely after that date.

A strike-bound firm's survival path is illustrated in Figure 1.

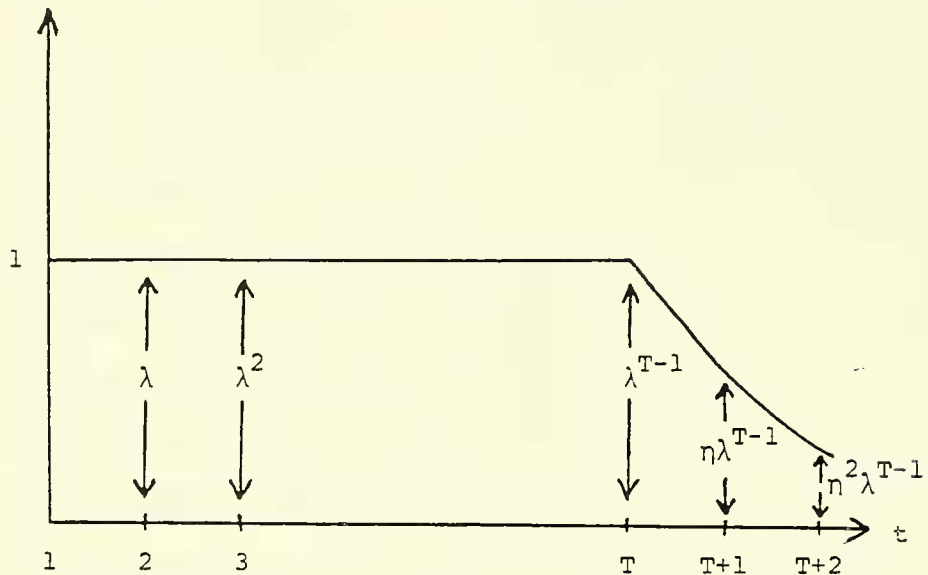Probability of a strike-bound firm surviving to date t

FIGURE 1

As in Section 2, we consider a union bargaining with a firm whose profitability $s = s_H$ with probability π_H and s_L with probability π_L. But now the firm faces stochastic decay, as described above. We compute the perfect Bayesian equilibrium under these conditions. Only two possibilities can arise. The first is that bargaining ends for sure on or before day T, while the second is that it doesn't. (We suppose that if the firm becomes valueless, this is public information and bargaining ceases at this point since there are no gains from trade. In what follows, we focus on a firm that survives. Note that the model of Section 2 is a special case of the present model with $\lambda = \eta = 1$.)

Possibility 1: Bargaining Ends on or Before Day T.

This possibility is easily analyzed along the lines of the last section. Suppose bargaining extends for n days. $1 \leq n \leq T$. Then on day n, the union's offered price must be s_L, so as to attract any remaining firm (i.e. any firm

that has survived, but has not yet accepted an offer). The prices on days 1, ... , n-1 will be such that a high firm is indifferent between accepting then and waiting until day n. This yields

$$w_n = s_L \tag{3.1}$$

$$s_H - w_k = \lambda^{n-k} \delta^{n-k} (s_H - s_L), \quad k = 1, \ldots, n-1 . \tag{3.2}$$

To understand (3.2), note that since the firm is risk neutral it is concerned only with expected discounted surplus. The probability that it survives to day n, given that it has survived to day k, is λ^{n-k}, in which case it receives discounted surplus of $\delta^{n-k} (s_H - s_L) / (1-\delta)$; while with one minus this probability it gets nothing. Let $\gamma \equiv \lambda\delta$. Then (3.1)-(3.2) can be rewritten as

$$w_k = (1 - \gamma^{n-k})s_H + \gamma^{n-k}s_L , \quad k = 1, \ldots, n. \tag{3.3}$$

In order to calculate the union's expected payoff from n period bargaining, $\hat{V}_n$, we proceed iteratively as in Section 2. Suppose that we have found that for the union to want bargaining to continue a maximum of k periods, the ratio of high firms to low firms must be at least $(1 - \hat{p}_k) : \hat{p}_k$ for $1 \leq k \leq n-1$, where $1 \equiv \hat{p}_1 > \hat{p}_2 > \ldots > \hat{p}_{n-1}$. Then

$$\hat{V}_n = (\pi_H - \frac{(1-\hat{\rho}_{n-1})}{\rho_{n-1}}\pi_L)w_1 + \delta(\lambda\frac{(1-\hat{\rho}_{n-1})}{\rho_{n-1}}\pi_L - \lambda\frac{(1-\hat{\rho}_{n-2})}{\rho_{n-2}}\pi_L)\,w_2$$

$$- \ldots - \delta^{n-2}(\lambda^{n-2}\frac{(1-\hat{\rho}_2)}{\rho_2}\pi_L - \lambda^{n-2}\frac{(1-\hat{\rho}_1)}{\rho_1}\pi_L)w_{n-1}$$

$$+ \delta^{n-1}\lambda^{n-1}\pi_L\, w_n \ . \tag{3.4}$$

Note that if $(1 - \frac{\hat{\rho}_{n-1}}{\rho_{n-1}})\pi_L$ high firms refrain from coming to agreement in

period 1, $(1 - \frac{\hat{\rho}_{n-1}}{\rho_{n-1}})\lambda\pi_L$ of them will survive to period 2 and since $\lambda\pi_L$ low

firms survive, the ratio of high to low firms at the beginning of period 2

will indeed be $(1 - \hat{\rho}_{n-1}): \hat{\rho}_{n-1}$. Similarly if $\lambda (1 - \frac{\hat{\rho}_{n-2}}{\rho_{n-2}}) \pi_L$ high firms

refrain from signing in period 2, the ratio of highs to lows in period 3 will
be $(1 - \hat{\rho}_{n-2}): \hat{\rho}_{n-2}$, etc.

Clearly the formula for $\hat{V}_n$ is exactly the same as in the previous
section, with $\gamma = \lambda\delta$ replacing δ everywhere. Hence so is the formula for $\hat{\rho}_n$:

$$\hat{\rho}_n = \frac{\gamma^{n-2}(s_H - s_L)}{s_H(\frac{1}{\rho_{n-1}} - \frac{(1-\gamma)}{\rho_{n-2}} - \gamma\frac{(1-\gamma)}{\rho_{n-3}} - \ldots - \gamma^{n-3}\frac{(1-\gamma)}{\rho_1})}, \qquad n = 2,3,.. \tag{3.5}$$

For future reference, it is useful to note that $\hat{V}_n$ is homogeneous of degree 1

in π_H, π_L, so that we can write

$$\hat{V}_n = \hat{V}_n \left[\frac{\pi_H}{\pi_L} \right] \pi_L . \qquad (3.6)$$

As in Section 2, the union will choose n = m to satisfy

$$\hat{\rho}_{m+1} < \pi_L < \hat{\rho}_m . \qquad (3.7)$$

We assume that the solution to (3.7), $\hat{m}$, is less than or equal to T, so that the crunch is not an effective constraint in Possibility 1:

(A) $\hat{m} \leq T$.

This is a weak assumption for, as we have just seen, smooth decay has the effect of increasing the discount factor from δ to $\lambda\delta$, and since $\hat{\rho}_n$ is increasing in the discount factor (Proposition 2), this means that the optimal value of n, $\hat{m}$, will be no greater than in the no decay case. That is, decay at the constant rate λ _shortens_ bargaining. This is hardly surprising given that lengthy bargaining becomes less profitable when productive opportunities can disappear. We will see that the presence of a crunch can dramatically change this conclusion.

Possibility 2: Bargaining Extends Beyond Day T

We now turn to the possibility that bargaining extends beyond day T. It is helpful to begin with the case where bargaining extends just past the crunch to date (T-1). In this case, $w_{T-1} = s_L$, while previous prices $w_1, \ldots$ $w_{\tilde{1}}$ are such that high firms are indifferent between accepting these and

holding on until (T+1):

$$w_{T+1} = s_L,$$

$$s_H - w_T = \eta\delta(s_H - w_{T+1}),$$

$$s_H - w_{T-1} = \lambda\delta(s_H - w_T), \text{ etc.}$$

We can rewrite this as

$$w_k = (1 - \gamma^{T-k}\zeta)s_H + \gamma^{T-k}\zeta s_L, \quad k=1, \ldots, T, \text{ where } \gamma = \lambda\delta, \ \zeta = \eta\delta.$$

Computation of the union's payoff is a little more difficult when bargaining extends past the crunch, since the environment is not stationary. The basic idea of the argument is the same as before, however. We compute the minimum number of high firms which must be left on day k for it to be credible that bargaining will continue to day (T+1).

Suppose the economy has reached day T. For the union not to want to end bargaining then, the number of high firms must be at least σ_T, where

$$\sigma_T w_T - \delta\eta\lambda^{T-1}\pi_L s_L = (\sigma_T + \lambda^{T-1}\pi_L)s_L$$

$$= \hat{V}_1 \left[\frac{\sigma_T}{\lambda^{T-1}\pi_L} \right] \lambda^{T-1}\pi_L . \qquad (3.8)$$

The left-hand side of (3.8) gives the union's payoff if the remaining highs accept on day T and the lows wait till (T-1), while the right-hand side is the payoff if bargaining ends on day T with a price of s_L. Note that $\lambda^{T-1}\pi_L$ is

the number of low firms still around on day T. (Of course, the left-hand side of (3.8) could exceed the right-hand side, but it will never be in the union's interest for this to happen.) (3.8) has a unique solution $\sigma_T > 0$. Note that σ_T is homogeneous of degree 1 in π_L, so that we can write $\sigma_T = \tilde{\sigma}_T \pi_L$, where $\tilde{\sigma}_T$ is independent of π_H, π_L.

Now consider day $(T-1)$. For it to be credible that bargaining will continue two more days, the number of high firms remaining at the beginning of period $(T-1)$, must be greater than or equal to σ_{T-1}, where

$$\left[\sigma_{T-1} - \frac{\sigma_T}{\lambda}\right] w_{T-1} + \delta\sigma_T w_T + \delta^2\eta\lambda^{T-1}\pi_L s_L = \text{Max}\left\{\hat{V}_1\left[\frac{\sigma_{T-1}}{\lambda^{T-2}\pi_L}\right]\lambda^{T-2}\pi_L, \hat{V}_2\left[\frac{\sigma_{T-1}}{\lambda^{T-2}\pi_L}\right]\lambda^{T-2}\pi_L\right\}. \quad (3.9)$$

The right-hand side of (3.9) is the union's maximum payoff from avoiding the crunch and ending the bargaining in one or two days, i.e. on day $T-1$ or day T. Since in this case we are in the smooth decay at rate λ model analyzed in Possibility 1, we can simply plug in the payoffs $\hat{V}_1$, $\hat{V}_2$ from this, with the appropriate initial conditions $\pi_H' = \sigma_{T-1}$, $\pi_L' = \lambda^{T-2}\pi_L$. Since $\hat{V}_1$ and $\hat{V}_2$ are linear in σ_{T-1} with coefficient smaller than w_{T-1}, it is easy to see that (3.9) has a unique solution $\sigma_{T-1} > \sigma_T/\lambda$. Moreover, it is the larger of the two solutions obtained by setting the left-hand side of (3.9) equal to $\hat{V}_1(\cdot)\lambda^{T-2}\pi_L$, $\hat{V}_2(\cdot)\lambda^{T-2}\pi_L$, respectively. Again $\sigma_{T-1} = \tilde{\sigma}_{T-1}\pi_L$, where $\tilde{\sigma}_{T-1}$ is independent of π_H, π_L.

The same procedure can be applied to obtain σ_{T-2}, σ_{T-3}, $\cdots$, σ_1. To find σ_{T-K}, we solve

$$(\sigma_{T-k} - \frac{\sigma_{T-k+1}}{\lambda})w_{T-k} + \delta(\sigma_{T-k+1} - \frac{\sigma_{T-k+2}}{\lambda})w_{T-k+1} + \cdots + \delta^K(\sigma_T - \frac{\sigma_{T+1}}{\lambda})w_T$$

$$+ \delta^{k+1} \eta \lambda^{T-1} \pi_L s_L$$

$$= \text{Max } \{\hat{V}_1 \left[\frac{\sigma_{T-k}}{\lambda^{T-k-1}\pi_L}\right]\lambda^{T-k-1}\pi_L, \ \hat{V}_2 \left[\frac{\sigma_{T-k}}{\lambda^{T-k-1}\pi_L}\right]\lambda^{T-k-1}\pi_L, \ \cdots$$

$$\cdots, \ \hat{V}_{k+1} \left[\frac{\sigma_{T-k}}{\lambda^{T-k-1}\pi_L}\right]\lambda^{T-k-1}\pi_L\}, \qquad (3.10)$$

where $\sigma_{T+1} \equiv 0$. In fact, the right-hand side can be simplified a bit when k is large: we need only consider the first $\hat{m}$ terms in the max expression, where $\hat{m}$ is the solution to (3.7). This is because once we have reached day T-k, given that some high firms will have accepted offers while no low firms will have, the ratio of high to low firms cannot exceed $\pi_H : \pi_L$. But it follows from Proposition 2 that bargaining will not last more than another $\hat{m}$ periods. Hence the terms $\hat{V}_j$, $j > \hat{m}$, can be ignored.

We have seen how to compute the union's payoff conditional on bargaining lasting (T-1) days. In particular, we have found the minimum number of high firms σ_1, σ_2, ... , σ_T which must remain at the beginning of periods 1, 2, ..., T for it to be credible that bargaining will continue a further T, T-1,..., 1 days. We have also seen that $\sigma_k = \tilde{\sigma}_k \pi_L$, where $\tilde{\sigma}_k$ is independent of π_H, π_L.

We must now compare this payoff to the payoff, $\hat{V}_{\hat{m}} (\pi_H/\pi_L)\pi_L$, which corresponds to Possibility 1. But this is easy, since in computing the σ_K's we have at each stage allowed the union to terminate bargaining before day

(T+1). In other words, if $\pi_H > \sigma_1$, then, by the definition of σ_1, the actual number of high firms on day 1 exceeds the minimum number necessary for the union to prefer the (T+1) period solution to the $\hat{m}$ period one. Hence the union does indeed prefer the (T+1) period solution in this case. On the other hand, if $\pi_H < \sigma_1$, the opposite is the case: the union prefers the $\hat{m}$ period solution.

So far we have considered the case where bargaining extends just to day (T+1). In general, of course, the union may wish bargaining to last longer than this. It is not difficult to show, however, (we sketch a proof below), that whenever the (T+1) day solution is preferred to the $\hat{m}$ day one, the union will choose bargaining to last <u>at least</u> (T+1) days. In other words, $\pi_H > \sigma_1$ is a <u>sufficient</u> condition (although perhaps not a necessary one) for extensive bargaining to occur.

<u>Proposition 3</u>: A sufficient condition for the union to want bargaining to extend past the crunch, i.e. to at least day (T+1), is that $\pi_H > \sigma_1$, or, equivalently, that $(\pi_H/\pi_L) > \tilde{\sigma}_1$.

<u>Proof</u> (sketch). Suppose $\pi_H > \sigma_1$. Let $V_t(\sigma)$ denote the (maximized) value to the union from bargaining from day t onwards, given the initial (i.e. date t) condition that the number of remaining high firms is σ; also let $w_t(\sigma)$ be the union's first (i.e. date t) wage offer (if the union is indifferent between several wage offers, choose the biggest). Similarly, let $V_t^{T-1}(\sigma)$ be the value to the union of following the (T+1) day solution, and let the first offer in this case be $w_t^{T-1}(\sigma)$. We will have proved the proposition if we can show that $V_1(\pi_H) \geq V_1^{T-1}(\pi_H)$. (Note that, given that $\pi_H > \sigma_1$, we know that the value of the $\hat{m}$ day solution is less than $V_1^{T-1}(\pi_H)$).

Recall that in the (T+1) day solution, the union's offers are $w_1, w_2, \ldots, w_{T+1}$, with $(\pi_H - (\sigma_2/\lambda))$ high firms accepting w_1, $\sigma_2 - (\sigma_3/\lambda)$ accepting $w_2, \ldots, \sigma_T$ accepting w_T, and all remaining low firms accepting w_{T+1}. Suppose the union and firm arrive at day T with σ_T high firms remaining, but the union now has the choice to extend bargaining beyond day T+1. Since it is feasible for the union to have all the high firms accept at w_T, this cannot make the union worse off; furthermore, to the extent that the union does choose to extend the bargaining beyond (T+1), its day T offer will rise (to keep the high firms indifferent between accepting now and waiting till bargaining terminates). Hence $V_T(\sigma_T) \geq V_T^{T+1}(\sigma_T)$ and $w_T(\sigma_T) \geq w_T^{T+1}(\sigma_T)$.

Now go back to day (T-1) and suppose that σ_{T-1} high firms remain. It is certainly feasible for the union to have $\sigma_{T-1} - (\sigma_T/\lambda)$ high firms accept its day (T-1) offer, just as in the (T+1) day solution. Since $V_T(\sigma_T) \geq V_T^{T+1}(\sigma_T)$, this would allow the union to do at least as well from day T onwards as in the (T+1) day solution; furthermore, to keep the high firms indifferent between accepting at (T-1) and at T, its (T-1) offer would equal $(1-\gamma)s_H + \gamma w_T(\sigma_T) \geq (1-\gamma)s_H + \gamma w_T^{T+1}(\sigma_T) = w_{T-1}^{T+1}(\sigma_{T-1})$, and so its date (T-1) payoff would rise or stay the same. Hence $V_{T-1}(\sigma_{T-1}) \geq V_{T-1}^{T+1}(\sigma_{T-1})$.

In addition, this argument shows that, given that the union starts on day (T-1) with σ_{T-1} high firms, there is an optimal strategy for the union which extends bargaining to at least day (T+1) (if $V_{T-1}(\sigma_{T-1}) > V_{T-1}^{T+1}(\sigma_{T-1})$, every strategy does this, while if $V_{T-1}(\sigma_{T-1}) = V_{T-1}^{T-1}(\sigma_{T-1})$, the (T-1) day solution does). Hence from the condition that high firms are indifferent between accepting today and waiting until the end of bargaining, we have $w_{T-1}(\sigma_{T-1}) \geq w_{T-1}^{T-1}(\sigma_{T-1})$.

Proceeding in this way for $t=(T-2), (T-3), \ldots$ we obtain $V_t(\sigma_t) \geq V_t^{T-1}(\sigma_t)$,

and $w_t(\sigma_t) \geq w_t^{T+1}(\sigma_t)$ for all t. In particular, $V_1(\pi_H) \geq V_1^{T+1}(\pi_H)$.

$$Q.E.D.$$

. The basic tradeoff facing the union can be understood as follows. Up to day T the union is involved in a bargaining game where the effective discount factor is $\gamma = \lambda\delta$; moreover, if the union terminates bargaining before day T+1, the union is involved <u>only</u> in this game. By dragging out the bargaining beyond day T+1, however, the union is able to participate in a second bargaining game with a lower effective discount factor $\zeta = \eta\delta$. Ceteris paribus this new game is more attractive for the union (at least over a certain range of parameters). In particular, if γ is close to 1, the payoff from the first game will be very close to s_L (by the Coase conjecture); while at the other extreme, if ζ is close to zero (the crunch is very severe), the union can, in the second game, approach its first-best payoff of $\pi_H s_H$ (a high firm that is very likely to disappear will pay close to s_H today even if it knows that the price will fall to s_L tomorrow).

So the union must trade off the benefits of participating in this second game against the costs of waiting until (T+1) for it to start. Proposition 3 tells us that the benefits of waiting outweigh the costs as long as $(\pi_H/\pi_L) > \hat{\sigma}_1$.

Since very severe crunches do not seem that realistic, in assessing the practical significance of the model, we need to know whether extensive bargaining is likely even when η is fairly close to 1.[10] Computing $\tilde{\sigma}_1$ analytically is difficult for large T, and so we have resorted to a computer for this. Some results are reported in Tables 1 and 2. It is not hard to get an idea of orders of magnitude, however. One strategy open to the union is to do nothing until the second game starts, i.e. to make no offers before day T;

at day T to offer $\hat{w}_T = (1-\zeta)s_H + \zeta s_L$ attracting every high firm; and at day (T+1) to terminate the bargaining with the price s_L, attracting every low firm. Although suboptimal, this is credible and gives a lower bound to the union's profit from a (T+1) day strategy. The payoff from this suboptimal strategy is

$$\gamma^{T-1}(\pi_H((1-\zeta)s_H+\zeta s_L) + \zeta\pi_L s_L) = \gamma^{T-1}(\pi_H(1-\zeta)s_H+\zeta s_L), \qquad (3.11)$$

which we must compare to $\hat{V}_m(\pi_H/\pi_L)\pi_L$. As we have noted, given "reasonable" values of π_L, π_H, and hence small values of $\hat{m}$, the latter will be very close to s_L. Hence, if

$$\gamma^{T-1}(\pi_H(1-\zeta)s_H + \zeta s_L) > s_L \qquad (3.12)$$

by more than a little, we can be confident that the union will prefer the (T+1) day strategy to the $\hat{m}$ day one. Setting $s_H = 2s_L$, $\pi_H = .85$, $\delta = .99974$, $\lambda = 1$, T = 90 days, we find that bargaining will extend to day 91 as long as $\eta = (\zeta/\delta) < .97$. Detailed computations for these parameters given in Table 1, row 1 support this conclusion, and show that 91 day bargaining will in fact occur for values of η as large as .99. That is, the model can explain extensive bargaining even when the crunch is quite mild (probability of death = 1% per "day").

Tables 1 and 2 also contain computations for other parameter values. (3.12) suggests that bargaining past the crunch is more likely to occur when (i) T is small; (ii) $\pi_H s_H/s_L$ is large; (iii) $\eta = (\zeta/\delta)$ is small (since the coefficient of ζ, $s_L-\pi_H s_H$, is negative); (iv) λ is large. These are all intuitive. If T is small or λ is large, it is cheap for the union to wait till the crunch. If η is small, the benefits to the union of waiting until

the crunch are large. Finally, if $(\pi_H \, s_H/s_L)$ is large, there are substantial gains from separating the highs from the lows.

(i)-(iii) are confirmed in Table 1. With T=90, s_H/s_L = 2 and λ = 1, the critical value of η for extensive bargaining to occur falls from .99 when π_H = .85 to .977 when π_H = .75 (recall that we require $\sigma_1 < \pi_H$). A decrease in (s_H/s_L) to 1.5 reduces the critical value of η further to .845, while an increase in T to 120 brings an additional reduction to .795.[11]

It is noteworthy that the crunch does not need to be very severe for the union to want to drag out the bargaining. For all the parameter values in Table 1, bargaining would last at most three days if η = λ. But with λ = 1, η < .968 and $s_H = 2s_L$, we can get bargaining of 91 or 121 days! Furthermore, the expected bargaining time conditional on a strike occurring is substantial, ranging from 58 to 104 days in Table 1.[12] [13]

While we have described a 1% probability of death per period as quite mild, it must be admitted that such a probability implies a very large attrition rate over an extended interval of time such as a year (97.5% probability of death if each period is a day; 71% probability of death if a period is three days). Note, however, that none of our results would change if the crunch were temporary rather than permanent. That is, suppose that the crunch starts on day T but is known to last only to day T+k (k $\geq$ 1), i.e. the survival probability of the firm reverts to λ at this date (the idea might be that there is a critical period during which the firm is vulnerable but that a firm which weathers this is (relatively) safe thereafter; this will, of course, give rise to much lower overall attrition rates). Then it is easy to see that if (T-1) day bargaining is optimal when the crunch is permanent, it will continue to be optimal when the crunch is temporary (the (T-1) day solution can still be implemented, while lengthier bargaining becomes less attractive). In particular, extensive bargaining will occur for all the

parameter values reported in Table 1 (see footnote 11).

It is also worth noting that our results would not change substantially if the increase in the decay rate from λ to η occurred more slowly, i.e. there was a gradual build-up to the crunch. In particular, the lower bound on the value of extensive bargaining obtained in (3.11) holds independently of the process by which the rate of decay reaches η, and so, as long as the gradual build-up does not greatly increase the attrition rate of firms before date T, the trade-off facing the union will remain very much the same.

In Table 1, the values of η are such that the union is almost indifferent between extensive and short bargaining (π_H is very close to σ_1). A consequence is that the probability of a settlement on day 1, $\pi_H - (\sigma_2/\lambda)$, is quite small. In Table 2 we consider cases where π_H is substantially greater than σ_1 and where the probability of a day 1 settlement is significant. In Figures 2 and 3, we graph the pattern of settlements for a representative case, corresponding to row 1 of Table 2. The distribution is strongly trimodal, with the vast majority of settlements by high firms occurring on days 1 and 90, and settlements of low firms (which are not graphed), occurring on day 91. The probability of a settlement on days 1, 90 or 91 is of the order of .88, while that of a settlement between day 1 and day 90 is about .12.

This trimodal feature is not observed in the data on the distribution of strikes.[14] In fact, the empirical histogram suggests that the frequency of strikes is not far from being a decreasing function of time (with a few hiccups). Our model can be made consistent with this observation, however, if we drop our assumption that the crunch starts on the same day T for all firms. In particular, suppose that there is a distribution of crunch dates in the population of firms; but continue to assume that each union knows its own firm's T before it starts bargaining (imagine that the other parameters s_{ij}.

s_L, π_H, π_L, η, λ are constant across firms). In general, the effect of such a distribution will be to smoothen out the frequency histogram. For the one case which we have studied in detail -- where T is uniformly distributed on [1,90] -- the overall frequency of strikes can be shown now to be a decreasing function of time.

As a final observation, it is worth noting that the model can explain substantial rates of wage decline, as long as η is not too close to 1. For example, when $(s_H/s_L) = 2$, $\pi_H = .75$, T = 90 and $\eta = .9$, the rate of wage decline is about 44% a year (row 1, Table 2), and this rises to about 75% a year when T = 120 and $\eta = .8$. The wage path is graphed for the former case in Figure 4.

In conclusion, let us mention some ways in which this work could be extended. First, a number of theoretical developments are possible. We have noted that it may be useful to consider the case where different firms have different crunch times. It may also be interesting to analyze the possibility that the crunch time is a random variable as of date 1, with the parties receiving information about its realization as bargaining proceeds. This also seems likely to smoothen out the bargaining process.

A second theoretical extension is to drop the assumption that the crunch date is exogenous. We have noted that one reason for an increase in the firm's rate of decay after a point is that the firm runs out of inventories. Inventories are, however, a choice variable for the firm and one might imagine that firms would try to build up their inventories before a strike starts. Introducing a strategic role for inventories seems likely to enrich the model considerably. [15].

It may also be worthwhile to drop the assumption that rates of decay are the same for all firms. It may be argued, for example, that supernormal profit opportunities are more fragile than normal ones, i.e. they have a

higher death rate, if only because even if the latter die, they are likely to be replaced by other normal opportunities. This suggests that rates of decay may be higher for profitable firms than for unprofitable firms. Preliminary investigation indicates that bargaining times will be even longer under this differential decay hypothesis. The reason is that delay to agreement now has extra value as a way to screen profitable firms from unprofitable ones. In fact it now appears that extensive bargaining can occur even if $\pi_H s_H < s_L$, i.e. even if the standard model would predict no strikes at all.

Finally, while we have tried to indicate that the model presented here is consistent with some of the data on strikes, we have made no attempt to subject it to a formal test. In future work, it may be desirable to do this, in the same way that Fudenberg-Levine-Ruud (1984) and Tracy (1983) have recently tried to test the standard bargaining model.

4. Concluding Remarks

We have shown that in a model where profitable opportunities decay over time at a nonconstant rate extensive bargaining can occur even if the intervals between bargaining are quite short. At least two major questions have not been addressed. First, some empirical work suggests, that, when other variables are corrected for, wages rise with strike length. This observation, if it is indeed correct, is not consistent with a model where only the firm has private information. It would be interesting to see where the ideas presented here could be extended to explain delay when the private information lies on the union side.

Secondly, bargaining models like the one presented here only explain delay during initial negotiations between the union and the firm. They do not explain why strikes occur at a later date after the first contract is signed. In other words they do not tell us why firms and unions do not sign a single

contract lasting to the end of time which, among other things, rules out future strikes. Transaction costs and contractual incompleteness seem to be the keys to this, but an analysis of how strikes arise in the presence of these factors remains to be carried out.

TABLE 1

Sets of Parameters that Illustrate the Largest Values
of Eta Consistent with Bargaining Until Day T+1

S_h	S_l	π_h	π_l	T	eta	σ_1	w_1	Expected Duration-1	Expected Duration-2	Annual % Wage Change
Parameters(**)						Results(***)				
2	1	.85	.15	90	.990	0.846	1.0330	57.53	57.58	-13.0
2	1	.75	.25	90	.977	0.743	1.0461	66.69	66.83	-17.9
2	1	.75	.25	120	.968	0.737	1.0617	89.24	89.49	-23.6
1.5	1	.75	.25	90	.845	0.743	1.0873	77.45	77.94	-32.6
1.5	1	.75	.25	120	.795	0.747	1.1147	103.09	103.96	-41.7

*) Recall that bargaining to day T+1 occurs as long as $\sigma_1 < \pi_h$.

**) Lambda = 1.0 (so no deaths before day T+1), Delta = .9997401

***) Expected Duration-1 is defined over the set of types who eventually
        settle, excluding those that settle immediately (without striking)
    Expected Duration-2 is defined over all types who don't settle
        immediately. The firms who die at time T+1 are treated as if they
   settled that day.

TABLE 2

Sets of Parameters that Illustrate Many
Settlements at Time 1

Parameters(*)						Results(**)				
S_h	S_l	π_h	π_l	T	eta	σ_1	w_1	Prob. of a Settlement at time 1	Expected Duration-2	Annual % Wage Change
2.0	1	.750	.250	90	.900	0.36677	1.1208	0.385	80.853	-43.72
2.0	1	.750	.250	120	.850	0.35458	1.1761	0.396	108.981	-60.73
1.5	1	.750	.250	90	.750	0.64682	1.1337	0.105	81.775	-47.82
1.5	1	.750	.250	120	.700	0.66515	1.1608	0.086	108.212	-56.16
2.0	1	.750	.250	90	.850	0.32791	1.1697	0.423	83.343	-58.83
2.0	1	.750	.250	120	.800	0.32847	1.2246	0.422	111.251	-74.37
1.5	1	.750	.250	90	.650	0.60358	1.1825	0.148	83.753	-62.60
1.5	1	.750	.250	120	.600	0.62236	1.2092	0.129	110.723	-70.17

(*) Lambda = 1.0 (so no deaths before day T-1), Delta = .9997401

(**) Expected Duration-1 is defined over the set of types who eventually
      settle, excluding those that settle immediately (without striking)
   Expected Duration-2 is defined over all types who don't settle
      immediately. The firms who die at time T+1 are treated as if they
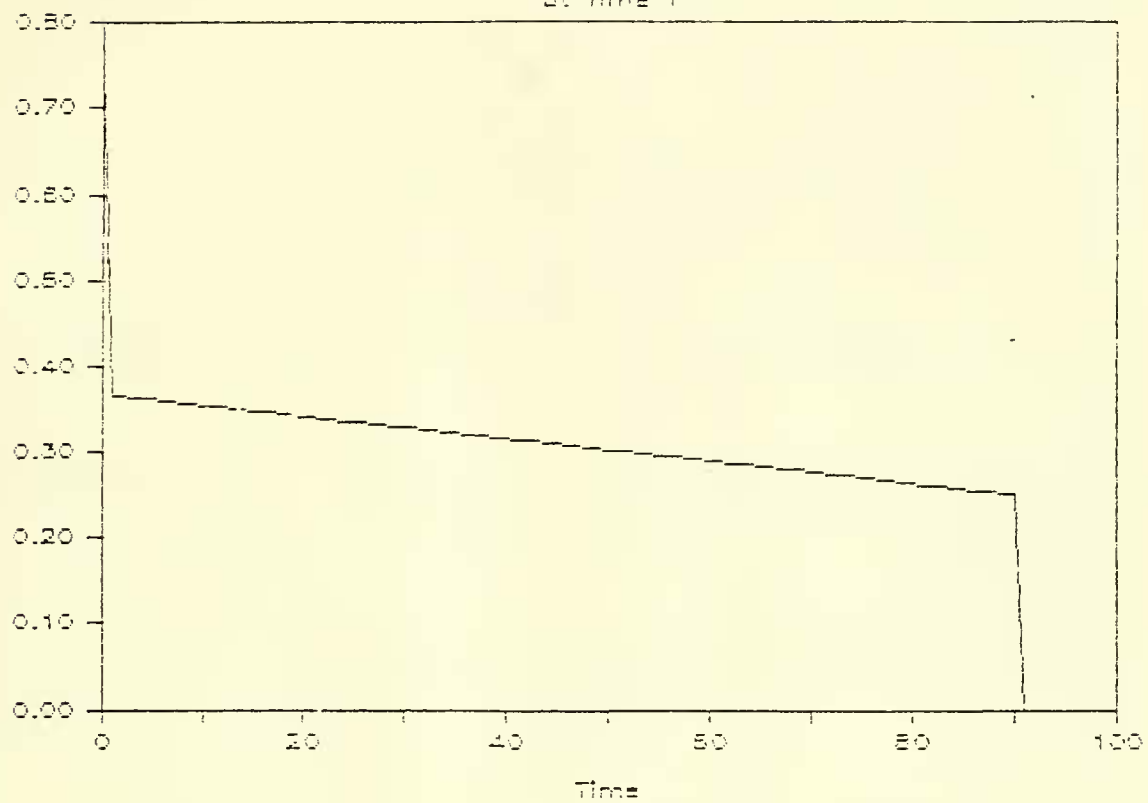   settled that day.

Probability of a High Type Settling
at Time T
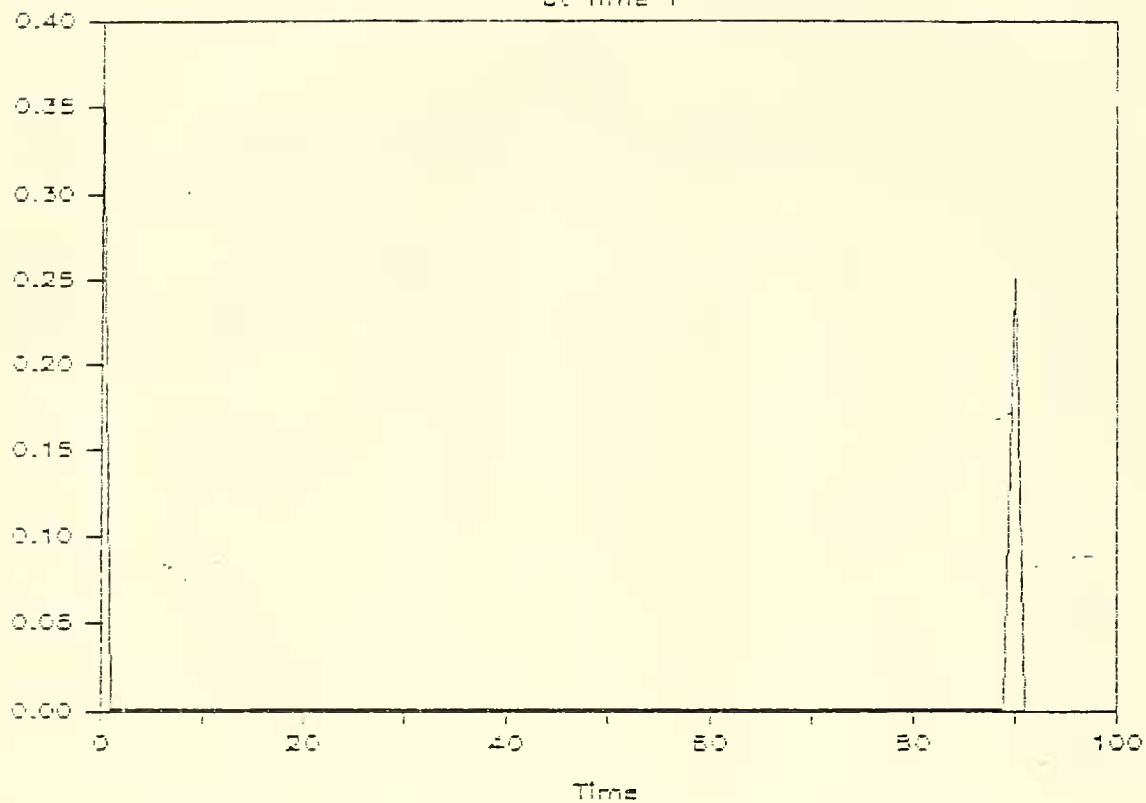
$S_H = 2$, $S_L = 1$, $\pi_H = .75$, $\pi_L = .25$, $T = 90$, eta $= .9$
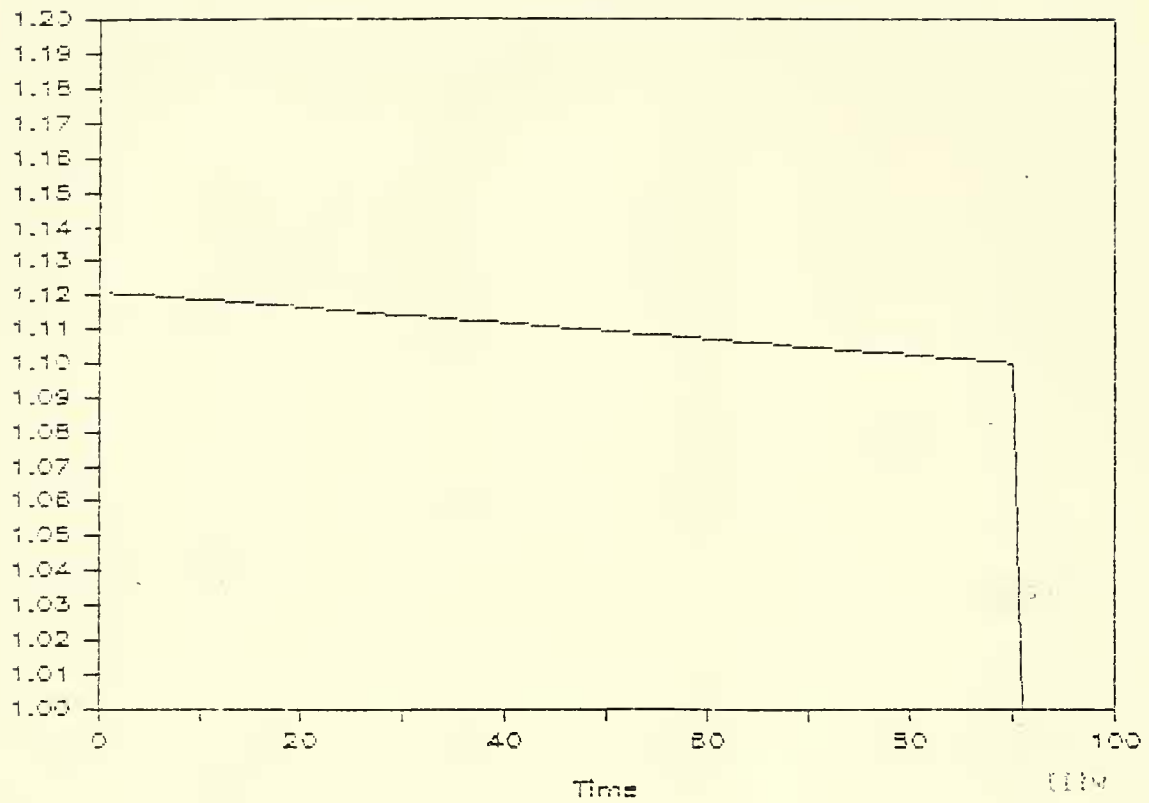
FIGURE 2

"Number" of High Types Remaining at Time T

$S_H = 2$, $S_L = 1$, $\pi_H = .75$, $\pi_L = .25$, $T = 90$, eta $= .9$

FIGURE 3

Wage Offer at Time T

$S_H = 2$, $S_L = 1$, $\pi_H = .75$, $\pi_L = .25$, $T = 90$, eta $= .9$

FIGURE 4

Footnotes

1. See, for example, the labor contracting model analyzed in Grossman-Hart (1981).

2. This idea is explored in a recent paper by Dewatripont (1985).

3. Other approaches to resolving this problem are possible. First, in some situations, it may be reasonable to suppose that one party can commit itself not to make another offer. In the insurance case, for example, an insurance company may be able to convince high risk customers that it will not lower the price of full coverage in the future by guaranteeing that if it does so it will offer the same terms to existing customers. This strategy seems less likely to be available in one-on-one situations involving a firm and a union or a manager and a principal, where there aren't many existing customers to "police" the commitment. Specifically, if a union, say, tries to commit itself not to lower wages in the future by promising to pay its firm a large penalty if it does so, then if gains from trade will be lost unless wages are lowered, it will be in the interest of the firm to release the union from this promise ex-post. (Having the union pay the penalty to a third party does not solve this problem if the third party can also be persuaded to release the union from the promise ex-post.)

   Secondly, even if commitment is impossible, reputation may sometimes substitute for this. For example, it may be credible to a firm that a union will not come back with another offer five minutes

after its first offer has been rejected, since this will hurt the union in future negotiations. Unfortunately, a desire to establish a reputation is also consistent with many other types of behavior, and so it may be dangerous to rely too much on this as an explanation of strikes (or inefficiency). Finally, the GSW "no delay" result applies only to one sided asymmetric information models. Delay can arise in models where workers also have private information -- e.g. about their opportunity costs. It's unclear at this stage, however, whether a "plausible" equilibrium with delay can occur when -- as seems realistic in most situations -- it's known in advance that there are certain gains from trade between the firm and union.

4. Think of the difficulty of organizing frequent department meetings!

5. While we have concentrated on behavior along the equilibrium path, it is straightforward to show that this solution is supported by appropriate behavior off the equilibrium path.

6. We ignore the unlikely possibility that $\pi_L = \rho_m$ for some m.

7. To be more specific, if very large values of (s_H/s_L) occur under conditions of asymmetric information, one would also expect to observe them when there is symmetric information. But under symmetric information, if the union has all the bargaining power, $w = s$, and so the result should be an enormous variation in wages across different firms. (Even if the union and firm split the surplus, the percentage variation would be enormous.) We do not seem to observe this.

8. In reality firms and unions sign limited term contracts (e.g. for three years in the U.S.) rather than the infinite length contracts supposed here. This has the effect of reducing the net present value of the firm's profit from $(s/(1-\delta))$ to $(ks/(1-\delta))$ where $k < 1$. This does not alter any of our results since only the relative net present values of different firms are important. However, under a more realistic set of assumptions, where, say, labor has an opportunity cost (see below), bargaining times are likely to be reduced.

Even when contracts are of limited term, it can be argued that to the extent that today's contract influences the terms of the next contract, each contract will have repercussions for the distant future. Given this, the infinite length contract assumption may actually not be a bad approximation to reality after all.

9. Perry, Kramer and Schneider (1982) emphasize that a firm's ability to maintain supplies to long-standing customers during a strike has a major impact on long-run profitability. Perry, Kramer and Schneider are concerned with firms that continue to operate during a strike, but what they report provides support for the idea that a firm which cannot continue production or obtain supplies elsewhere will find its profitability shrinking rapidly once it runs out of inventories (or is perceived to be about to run out).

10. Note that a low value of η becomes more reasonable the longer is the period between successive offers. A death rate of 5% is more plausible if the period in question is three days than if it is one day.

11. It is worth mentioning that, for all the parameter values in Tables 1 and 2, we have used the computer to check that the union will want to terminate bargaining on day (T+1) rather than at a later date; i.e. the (T+1) day solution really is optimal in these cases.

12. An issue arises about how to deal with the firms that don't survive during the bargaining period. Given that their value is zero and the union's opportunity cost is also zero, the union is indifferent between settling with them (at a price of zero) and not. Our figures for the expected strike length conditional on a strike occurring are therefore reported both for the case where survivors are included and for the case where they aren't. (In Tables 1 and 2, $\lambda=1$ and so deaths occur only on day T+1.) In fact, as we noted in Section 2, very few strike negotiations seem to lead to closure, so perhaps a better assumption in general is that nonsurvivors have a low profitability $\underline{s}$, which is strictly above the union's opportunity cost. Given our assumption that the "death" of a firm is publically observed, death will be followed immediately by a settlement at $\underline{s}$. Since nonsurviving firms get no surplus, our calculations of the perfect Bayesian equilibrium are unaltered by this modification.

13. As we have noted, the data on strikes yield a smaller conditional expected bargaining time of around 40 days. Our results can easily be made consistent with this figure, however. Simply suppose that the empirical distribution of firms is a mixture of two distributions, one of which is the "high variance" distribution we have considered and the other of which is a "low variance" distribution. Assume furthermore that the union observes which distribution its firm is drawn from. Then

the low variance distribution will generate short strikes, which will
bring the conditional expected bargaining time down. Note also that, in
this way, the overall probability of a strike can be made close to the
empirically observed figure of 15%.

14. See, for example, the data on part of U.S. manufacturing collected by
Wayne Vroman at the Urban Institute, Washington; Vroman (1981, 1982).

15. See Reder and Neumann (1980). Reder and Neumann find that firms for
which inventory holding is cheap experience <u>longer</u> strikes, which
appears to go against what our model would suggest. Note, however,
that, as Reder and Neumann recognize, this positive correlation could
result from the fact that firms which are likely to experience strikes
for other reasons (e.g. because $(\pi_H s_H/s_L)$ is large) build up
inventories.

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