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A MODEL OF WAGE CONTRACT BARGAINING WITH IMPERFECT INFORMATION AND STRIKES

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I. Introduction

This paper presents a model of bargaining and strike activity based on rational behavior and incomplete information. We assume that both the union and the firm have private information about their own position and that both parties disguise their optimal wage when making wage offers. Both the firm and union bargain to extract information about the other's position.

Our model formally describes the effects on bargaining of some costs in Ashenfelter and Johnson [1]. We include costs of prestrike bargaining and of bargaining during strike as well as a measure of expected costs of negotiating a suboptimal contract. The model features uncertainty on both sides of bargaining and allows negotiations to occur during both the current contract and subsequent strike or lockout. These are realistic extensions of the incomplete information literature on bargaining as presented in Hayes [2] and Tracy [4].

II. Wage Offers

The basis of wage offers in our model are the union's labor supply and the firm's labor demand which are:

$$l^s = e^s(w - p) + \alpha$$
$$l^d = e^d(w - p) + \beta.$$

The model is in log-linear form. Both labor supply, l^s, and labor demand, l^d, are functions of the real wage. The supply and demand elasticities are e^s and e^d, respectively. Following Mauro [3], private information is incorporated into the model through α, known only by the union, and β, known only by the firm. The term α might represent union tastes while β might represent technology.

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In each round of negotiations, both the union and the firm present wage offers. We assume that the nominal wage is jointly determined from the offers in the final round of negotiations. Employment during the contract is determined either by rationing or by labor demand. We also assume that both the union and the firm wish to achieve the market clearing wage, w^*, which will be

$$w^* = p - (\alpha - \beta)/(e^s - e^d).$$

If the parties did not disguise their wage offers and there were no private information, the wage w^* would be chosen by both parties. The existence of private information alone creates a situation where one round of bargaining would be sufficient to infer the missing information. Since each party may benefit (at the other's expense) if complete information about the other's position were available, we assume that both parties disguise their estimate of the market clearing wage before presenting their wage offers. With both imperfect information and disguised wage offers, several rounds of negotiation are necessary to obtain low variance estimates of the private information.

Wage offers presented by the union and firm in each round of negotiations are based on their expectations of the market clearing wage given their current information. Only the union's behavior is discussed below because the firm's problem is formally equivalent. Both the union and firm have prior distributions for the private information of the other party. We assume that these distributions are publicly known, normal, and independent. Initial public information also includes e^d, e^s, and the price level p. The union's initial information set is $I_{u0} = \{e^d, e^s, \alpha, p\}$. The union's expected nominal market clearing wage is

$$E[w^*|I_{u0}] = p - \theta\alpha + \theta\beta_0,$$

where $\beta_0 = E[\beta|I_{u0}]$, the mean of the union's prior distribution for β, and $\theta = 1/(e^s - e^d)$. The union disguises the wage offer by adding a random term, μ_1, to the expectation of the market clearing wage to obtain a wage offer of

$$w_{u1} = p - \theta\alpha + \theta\beta_0 + \mu_1.$$

The firm disguises its offer with a similar random term, ϵ. Both μ and ϵ are assumed to have normal distributions with zero means and publicly known variances σ_μ^2 and $\sigma_\epsilon.^2$.

After each round of bargaining, the information sets of the union and firm are augmented by the additional information contained in the wage offers: For the union after round n, the updated information set becomes $I_{un} = \{I_{un-1}, \Gamma_n\}$ where $\Gamma_n = w_{fn} - p + \theta E[\alpha|I_{fn-1}] = \beta\theta + \epsilon_n$. Here w_{fn} is the firm's wage offer and $E[\alpha|I_{fn-1}]$ represents the firm's expectation of α given information, I_{fn-1}, available after $n-1$ rounds.

Both parties use Bayesian theory to update their estimates of the other party's unknown information. The union's expectation of the firm's private information is

$$E[\beta|I_{un}] = \{n\Sigma\Gamma_i/\theta + \sigma_\epsilon^2\beta_0/(\theta^2\sigma_0^2)\}/\{n + \sigma_\epsilon^2/(\theta^2\sigma_0^2)\},$$

where σ_0^2 is $\mathrm{Var}(\beta|I_{u0})$.The conditional variance of the unknown information is

$$\mathrm{Var}[\beta|I_{un}] = \{n\theta^2/\sigma_\epsilon^2 + 1/\sigma_0^2\}^{-1}.$$

As n goes to infinity, the posterior mean will approach β. The longer the union negotiates, the better its prediction of the market clearing wage. However, if negotiating is costly, the union and firm will not bargain indefinitely.

III. Costs of Contract Negotiation

The total number of negotiation rounds is $n = b + s$. In this expression, b is the length of pre-contract expiration bargaining and s is the strike length, measured by the number of negotiation rounds following contract expiration. Time T^* is the expiration date of the current contract. Contract negotiations will extend from time $T^* - b$ to $T^* + s$, while the next contract runs from $T^* + s$ to $T^* + s + T'$.

Each round of negotiations creates a fixed administrative cost, c_n. If negotiations are not successfully completed by the expiration of the current contract, we assume that a strike or lockout will occur. This generates an additional fixed cost per round, c_s, which represents either utility or wage loss for the union and profit loss for the firm. A third cost is the opportunity cost of not achieving the optimal wage for the contract. This cost, c_e, is positive as long as some private information exists at the end of contract negotiations. For the union, c_e is proportional to the variance of $w^*|I_{un}$, the estimate of the market clearing wage given information received or

$$c_e = \{K/\theta^2\}/\{\theta^2(b+s)/\sigma_\epsilon^2 + 1/\sigma_0^2\}.$$

K will increase with both the cost of not achieving the market clearing wage and the degree of union risk aversion. This cost is incurred for each period in the life of the next contract.

Thus, costs per round are c_n prior to contract expiration and the sum of c_n and c_s following contract expiration. Each round of negotiations reduces the cost of contract inefficiency, c_e. This reduction occurs because each wage offer contains additional information about the true value of the market clearing wage.

IV. The Optimal Length of Negotiations

The parties to bargaining choose the length of negotiations to minimize the costs of negotiation. We consider this problem in two parts: First, we examine the behavior of the union. We derive the optimal length of negotiations when the union is unconstrained and when it is constrained by the optimizing decision of the firm. Second, we combine the union and firm solutions to find the negotiation pattern consistent with the behavior of both parties.

Analysis of Union Behavior

In this section we derive the behavior of the union under our assumptions on information gathering. We assume that the union discounts costs at a constant rate, r. Costs are measured at time $t = 0$, where the time horizon of interest is the negotiation and contract cycle which runs from $T^* - b$ to $T^* + s + T'$.

The union faces the following costs of negotiation:

$$C = \int_{T^*-b}^{T^*} c_n e^{-rt}dt + \int_{T^*}^{T^*+s} (c_n + c_s)e^{-rt}dt + \int_{T^*+s}^{T^*+s+T'} c_e e^{-rt}dt \tag{1}$$

The first integral is the cost of bargaining for b periods prior to contract expiration. The second integral is the cost of negotiating during a strike of s periods. The third integral is the cost of not achieving the optimal wage. The partial derivatives of this cost equation with respect to b and s are:

$$dC/db = e^{-rT^*}[c_n e^{rb} + \{K/r\sigma_\epsilon^2\}\{\theta^2(b+s)/\sigma_\epsilon^2 + 1/\sigma_0^2\}^{-2}e^{-rs}(e^{-rT'} - 1)] \tag{2}$$

and

$$\begin{aligned} dC/ds =& e^{-rT^*}[(c_n + c_s)e^{-rs} + \{K/r\sigma_\epsilon^2\}\{\theta^2(b+s)/\sigma_\epsilon^2 + 1/\sigma_0^2\}^{-2}e^{-rs}(e^{-rT'} - 1) \\ &+ \{K/\theta^2\}\{\theta^2(b+s)/\sigma_\epsilon^2 + 1/\sigma_0^2\}^{-1}e^{-rs}(e^{-rT'} - 1)] \end{aligned} \tag{3}$$

Investigation of the second order conditions shows that no pair (b, s) that sets (2) and (3) to zero also minimizes (1). The solution of this cost minimization problem will involve

either all strike or all precontract expiration bargaining with strike more likely the smaller is c_s or the larger is r.

First, consider the case where the union wishes to strike exclusively. The solution for strike length, s, will set (3) to zero subject to $b = 0$. This equation may be solved for positive s as long as

$$c_n + c_s \leq K\sigma_0^4(1 - e^{-rT'})/(r\sigma_\epsilon^2) + K\sigma_0^2(1 - e^{-rT'})/\theta^2 \tag{4}$$

The first term on the right hand side of (4) is the reduction in inefficiency cost over the life of the contract due to the initial round of negotiation. The second term represents the reduction in cost from postponing the inefficiency cost one period. Thus, the union would choose to strike as long as the benefits to the first round of striking exceeds the costs.

Comparative statics analysis shows that increases in either the cost of negotiation, c_n, or the cost of strike, c_s, decrease the optimal strike length. An increase in contract length, T', increases the desired strike length. An increase in the cost of deviating from the optimal wage, K, increases the optimal strike length as does an increase in the noise in the firm's wage offers, σ_ϵ^2.

These results may change if the union optimizes subject to the firm's behavior. The union's optimal decision will not be affected either by the firm's desire to bargain before the current contract ends or by the firm's desire to lockout for less time than the union's unconstrained optimal strike length. If the firm wishes to negotiate for a longer period, s', than the union after the contract has expired then the cost minimizing choice is to strike for s' periods.

The second case to consider is that where the union's optimal choice is bargaining prior to contract expiration. The optimal length of bargaining is derived by setting equation (2) to zero with $s = 0$. The optimal amount of prestrike negotiation is positive as long as

$$c_n < K\sigma_0^4(1 - e^{-rT'})/(r\sigma_\epsilon^2) \tag{5}$$

This will hold as long as the reduction of inefficiency costs associated with the first round of negotiation exceeds the cost of negotiation.

Comparative statics analysis shows that an increase in the cost of prestrike negotiation unambiguously reduces the desired amount of bargaining. An increase in the cost of not achieving the optimal wage, K, leads to an increase in the desired amount of bargaining. An increase in either contract length, T', or in the noise in the firm's wage offers, σ_ϵ^2, increases the optimal amount of bargaining.

If aware of the firm's behavior, the union may modify its optimizing decision to bargain prior to contract expiration. There are two possible types of firm behavior: First, the firm may wish to negotiate for a period, n', longer than the union. If n' is long enough that the present discounted cost of the first period of bargaining is greater than the present discounted cost of the last period of strike, the union's cost minimizing decision is to strike exclusively. If n' is short, the cost minimizing decision is to bargain for the length of time required by the firm. The optimal strike length will be zero.

Second, the firm may wish to negotiate for a shorter time than the union. The union's optimal choice is a combination of pre-expiration bargaining and strike. The total length of negotiations will be less than the amount of time the union wished to spend in pre-expiration bargaining.

We have not explicitly discussed the firm's optimization decision in this section. Since the problems of the union and firm are formally identical our discussion above would also apply to the firm.

Equilibrium

In this section we outline the determination of negotiation duration when each party (union and firm) makes its decision conditional on the behavior of the other party. There are four possible outcomes:

First, the unconstrained optimal decisions for both parties are exclusively pre-expiration negotiations. In this case the party with the longer desired negotiation period will be willing to strike. The party with the shorter desired period of negotiations is willing to match the other party's negotiation period, however. We observe negotiations beginning early enough prior to contract expiration to accommodate the party with the longest desired negotiation period.

Second, the unconstrained optimizing decision of the union is to strike while the optimum for the firm is pre-contract expiration negotiation. In this situation the firm cannot force the union to negotiate. The firm must determine its desired period of negotiations during a strike. The actual amount of post-expiration negotiations will be determined by the party with the longer desired strike or lockout period.

Third, the firm's unconstrained optimum is lockout while the union's unconstrained optimum is pre-expiration negotiations. The union must determine its desired period of post-expiration negotiation. As in the second case, the actual amount of post-expiration negotiation is determined by the party with the longer desired negotiation period. Although we have not proven this, our presumption is that the firm will determine the length of negotiations in this case while the union would for the second case.

Finally, the unconstrained decision of the union is to strike and the firm's decision is to lockout. Since the party with the shorter post-expiration negotiation period cannot force the other to change, the length of strike or lockout in this case is determined by the party that wishes to negotiate the longest after the contract expires.

This discussion shows that strikes or lockouts may occur even when each party is completely aware of the behavior of the other. As long as one party wants to strike or lockout a work stoppage occurs.

V. Extensions

We are currently developing several extensions of the model. Some are outlined below:

Contract length could be determined by this model if we assumed that the union and firm have a joint fixed time horizon. Contract length could be endogenous without a fixed time horizon if we allowed α and β to be time dependent.

Although we have specified that negotiations after contract expiration may only occur during a lockout or strike, this is not required by our model. Presumably if work continued after contract expiration the c_s terms for each party would be lower. Post-contract negotiation would be more likely in this case. To incorporate that possibility fully, the c_s term must also measure inefficiency losses to operating under the old contract.

We have assumed that the cost per period of negotiation is constant. This may not be completely realistic for either unions or firms. Union members may experience decreasing costs if they take other jobs during a strike. This may increase the propensity of the union to strike. The firm's costs per period of strike or lockout may increase over time as inventories run out. This would decrease the likelihood of firms wishing to lockout.

VI. Conclusion

We presented a model wage bargaining between a union and firm was valuable because it allowed each party to gather information about the other. The model makes detailed

predictions about the extent of contract negotiation observed. In some cases information gathering can be valuable enough that a strike or lockout is optimal behavior.

References

1. Ashenfelter, Orley and Johnson, George, E., "Bargaining Theory, Trade Unions, and Industrial Strike Activity." *American Economic Review*, March 1969, 35-49.

2. Hayes, Beth, "Unions and Strikes with Asymmetric Information." *Journal of Labor Economics*, January 1984, 57-83.

3. Mauro, Martin J., "Strikes as a Result of Imperfect Information." *Industrial and Labor Relations Review*, July 1982, 333-355.

4. Tracy, Joseph S., "Contract Negotiations and Strikes," manuscript, Yale University, 1985.