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Sequencing Strategically: Wage Negotiations Under Oligopoly

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ABSTRACT

In a unionized oligopoly, such as the American automobile industry, should the union (such as the United Auto Workers) negotiate new contracts by bargaining with the firms simultaneously, or should it "strategically sequence" its bargaining partners? This paper analyzes two models of noncooperative bargaining and product market oligopoly. In the first, bargaining is over wages and employment, in the second, it is over wages alone; employment and output are determined by the firms in a post negotiation product market game. One effect of sequencing bargaining partners is present in both scenarios : it allows preexisting contracts at the firms not being currently bargained with to act as "status quo points" that influence the bargaining outcome of the negotiations currently on. The better are the preexisting contracts from the union's point of view, the more attractive is the option of sequencing. In the second model, there is another channel, operating via the post negotiation product market game that tends to make sequencing preferable. By negotiating a relatively high wage with the first firm, the union can raise the profitability of the second firm in the product market game ; consequently, it can get a higher wage there as well, as its share in the incremental revenue that accrues. Moreover, the first firm is less reluctant to concede a higher wage (than under simultaneity) since it knows that the negative impact of that on its profits will be partly alleviated as the second firm will also make a larger concession.

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1. INTRODUCTION

Should the United Auto Workers (UAW) bargain over wage contracts simultaneously with GM, Ford and Chrysler, or should it "strategically sequence" its bargaining partners? Should a firm with multiple input suppliers negotiate cost reductions with them simultaneously or should it bargain with them one at a time? Should the U.S. target and negotiate with trade offenders simultaneously or sequentially? These settings have in common an agent who must bargain over several pies with several players. A natural question to ask then is whether bargaining with these players one at a time affords any advantage over bargaining with them simultaneously.

The instances provided above suggest that this is a problem faced by a variety of economic agents; yet, the literature that investigates this issue is sparse. It gets a brief mention in Dixit and Nalebuff (1991). A discussion is available in Sebenius (1991). But the only analytical model that I am aware of (other than this paper) that attempts to study the problem is in Chatterjee and Kim (1998, mimeo). In their paper, Chatterjee and Kim model the agent who must bargain with several players over several pies as having private information about the value to him(or her) of the different pies. Under some circumstances, sequencing his bargaining partners strategically allows the agent to reveal his private information via the agreement reached with the first partner. This influences the pie division with the second partner. If this influence is to the benefit of the agent, then he will,(under certain conditions), choose to indeed sequence his bargaining partners rather than bargain with them simultaneously. The present paper is quite different in scope and focus.

In what follows, the object of consideration is an oligopoly with a unionized (industrywide) workforce, such as the UAW and the Big Three. (For reasons of simplicity, the actual models deal with duopolies. Davidson (1988) and Jun (1989) provide such models in the context of issues different from that in this paper. However, the modeling in the former paper is a crucial input in the second model of the present article). No player has any private information. Settings with private information may turn out to be very useful in understanding the importance or otherwise of strategic sequencing; however, I feel that oligopolistic settings even under complete information have features which may explain such sequencing. I have attempted to isolate these features, leaving the study of the role of information under oligopoly to the future.

There are two models. In the first, the industry-wide union negotiates a separate wage and employment contract with each firm; in the second, it negotiates separate wage contracts, with firms choosing their employment levels after the wage agreements are reached. Precise formulations of the two models are in the ensuing sections; here, I discuss a few key features of these models and preview the results.

Negotiations between the union and the firms in both models use noncooperative bargaining theory, specifically, variants of Rubinstein's (1982) model of noncooperative bargaining. In doing so, the process of negotiation is modeled in a precise manner; moreover, noncooperative bargaining meshes well with the noncooperative product market game that the firms are assumed to be playing. In the first model, the players bargain over both wages and employment. For a bilateral monopoly, this is efficient (Leontief (1946)). It turns out that efficiency continues to hold in the oligopolistic setting of the present paper; (I therefore also call this model the efficient bargaining model). This is not the only natural formulation, because the law may permit firms to choose employment levels independently of the union; employment may not be on the negotiating table. The "right to manage" law in the U.S., for instance, gives firms this power. The second model in this paper therefore assumes that the union and the firms bargain over wages only; (I call this the "right to manage" model); once wage agreements are reached, firms choose employment levels. Specifically, post wage agreement, firms play as in a Cournot duopoly (we could also work in a differentiated product, price setting environment, but the algebra is much more messy and the thrust of the arguments for and against strategic sequencing stays the same). This model allows for much richer interaction between bargaining and product market behavior than does the first one; for instance, consider two alternative wage agreements (high wage, and low wage) between the union and firm 1 : the agreement on the higher wage implies higher costs for firm 1. If the two firms' products are strategic substitutes, this implies a lower Nash equilibrium output for firm 1, and higher output and profits for firm 2.In this model, the wage bill that the union gets from firm 2 is higher, as a result. In contrast, the first model has, in equilibrium, a unique employment level (the efficient one) that is agreed upon with each firm, irrespective of the agreed-upon wage.

In this paper, the newly negotiated contracts replace existing contracts; one key factor that determines whether the union prefers strategic sequencing to two simultaneous negotiations is the utility that it derives from the two old contracts (I assume that the union's utility is separable across the two wage contracts negotiated; for simplicity I assume that it is equal to the two wage bills that it gets as a result of the contract agreements), relative to the utility it gets from the new contracts resulting from simultaneous negotiations, in equilibrium. In both models, in the simultaneous bargaining case, there is a unique subgame perfect equilibrium outcome in which the opening offers made by the union are immediately accepted by the firms. If, instead, one firm (say firm i) were to reject this equilibrium offer, while firm j accepts, then bargaining would continue between the union and firm i, while firm j becomes a (temporary) monopoly producer. Thus the union's wage bill from firm j becomes a "status quo" point that influences the contract agreement with firm i. The higher is this wage bill, the better the contract with firm i as well. Suppose instead that the union sequenced the firms, opening negotiations first with firm i, while continuing production at firm j under the terms of the preexisting contract there. The wage bill that the union gets at firm j under this contract then functions as the status quo point; it turns out in the efficient bargaining model that if this wage bill is larger (respectively, smaller) than the wage bill that the union gets from firm j in the simultaneous bargaining equilibrium, the union prefers sequencing (firm i, then firm j) to simultaneous bargaining (and vice versa).

The situation is much more complicated in the right to manage case, because the firms are allowed the freedom to set their output (and hence employment) levels, post wage agreements. Thus consider strategic sequencing. If the union negotiates a relatively high wage with firm i, this makes the firm a relatively weak product market competitor, raising the potential profitability of firm j, and thereby the wage bill that the union can get out of firm j as shared rents via the bargaining process. Moreover, firm i is less reluctant to concede a higher wage (than under simultaneity) since it knows that part of the negative effect of this on its profits will be alleviated as firm j will also concede a higher wage as a result. This second channel through which sequencing can become better for the union compared to simultaneous negotiations operates because the firms can adjust output and employment.

The rest of the paper is organized as follows. In section 2, I introduce the efficient bargaining model, and its workings under the two bargaining protocols - simultaneous negotiations, and sequencing. Section 3 presents an analysis of the model under these two protocols, and compares the outcomes from the point of view of the union. Sections 4 and 5 are devoted to the " right to manage" model - the presentation and analysis attempts at corresponding closely to the pattern of sections 2 and 3. Section 6 concludes. Proofs are relegated to the appendix.

2. AN EFFICIENT BARGAINING MODEL

Players : The union, and the two firms, firm 1 and firm 2.

Production : Firm j operates the production function $q_j(L_j), j = 1,2$, where L_j is the labor hired by firm j. $q_j(0) = 0, q_j' > 0, q_j'' \leq 0$.

Demand : P(.) is the inverse demand function. P' < 0. Also, demand is "not too convex", this will be concretized when it is required, in a later section.

Costs : Labor is the only factor of production. Wage per unit labor in firm j is denoted w_j .

Bargaining Protocol – *Simultaneous Offers* : In period 0, the union simultaneously offers wage-employment pairs $(w_1, L_1), (w_2, L_2)$ to the two firms. If firm i rejects (w_i, L_i), and firm j accepts (w_j, L_j), then firm j becomes a temporary monopoly. Bargaining between firm i and the union continues, with firm i now making a counteroffer (w_i', L_i'), the union accepting or rejecting and making a counteroffer, and so forth, in the manner of Rubinstein's (1982) alternating offers game. Each period that bargaining continues between firm i and the union, firm j produces $q_j(L_j)$, sells it at price $P(q_j(L_j))$, and makes a profit of $[P(q_j(L_j))q_j(L_j) - w_j L_j]$. Once agreement is reached between firm i and the union, on some (w_i, L_i), the firms produce $q_1(L_1)$ and $q_2(L_2)$ in each period from then on, earning profits $P(q_1(L_1) + q_2(L_2))q_i(L_i) - w_i L_i, i = 1,2$. Note we are assuming that while bargaining is on between a firm j and the union, no production takes place at that firm. This is a simplifying assumption; all we need is for some efficiency loss to result while a new contract is being negotiated.

If both firms reject the union's time 0 offers, then at time 1 they simultaneously propose counteroffers $(w_1^{'}, L_1^{'}), (w_2^{'}, L_2^{'})$. If the union accepts $(w_j^{'}, L_j^{'})$ and rejects $(w_i^{'}, L_i^{'})$, then firm **j** becomes a temporary monopoly, and bargaining between the union and firm i proceeds a la Rubinstein. If the union rejects both counteroffers, then at time 2 it again makes simultaneous offers of wage-employment pairs to the two firms, and so on. Thus this subgame is isomorphic to the game at the start of period 0 (given our assumption that all players discount the future using (the same) discount factor).

Payoffs **:** While bargaining is on with a firm, it makes no profits. In a period in which firm j is the only producer, its profit $\pi_j = P(q_j(L_j))q_j(L_j) - w_j L_j$; if both firms are producing, its profit $\pi_j = P(q_i(L_i) + q_j(L_j))q_j(L_j) - w_j L_j$. Firm j's discounted payoff is thus $\Pi_j = \Sigma_{t=0}^{\infty} \delta^t \pi_{jt}$.
The union's payoff : If agreement with firm i is reached in period T_i and that with firm j in period T_j, its payoff is $\Sigma_{t=T_i}^{\infty} \delta^t w_i L_i + \Sigma_{t=T_j}^{\infty} \delta^t w_j L_j$.

Note, first, that the wage bill is taken to be the union's payoff for simplicity. A payoff that is a general, concave function of the two wages and employment levels yields the same qualitative results (in fact, in the "right to manage" formulation, it is also somewhat easier to work with). Second, in subgame perfect equilibrium, agreement on both contracts is simultaneous, so that the firms' discounted profits, and the union's discounted wage bill, simply rescale their per-period profits and wage bill. Henceforth we will talk in terms of these per period payoffs. Finally, as is usual, we will be interested in the limit of the subgame perfect equilibrium payoffs as the time between successive offers tends to zero ($\delta \to 1$). It can be shown that in this case, the limit of the payoffs in the above game is the same as that of the finite horizon version of the game, so the conclusions of our analysis here holds for that game as well.

***Bargaining Protocol** – Sequencing* : The union selects a firm, say firm i, to which it makes an offer (w_i, L_i). Firm i may accept, or reject and make a counteroffer, and so on, along the lines of Rubinstein (1982). While negotiations are on, no production takes place at firm i ; meanwhile, production at firm j continues on the terms of the *preexisting* contract, (w_j^0, L_j^0), every period. Once agreement with firm i is reached, the union makes its opening offer, (w_j, L_j), to firm j.

Offers are exchanged a la Rubinstein, and no production takes place at firm j while negotiations are on ; firm i, meanwhile, produces every period on the terms of its newly negotiated contract.

3. ANALYSIS OF THE EFFICIENT BARGAINGING MODEL

3.1. *Results for the Simultaneous Offers Protocol*

Let $\beta_j(L_i) = \arg\max_{L_j} P(q_i(L_i) + q_j(L_j))q_j(L_j), \quad i,j = 1,2, i \neq j$. That is, given L_i, $\beta_j(L_i)$ is the employment level of firm j that maximizes its total revenue – it is the "efficient" level of employment. Let $R_j(L_i)$ be the maximum revenue function. Strict concavity of total revenue in L_j ensures the existence of $\beta_j(L_i)$. For this we need that demand not be "too convex" (see the appendix for details). Let (L_1^*, L_2^*) solve $L_1 = \beta_1(L_2), L_2 = \beta_2(\beta_1(L_2))$. To facilitate comparative statics and comparability across models, we impose the sufficient condition $\beta_1', \beta_2' < 1$, which guarantees existence and uniqueness of the solution (see appendix). For instance, in the case of linear demand and production function $q_i(L_i) = L_i, i = 1,2, \beta_1' = \beta_2' = -\dfrac{1}{2}$.

L_1^*, L_2^*, are efficient responses to each other ; given the first, the second maximizes the size of the pie to be shared between the union and firm 2, and vice-versa. I first show that in subgame perfect equilibrium, the outcome is simultaneous agreement on the offers $(w_1^*, L_1^*), (w_2^*, L_2^*)$. That is, total revenue or pie size is maximized at each firm, and the wages are ones that result in Rubinstein splits of the pie at each firm. The exact split depends upon whether the union, or the firms, made the offers (there is a first mover advantage). Thus $w_i^* = w_{ir}$ if the union made the offers, and equals w_{ir}' if the firms made the offers (where $w_{ir}L_i = \dfrac{1}{1+\delta}(P(q_i(L_i) + q_j(L_j))q_i(L_i))$, etc., so that the wages depend on the employment levels, via the size of the pies).

Lemma 1 : *Suppose the firms and the union are still bargaining in period t. If firm i and the union reach agreement on (w_i, L_i) in period t, then in subgame perfect equilibrium, firm j and the union also settle at time t, on $(w_j^*, \beta_j(L_i))$.*

Proof: Appendix.

Applying lemma 1 now to firm i, if the two firms and the union are still bargaining at time t, and firm i settles as above, then since firm j will settle simultaneously on the contract specified in lemma 1, it follows that in subgame perfect equilibrium firm i settles on $(w_i^*, \beta_i(\beta_j(L_i)))$. Hence we have the following corollary.

Corollary: *In a SPE, the 2 firms must settle with the union in the same period, at* $(w_j^*, L_j^*), j = 1,2$.

We now use this result to propose a subgame perfect equilibrium in which there is immediate agreement on the union's opening offers, $(w_{1r}, L_1^*), (w_{2r}, L_2^*)$. In this equilibrium, the union always offers these wage –employment pairs in subgames in which it makes offers to both firms. The firms always offer $(w_{1r}', L_1^*), (w_{2r}', L_2^*)$ in subgames in which the firms make simultaneous offers. To see that this is part of a SPE, suppose the union offers $(w_1, L_1^*), (w_2, L_2^*)$, (by lemma 1, we restrict ourselves to these employment levels), and suppose that if firms reject, then agreement is reached next period on their proposals $(w_1', L_1^*), (w_2', L_2^*)$. Let $Q^* = q_1(L_1^*) + q_2(L_2^*); P^* = P(Q^*)$. Consider the following problem for the union.

***Problem U*:** $\max_{w_1, w_2} w_1 L_1^* + w_2 L_2^*$

$$\text{s.t.} \quad P^* q_1(L_1^*) - w_1 L_1^* \geq \delta[P^* q_1(L_1^*) - w_1' L_1^*] \qquad (1)$$

$$P^* q_2(L_2^*) - w_2 L_2^* \geq \delta[P^* q_2(L_2^*) - w_2' L_2^*] \qquad (2)$$

$$P^* q_1(L_1^*) - w_1 L_1^* \geq \delta[P^* q_1(L_1^*) - w_{1r}' L_1^*] \qquad (3)$$

$$P^* q_2(L_2^*) - w_2 L_2^* \geq \delta[P^* q_2(L_2^*) - w_{2r}' L_2^*] \qquad (4)$$

Constraints (1) and (2) ensure that both firms prefer to settle for $(w_i, L_i^*), i = 1,2$, rather than in the next subgame in which both make simultaneous offers $(w_i', L_i^*), i = 1,2,$ that are accepted. Constraint (3) ensures that if firm 2 settles at (w_2, L_2^*), then firm 1 prefers to settle at (w_1, L_1^*) rather than settle next period on the Rubinstein split that it then proposes. Constraint (4) is the same condition for firm 2.

If $w_1' = w_{1r}'$ and $w_2' = w_{2r}'$, then (1) and (3), and (2) and (4), are identical. The solution is then clearly w_1 such that (1) holds with equality, w_2 such that (2) holds with equality. Since it is the case that $w_{ir}^{'}L_i^* = \frac{\delta}{1+\delta}P^* q_i(L_i^*), i = 1,2$, we have $w_i L_i^* = \frac{1}{1+\delta}P^* q_i(L_i^*), i = 1,2$, or $w_i = w_{ir}, i = 1,2$.

Now consider a subgame in which the firms (simultaneously) make the opening offers, $(w_1^{'}, L_1^*)$, $(w_2^{'}, L_2^*)$. Consider the following problems for the firms.

Problem F : $\max_{w_1^{'}} P^* q_1(L_1^*) - w_1^{'} L_1^*$ and $\max_{w_2^{'}} P^* q_2(L_2^*) - w_2^{'} L_2^*$

s.t. $$w_1^{'} L_1^* + w_2^{'} L_2^* \geq \delta(w_1 L_1 + w_2 L_2) \quad (5)$$

$$w_1^{'} L_1^* \geq \delta w_{1r} L_1^* \quad (6)$$

$$w_2^{'} L_2^* \geq \delta w_{2r} L_2^* \quad (7)$$

Constraint (5) ensures that the union prefers to accept both $(w_1^{'}, L_1^*), (w_2^{'}, L_2^*)$, rather than reject both and get its counteroffers $(w_1, L_1), (w_2, L_2)$ accepted in the next period. Constraint (6) ensures that the union prefers to accept both offers rather than accept $(w_2^{'}, L_2^*)$, reject $(w_1^{'}, L_1^*)$, and get its Rubinstein split accepted next period. Constraint (7) is similar.

If $w_1 = w_{1r}, w_2 = w_{2r}$, then (6) and (7) together imply (5). The solutions to the firms' problems are therefore $w_1^{'} L_1^* = \delta w_{1r} L_1^*, w_2^{'} L_2^* = \delta w_{2r} L_2^*$. That is, $w_i^{'} = w_{ir}^{'}, i = 1,2$. From this analysis, we have

Theorem 1 : *There exists a SPE in which the outcome is immediate agreement on the union's opening offers,* $(w_{1r}, L_1^*), (w_{2r}, L_2^*)$. *The union's payoff is* $w_{1r} L_1^* + w_{2r} L_2^* = \frac{1}{1+\delta} P^* Q^*$. *Firm j's payoff is* $\frac{\delta}{1+\delta} P^* q_j(L_j^*), j = 1,2$. *The limits of these payoffs, as the time between offers tends to zero, are* $\frac{1}{2} P^* Q^*$ *for the union, and* $\frac{1}{2} P^* q_j(L_j^*), j = 1,2$ *for the firms.*

As there is no natural length for a time period, and since the players have an incentive to settle as soon as possible, the literature often focuses on the payoffs in this limit; so do we. Next we note that the equilibrium above is unique.

Theorem 2 : *The SPE described above is the unique SPE.*

Proof : Appendix.

3.2. *Results for the Sequencing Protocol*

First, note that in SPE, the employment levels will be (L_1^*, L_2^*). Suppose the union and firm 1 bargain first and settle on (w_1, L_1). Given this, it follows from the proof of lemma 1 that firm 2 and the union will settle immediately on some (w_2, L_2) with $L_2 = \beta_2(L_1)$. In SPE, therefore, by backward recursion, the union and firm 1 will settle on $L_1 = \beta_1(\beta_2(L_1))$. Thus $L_1 = L_1^*, L_2 = L_2^*$. It is now easy to construct the SPE under sequencing.

Suppose the union bargains first with firm i , then with firm j. Once agreement is reached with firm i , the union will offer, in the next period, (w_{jr}, L_j^*) to firm j, which will accept. So this agreement will affect the payoffs of firm i and the union in their bilateral bargaining game. Thus that game will have a unique SPE, whose outcome is calculated from the following equations (it helps to write the payoffs as discounted streams):

$$\frac{1}{1-\delta}[P^* q_i(L_i^*) - w_i L_i^*] = \frac{\delta}{1-\delta}[P^* q_i(L_i^*) - w_i' L_i^*] \tag{8}$$

$$\frac{1}{1-\delta} w_i' L_i^* + \frac{\delta}{1-\delta} w_{jr} L_j^* + w_j^0 L_j^0 = w_j^0 L_j^0 + \frac{\delta}{1-\delta} w_i L_i^* + \delta w_j^0 L_j^0 + \frac{\delta^2}{1-\delta} w_{jr} L_j^* \tag{9}$$

Equation (8) says that firm i is indifferent between accepting the union's offer (w_i, L_i^*) and rejecting it and getting its counteroffer (w_i', L_i^*) accepted next period. Equation (9) is the analogous equation for the union : Accepting firm i's offer (w_i', L_i^*) gives it the discounted stream $\frac{1}{1-\delta} w_i' L_i^*$, plus the wage bill $w_j^0 L_j^0$ from the existing contract with firm j for this period, and starting next period, the discounted stream $\frac{\delta}{1-\delta} w_{jr} L_j^*$ from the new agreement with firm j. Rejecting firm i's offer gives it the payoff on the right hand side of equation (9). We solve for w_i, w_i'. Using the result, we calculate the union's wage bill in the unique SPE in which the union's opening offer (w_i, L_i^*) is accepted by firm i, and in the next period, its offer (w_{jr}, L_j^*) is accepted by firm j. The payoff

$$\frac{1}{1-\delta} w_i L_i^* + \frac{\delta}{1-\delta} w_{jr} L_j^* + w_j^0 L_j^0 = \frac{1}{1-\delta}[(1-\delta+\frac{\delta^2}{1+\delta})(P^* q_i(L_i^*) + w_j^0 L_j^0) + (\delta - \frac{\delta^2}{1+\delta}) w_{jr} L_j^*]$$

Is thus what the union gets in SPE. The expression inside the square brackets on the right hand side is the union's per period payoff (note that $w_{jr}L_j^* = \frac{1}{1+\delta}P^*q_j(L_j^*)$). As the time between successive offers tends to zero, the union's per period payoff tends to $\frac{1}{2}(P^*Q^* + w_j^0L_j^0 - w_j^*L_j^*)$. (Note that $w_j^*L_j^* = \frac{1}{2}P^*q_j(L_j^*)$). Comparing this with the union's per period payoff under the simultaneous offers protocol (Theorem 1), we have

Theorem 3 : *The union will prefer sequencing (firm j after firm i) to the simultaneous offers protocol if its wage bill from the preexisting agreement with firm j,* $w_j^0L_j^0$*, exceeds its wage bill from the new agreement with firm j.*

Corollary : *If the union chooses to sequence, it will bargain first with that firm i with respect to which* $(w_i^0L_i^0 - w_i^*L_i^*)$ *is the lesser.*

I will interpret this result in the next subsection. Here, let us note some implications. First, if the wage bill from a preexisting contract with any firm is higher than the one that will result from the simultaneous offers protocol, the union will choose to sequence; of course, then, the union may have the highest payoff by choosing to stick with the existing contracts. We are assuming that this is not an option. This issue, and others that arise in this light (such as whether it is better for the union not to strike but to holdout (Cramton and Tracy (1992)), the structure of equilibria when the union can switch every period between striking and not striking (Haller and Holden (1989), Fernandez and Glazer (1990))), are not investigated here, since the focus is on sequencing. Second, once new agreements are negotiated, if there's no change in demand or technology in the future, then the union has no incentive to negotiate new contracts in the future – both the simultaneous offers protocol and the sequencing protocol leave its payoff unchanged. Third, if demand expands or technology improves in the future, so that there is incentive for the union to recontract, the new contracts (under simultaneous offers) will likely have higher wage bills than the existing contracts – in that case, simultaneous offers will be preferred to sequencing. Contrarily, if the industry contracts, sequencing may be preferred.

3.3. *Interpreting the Results*

Since the employment levels are efficient, we can interpret the results, in the case where the time between offers tends to zero, in terms of the Nash Bargaining solution. In the simultaneous offers case, we have seen that the SPE outcome basically gives us that given agreement on (w_{2r}, L_2^*), we have simultaneous agreement on (w_{1r}, L_1^*), and vice-versa. Thus, (w_{1r}, L_1^*) is the solution to

$\max_{w_1 L_1^*}(w_1 L_1^* + w_{2r} L_2^* - w_{2r} L_2^*)(P^* q_1(L_1^*) - w_1 L_1^*)$, which gives $w_1 L_1^* = \frac{1}{2} P^* q_1(L_1^*)$. Similarly, $w_2 L_2^* = \frac{1}{2} P^* q_2(L_2^*)$. So with respect to the bargaining problem between the union and firm i, $w_{jr} L_j^*, j \neq i$, operates as the union's disagreement or status quo point. The principal difference in the sequencing case is that, with respect to the bargaining problem between the union and firm i (the "first" firm), the union's disagreement point is $w_j^0 L_j^0$, the wage bill from the preexisting contract. The problem is to $\max_{w_i L_i^*}(w_i L_i^* + w_{jr} L_j^* - w_j^0 L_j^0)(P^* q_i(L_i^*) - w_i L_i^*)$.

Clearly, if the disagreement point $w_j^0 L_j^0 > w_{jr} L_j^*$, the union is better off sequencing. One concludes that sequencing allows the union to "switch" its disagreement point from the wage bill to be contracted with firm j, to its preexisting wage bill. Whether or not sequencing is better derives entirely from which disagreement point is better for the union.

4. "RIGHT TO MANAGE" MODEL

The basic difference here is that employment is not on the bargaining table; only wage is. Once a wage is agreed upon, the firm has a "right to manage" – to choose employment to maximize profits. This assumption is closer to the condition prevailing, say, in the case of the UAW and the American automobile companies. We retain the notation of section 2. The implication of the "right to manage" assumption can be exposited by describing the 2 bargaining protocols under it. ***Simultaneous Offers Protocol*** : The union opens in period 0 with simultaneous offers (w_1, w_2) to the two firms. If firm i rejects w_i and firm j accepts w_j, then firm j becomes a temporary monopoly. (In every period that bargaining between the union and firm i continues, firm j chooses the monopoly profit maximizing employment and output levels, $L_{jm}(w_j)$ and $q_{jm}(w_j)$). In period 1, firm i makes a counteroffer $w_i^{'}$, the union accepts or rejects, and so forth, as in Rubinstein (1982). Once agreement is reached on some w_i, the two firms become Cournot competitors (modelling price competition under product differentiation is much messier without changing the results), employing and producing at the unique Cournot equilibrium levels $L_{ic}(w_1, w_2), q_{ic}(w_1, w_2), i = 1,2,$ thereafter.

If both firms reject the union's time '0' offers, then at time 1 they simultaneously propose counteroffers $(w_1^{'}, w_2^{'})$. If the union accepts $w_j^{'}$, and rejects $w_i^{'}$, then firm j becomes a temporary monopoly, and bargaining between the union and firm i proceeds along the lines of Rubinstein (1982); if the union rejects both offers, then at time 2 it makes simultaneous offers, and so forth.

***Sequencing Protocol*:** Again, this is exactly as in section 2 ; if the union bargains first with firm i , firm j produces meanwhile as a monopoly, at the preexisting wage w_j^0, and employment level L_j^0, which could now connote the monopoly profit maximizing level of employment at that wage. Once both agreements are reached, the firms play as Cournot competitors.

Note that the profit of firm i when both firms are producing is given by:

$\pi_i(L_i, L_j) = P(q_i(L_i) + q_j(L_j))q_i(L_i) - w_i L_i$. We assume that this is strictly concave in L_i, so reaction functions are continuous. With endogenously determined wages, existence of Cournot equilibrium requires only $q_j^{-1}(0) > q_{im}, j \neq i$, where q_j^{-1} is the inverse of firm j's reaction function. $\left|\frac{\partial^2 \pi_i}{\partial L_i^2}\right| > \left|\frac{\partial^2 \pi_i}{\partial L_i \partial L_j}\right|$ is sufficient for uniqueness. All these assumptions are satisfied, for instance, for the case of linear production and demand functions. An additional assumption (also satisfied in the linear case) we make is that the Cournot profit function satisfies $\frac{\partial \pi_{jc}(w_i, w_j)}{\partial w_j} < 0, j \neq i$.

5. ANALYSIS OF THE RIGHT TO MANAGE MODEL

5.1. *Simultaneous Offers Protocol*

For simplicity, we conduct the analysis in terms of the limits of the players' payoffs as the time between offers tends to zero. Also, as in section 3, since production every period leads to a payoff that is a scaling of the per period payoff, we use the latter payoff specification. First, we state the analogue of lemma 1.

Lemma 2 : *Suppose the firms and the union are still bargaining in period t. If firm i and the union reach agreement on* w_i *in period t, then in SPE, firm j and the union also settle at time t, on the Rubinstein wage* $r_j(w_i)$.

Basically, given w_i, we have a standard alternating offers bargaining game between the union and firm j. Applying the well known result of Binmore (1987), the Rubinstein wage for firm j, in the limit as the time between offers tends to zero, is the argmax of the Nash Bargaining solution given by $\max_{w_j}[w_i L_{ic}(w_i,w_j)+w_j L_{jc}(w_i,w_j)-w_i L_{im}(w_i)]\pi_{jc}(w_i,w_j)$. We call this "*Problem j*", to refer to the bargaining problem between the union and firm j. Here, the union's payoff from the agreement is the sum of the first two terms in the square brackets ; its "disagreement point" is the wage bill $w_i L_{im}(w_i)$ that accrues to it in the event that it can't settle on an agreement with firm j. Firm j's disagreement point equals zero profits. In the event of agreement, it gets the Cournot profit $\pi_{jc}(w_i,w_j)=P(q_{1c}(w_1,w_2)+q_{2c}(w_1,w_2))q_{jc}(w_1,w_2)-w_j L_{jc}(w_1,w_2)$. The argmax of Problem j is a function of w_i, so we write $w_j = r_j(w_i)$. To ensure that a unique solution exists, we impose conditions under which the objective in Problem j is strictly concave and single-peaked (see appendix for details). If we had directly specified the union's payoff as a strictly concave function of wages and employment levels, the conditions would have been less restrictive; however, for comparability with the efficient bargaining model, we work here, too, with the wage bill as the union's payoff. It is well known in this setting (Davidson (1988)) that the set of attainable pairs of wage bill and profit is convex, and that at the Nash Bargaining solution, $\frac{\partial[w_i L_{ic}+w_j L_{jc}]}{\partial w_j}\geq 0$.

The reason is that as $\dfrac{\partial \pi_{jc}(w_i, w_j)}{\partial w_j} < 0$, if the wage bill were decreasing in w_j, then we are not at the maximum : both union and firm j can gain by a reduction in w_j.

Applying the same reasoning to lemma 2 as was done in the corollary to lemma 1, we have a similar conclusion here : in SPE, the outcome is simultaneous agreement on the pair of wages (w_1^*, w_2^*) that solve $w_1 = r_1(w_2), w_2 = r_2(r_1(w_2))$. The appendix gives conditions under which $r_j(0) > 0, j = 1{,}2$ and $\dfrac{dr_j(w_i)}{dw_i} < 1$, so that a solution exists. A key assumption is that the wage bill of firm j, j=1,2, is strictly concave in w_j. Note here that $\dfrac{dr_j(w_i)}{dw_i}$ is likely positive (in the linear case, it equals ½). A higher w_i implies that firm i's costs are higher, which implies higher profitability of firm j in Cournot competition. A higher w_j usually results from the sharing of firm j's incremental revenue with the union. For simplicity, we restrict our further analysis to this case. Note also that the agreement is on the same pair of wages irrespective of who (union or the firms) is making the offers – as the time between offers tends to zero, the "first mover advantage" vanishes.

Lemma 2 can be used to describe the following SPE of the game in which the time between offers is arbitrarily small. The union always offers (w_1^*, w_2^*), in subgames in which it makes offers to both firms. Firm i, i = 1,2, accepts all $w_i \le w_i^*$, and rejects higher wage offers. In subgames in which both firms make offers, they always offer w_1^*, w_2^*. The union accepts all (w_1, w_2) with $w_i \ge w_i^*, i = 1{,}2$, and rejects all (w_1, w_2) with $w_i < w_i^*. i = 1{,}2$. If (w_1, w_2) is such that $w_i \ge w_i^*$, $w_j < w_j^*$, the union accepts w_i, rejects w_j, and counteroffers $r_j(w_i)$. In subgames in which the union is bargaining with firm j, but has settled already with firm i at wage w_i , the union and firm j make the Rubinstein offer $r_j(w_i)$ (when it is their turn to make the offer); the union accepts wage offers greater than this, rejecting lower offers, the firm doing the opposite. This gives us

Theorem 4 : *There exists a unique SPE in which there is immediate agreement on the union's opening offers* (w_1^*, w_2^*). *The union's equilibrium payoff is* $w_1^* L_{1c}(w_1^*, w_2^*) + w_2^* L_{2c}(w_1^*, w_2^*)$. *Firm i's payoff is* $\pi_{ic}(w_1^*, w_2^*) = P(q_1(L_{1c}) + q_2(L_{2c}))q_i(L_{ic}(w_1^*, w_2^*)) - w_i^* L_{ic}(w_1^*, w_2^*), i = 1,2$.

Proof : It is clear from the description of strategies preceding the theorem that they comprise a SPE.Uniqueness is proved in the appendix.

5.2. *Sequencing Protocol*

Suppose the union bargains and settles first with firm i, then with firm j. Since the agreed outcome w_i is known to firm j and the union in their bargaining, they settle immediately on $r_j(w_i)$, the solution to Problem "j". So the SPE outcome is $(w_i^s, r_j(w_i^s))$, where w_i^s solves Problem "S" below:

Problem S : $\max_{w_i} [w_i L_{ic}(w_i, r_j(w_i)) + r_j(w_i) L_{jc}(w_i, r_j(w_i)) - w_j^0 L_j^0] \pi_{ic}(w_i, r_j(w_i))$.

Here, $w_j^0 L_j^0$ is the union's wage bill accruing from firm j, from the preexisting contract. If employment was not negotiable in that, then it equals the monopoly level of employment.

We are now in a position to compare the union's SPE payoffs from the two protocols. At the equilibrium outcome $(w_i^s, r_j(w_i^s))$ above, the wage bill is increasing in w_i. Therefore, sequencing is better (worse) for the union, compared to simultaneity, if and only if $w_i^s > (<) w_i^*$.

The first order condition for Problem S is

$$[w_i \frac{dL_{ic}(w_i, r_j(w_i))}{dw_i} + L_{ic}(w_i, r_j(w_i)) + r_j(w_i) \frac{dL_{jc}(w_i, r_j(w_i))}{dw_i} + L_{jc}(w_i, r_j(w_i)) \frac{dr_j(w_i)}{dw_i}] \pi_{ic}(w_i, r_j(w_i))$$

$$[w_i L_{ic}(w_i, r_j(w_i)) + r_j(w_i) L_{jc}(w_i, r_j(w_i)) - w_j^0 L_j^0] \frac{d\pi_{ic}(w_i, r_j(w_i))}{dw_i} = 0 \qquad (10)$$

The solution is w_i^s. On the other hand, the first order condition for the Nash Bargaining problem between firm i and the union, under the simultaneous offers protocol, at the solution (w_1^*, w_2^*), is

Given by equation (11) below:

$$[w_i \frac{\partial L_{ic}(w_i, w_j^*)}{\partial w} + L_{ic}(w_i, w_j^*) + w_j^* \frac{\partial L_{jc}(w_i, w_j^*)}{\partial w_i}]\pi_{ic}(w_i, w_j^*) + [w_i L_{ic}(w_i, w_j^*) + w_j^* L_{jc}(w_i, w_j^*) -$$

$$w_j^* L_{jm}(w_j^*)]\frac{\partial \pi_{jc}(w_i, w_j^*)}{\partial w_i} = 0$$

The solution is w_i^*. To evaluate the first derivative of Problem S at (w_i^*, w_j^*), we plug equation (11) in equation (10). After cancellations, the expression which remains (expression (12) below) is (where all functions are evaluated at (w_i^*, w_j^*), so this argument is dropped to avoid a mess) :

$$[w_i^* \frac{\partial L_{ic}}{\partial w_j} + w_j^* \frac{\partial L_{jc}}{\partial w_j} + L_{jc}]\pi_{ic} \frac{dr_j(w_i)}{dw_i} + [w_i^* L_{ic} + w_j^* L_{jc} - w_j^0 L_j^0](\frac{\partial \pi_{ic}}{\partial w_j})(\frac{dr_j(w_i)}{dw_i}) +$$

$$[w_j^* L_{jm}(w_j^*) - w_j^0 L_j^0]\frac{\partial \pi_{ic}}{\partial w_i} \qquad (12)$$

From this, we have

Theorem 5 : *Sequencing (resp. simultaneity) gives the union a higher payoff if, and only if, expression (12) is positive (resp. negative).*

The expressions inside the first two square brackets in expression (12) are positive (the first is the derivative of the wage bill with respect to w_j), as are their multiplicands. Hence, if $w_j^0 L_j^0 \geq w_j^* L_{jm}(w_j^*)$, then expression (12) is positive. This implies that the solution w_i^s to Problem S is greater than w_i^*, that is, it pays the union to sequence.

As with the efficient bargaining model, if the preexisting wage bill $w_j^0 L_j^0$ is higher than the one that would result from the SPE of the simultaneous offers protocol bargaining game, we have the case where sequencing firm j after firm i gives the union a higher disagreement point than under the simultaneous offers game. Thus the union is better off sequencing. However, even if $w_j^0 L_j^0 < w_j^* L_{jm}(w_j^*)$, expression (12) could well be positive, implying that sequencing remains the union's preferred choice. The reason is that increasing w_i beyond w_i^* raises firm i's costs, and in Cournot equilibrium, raises firm j's profits. As employment is adjusted by the firms, firm j raises employment and wages to share its incremental rent with the union (in turn, this dilutes the negative impact of the increase in w_i on firm i's profits). Hence, because employment is adjustable under right-to-manage law, there is a second channel through which sequencing can become preferred by the union.

In the efficient bargaining model, since sequencing is preferred if and only if a preexisting wage bill exceeds the equilibrium wage bill under simultaneity, sequencing could coincide with the case where the union is better off remaining with both preexisting contracts rather than negotiate new ones. In the right to manage model, this rigid relationship is broken due to the extra channel at work. Thus, the case for explaining sequencing by appealing to our complete information setting is much stronger in a set up where a right to manage type of law or environment exists.

Finally, note that short of computation, it is not clear from expression (12) which way to sequence the two firms in order to maximize the union's payoff. Even in symmetric (in terms of technology) cases, where only the level of the preexisting wage bills are different, there is a trade-off between a higher value to the product of last two terms (via a higher $w_j^0 L_j^0$) and a lower value to the product of the third and fourth terms of expression (12).

5.3. *A Simple Linear Example*

Demand : $P = a - b\,Q$; Production function : $q_i(L_i) = L_i, i = 1,2$.

The expression for Problem j, j=1, is then :

$$\max_{w_1} \left[w_1 \frac{(a + w_2 - 2w_1)}{3b} + w_2 \frac{(a + w_1 - 2w_2)}{3b} - w_2 \frac{(a - w_2)}{2b}\right] \frac{(a + w_2 - 2w_1)^2}{9b}$$

The objective is single peaked, and the solution is $w_1 = \frac{a + 4w_2}{8}$. By symmetry, we have $w_1 = w_2 = \frac{a}{4}$, and the equilibrium wage bill under the simultaneous offers protocol equals $\frac{2a^2}{16b}$. The disagreement point (the third term in the square brackets in the objective above) is $\frac{3a^2}{32b}$, evaluated at the equilibrium. Using the *same* disagreement point in the sequencing problem (bargain with firm 2, then firm 1) isolates the benefit to sequencing via the second channel of the product market game. The objective in problem S is single peaked, and indeed, the equilibrium wage,

$w_2 = 0.304806a$ is higher than (a/4), the wage under simultaneity. $w_1 = 0.277403a$ is also higher. The wage bill is now greater; it equals $\frac{2.1952a^2}{16b}$.

6. CONCLUSION

In evaluating the efficacy of sequencing vis-à-vis simultaneity from the point of view of the union in an oligopoly, we have isolated two effects. In choosing to sequence, the union takes recourse to the preexisting wage bill at the firm with whom it will negotiate only later, as the status quo point ; whereas under simultaneity, the status quo point is, in effect, the equilibrium wage bill at this firm. Therefore, if the preexisting wage bill is greater than the equilibrium wage bill obtained under simultaneity, sequencing is preferable. If both wages and employment are on the negotiating table, this consideration alone determines the union's decision to sequence. If, however, only wages are negotiated with the union, and outputs and employment levels are determined by the firms in a subsequent product market game, (which is how we have chosen to model a right-to-manage type of law), the anticipated product market outcome feeds back into the wage negotiations. In this scenario, sequencing can be beneficial owing to the way in which wage costs influence product market competition. A higher wage with the first firm weakens the firm's post bargaining competitive position in the product market game, and therefore allows a settlement with the second firm at a higher wage as well. This clearly benefits the union. The first firm, too, is more amenable to conceding a higher wage (than under simultaneity) since it knows that as a result, the second firm will have to follow suit, thereby alleviating somewhat the negative impact on its profits. As a result, a union operating under a right to manage environment is much more likely to sequence than one which negotiates both wages and employment.

APPENDIX

3.1.1. *Uniqueness of $\beta_j(L_i)$; existence of (L_1^*, L_2^*)*

For the first we need total revenue to be strictly concave in L_j. Twice differentiating the total revenue function and setting < 0, gives us the condition

$P'' < -\frac{1}{q_j(L_j)[q_j'(L_j)]^2}[Pq_j''(L_j) + 2P'[q_j'(L_j)]^2 + P'q_j(L_j)q_j''(L_j)], L_i, L_j \geq 0$, which is a "demand is not too convex" assumption.

For the second, note that $\beta_j(0) > 0, j = 1,2$. Hence it suffices to have $\beta_j' < 1, j = 1,2$. Differentiating wrt L_i the first order condition for optimal L_j for revenue maximization, we get

$\beta_j'(L_i) = \frac{-q_i' q_j'(q_j P'' + P')}{(q_j')^2(q_j P'' + 2P') + q_j''(q_j P' + P)}$. We assume this is less than 1.

3.1.2. *Proof of Lemma 1*

Step 1: Given (w_i, L_i), no accepted offer (w_j, L_j) in equilibrium can have $L_j \neq \beta_j(L_i)$. For suppose such an offer is made by firm j and accepted by the union. The union gets $w_j L_j$, which must be at least as large as its continuation value from rejecting the offer. Firm j gets $P(q_i(L_i) + q_j(L_j))q_j(L_j) - w_j L_j$. Therefore, it is better for firm j to offer $(\overline{w}_j, \beta_j(L_i))$, such that $\overline{w}_j \beta_j(L_i) = w_j L_j$. The union will accept, and since $\beta_j(L_i)$ maximizes firm j's revenue, it increases firm j's profits. Assimilar argument applies if the union had made the offer.

Step 2 : Thus we can restrict ourselves to offers $(w_j, L_j) s.t. L_j = \beta_j(L_i)$, and the pie is fixed at $R_j(L_i)$. From Rubinstein (1982), it then follows that agreement is immediate on $(w_j^*, \beta_j(L_i))$, where $w_j^* \beta_j(L_i) = w_{jr} \beta_j(L_i) = \frac{1}{1+\delta} R_j(L_i)$, if the union made the offer, and equals $w_j' \beta_j(L_i)$ $= \frac{\delta}{1+\delta} R_j(L_i)$, if the firm made the offer.

3.1.2. *Proof of Theorem 2*

We exploit the fact that subgame perfect equilibria result in simultaneous agreements.

Step 1 : (w_{1r}, w_{2r}) is the highest pair of wages that the firms can simultaneously agree to, in equilibrium.

Proof: Suppose the union offers $(w_1, L_1^*), (w_2, L_2^*)$. Given firm i accepts (w_i, L_i^*), firm j will accept (w_j, L_j^*) iff $w_j \leq w_{jr}$. Else, it will reject, and get its counteroffer (w_{jr}', L_j^*) accepted next period, and be better off.

Step 2 : $(w'_{1r}, L_1^*), (w'_{2r}, L_2^*)$ is the only pair of offers that the firms make that is accepted simultaneously in SPE.

Proof : $(w'_1, L_1^*), (w'_2, L_2^*)\ s.t.\ w'_i < w'_{ir}$, for any i=1,2, cannot be simultaneously accepted by the union. For suppose $w'_i < w'_{ir}$. Rather than accept both wage-employment proposals, the union does better by accepting (w'_j, L_j^*), rejecting (w'_i, L_i^*), and settling next period on (w_{ir}, L_i^*). (Since $w'_i < w'_{ir} = \delta w_{ir}$). The remaining case is of offers $(w'_1, L_1^*), (w'_2, L_2^*)$ that satisfy $w'_i > w'_{ir}, i = 1,2$. Suppose the union simultaneously accepts these offers, in SPE. Note that accepting both is better than accepting one, rejecting the other and settling next period on the Rubinstein split. Suppose rejecting both offers gives the union a continuation value V, next period, in SPE. Since the firms' offers must be best responses to each other, they must just satisfy $w'_1 L_1^* + w'_2 L_2^* = \delta V$. For V to be the union's continuation value, there must exist offers $(w_1, L_1^*), (w_2, L_2^*)$ that the union makes in subgames where it makes the opening offers, that are simultaneously accepted, such that the wage bill from these offers adds up to V. However, we then have $w'_1 L_1^* + w'_2 L_2^* = \delta V > w'_{1r} L_1^* + w'_{2r} L_2^* = \delta[w_{1r} L_1^* + w_{2r} L_2^*] \ge w_1 L_1^* + w_2 L_2^* = V$, where the first inequality is by assumption, and the second follows from step 1. Contradiction.

Step 3 : In SPE, $(w_{1r}, L_1^*), (w_{2r}, L_2^*)$ is the only pair of proposals that the union will offer and the firms will simultaneously agree to.

Proof : Given the unique pair of proposals that the firms will offer (step 2), and given step 1, this is the best that the union can do.

5.1.1. *Existence of $r_j(w_i)$ for Problem j*:

The first derivative of the objective in Problem j is $\pi_{jc}(w_i, w_j)(\frac{\partial f}{\partial w_j}) + f(w_i, w_j)\frac{\partial \pi_{jc}(w_i, w_j)}{\partial w_j}$, where $f(w_i, w_j) = w_i L_{ic}(w_i, w_j) + w_j L_{jc}(w_i, w_j) - w_i L_{im}(w_i)$. The first two terms of "f" add up to the wage bill. Assume that this is strictly concave and single peaked. Then so is "f". Therefore, at $w_j = 0$, the first addend of the first derivative is positive, while the second is the product of two negatives, and hence also positive. $(f(w_i, 0) = w_i(L_{ic}(w_i, 0) - L_{im}(w_i)))$; Cournot output and employment levels, with positive costs are less than the monopoly level, and a fortiori so if the competitor's cost is zero. On the other hand, at the wage bill peak, $\frac{\partial f}{\partial w_j} = 0$, while the second term is negative. So there must exist a local maximum of the objective in this range. This is the unique maximum if the objective is strictly concave. The second derivative with respect to w_j is

$$2\frac{\partial f}{\partial w_j}\frac{\partial \pi_{jc}(w_i,w_j)}{\partial w_j} + \pi_{jc}(.)\frac{\partial^2 f}{\partial w_j^2} + f(.)\frac{\partial^2 \pi_{jc}(.)}{\partial w_j^2}$$

. The first term is negative. The second is negative by the strict concavity of the wage bill. We assume that the third is not "too positive", that is, profit is not too convex in own wage (which holds, eg., in the linear demand case), to ensure strict concavity of the objective.

5.1.2. *Existence of* (w_1^*, w_2^*) :

Differentiating the first order condition of Problem j with respect to w_i and rearranging, we get

$$\frac{dr_j(w_i)}{dw_i} = -\frac{A}{B}, where$$

$$:A = \pi_{jc}(w_i,w_j)\left(\frac{\partial L_{ic}}{\partial w_j} + \frac{\partial L_{jc}}{\partial w_i}\right) + \left(\frac{\partial \pi_{jc}}{\partial w_i}\right)\left[w_i\frac{\partial L_{ic}}{\partial w_j} + w_j\frac{\partial L_{jc}}{\partial w_j} + L_{jc}\right] + \left(\frac{\partial^2 \pi_{jc}}{\partial w_i}\right)\left[w_i L_{ic} + w_j L_{jc} - w_i L_{im}\right] +$$
$$\left(\frac{\partial \pi_{jc}}{\partial w_j}\right)\left[L_{ic} + w_i\frac{\partial L_{ic}}{\partial w_i} + w_j\frac{\partial L_{jc}}{\partial w_i} - w_i\frac{\partial L_{im}}{\partial w_i} - L_{im}\right]$$

$$B = 2\pi_{jc}\frac{\partial L_{jc}}{\partial w_j} + 2\left(\frac{\partial \pi_{jc}}{\partial w_j}\right)\left[w_i\frac{\partial L_{ic}}{\partial w_j} + w_j\frac{\partial L_{jc}}{\partial w_j} + L_{jc}\right] + \left(\frac{\partial^2 \pi_{jc}}{\partial w_j^2}\right)\left[w_i L_{ic} + w_j L_{jc} - w_i L_{im}\right]$$

The first two terms of A are positive (the expression inside the square brackets of the second product is positive at the solution – it is the derivative of the wage bill). The third is usually negative (including in the linear case, since the cross partial is negative), and the fourth is usually positive, so that A is likely to be positive. Of the three terms in B, only the third is positive (if profit is convex in own wage, as in the linear demand case), so that B is likely negative. To ensure existence, we need - (A/B) < 1.

5.1.3. *Proof of uniqueness of SPE in Theorem 4* :

The method is similar to the proof of uniqueness in Theorem 2. It should be borne in mind that in SPE, there is simultaneous agreement on both wage offers, both when the union makes offers, and when the firms make them.

Step 1 : $\{(w_1,w_2): w_1 \leq r_1(w_2), w_2 \leq r_2(w_1)\}$ is the set of wage offers of the union for which simultaneous agreement by the firms can be a Nash Equilibrium.

Proof : Suppose the union offers a pair (w_1,w_2). Given that firm i accepts w_i, firm j will accept w_j if, and only if, $w_j \leq r_j(w_i)$. Else, it will reject, and immediately settle at its counteroffer $r_j(w_i)$.

Step 2 : (w_1^*,w_2^*) is the only pair of wage the firms can offer that the union will accept, in SPE.

Proof : For a pair $(w_1^{'},w_2^{'})$, such that for some i=1,2, $w_i^{'} < r_i(w_j^{'})$, simultaneous acceptance is not the best response for the union. Accepting $w_j^{'}$, rejecting $w_i^{'}$, and settling immediately on the counteroffer $r_i(w_j^{'})$ is better. Consider the remaining case of a pair $(w_1^{'},w_2^{'}) s.t. w_i^{'} > r_i(w_j^{'}), i = 1,2$, which the union accepts simultaneously. Clearly, simultaneous acceptance is better than accepting one and rejecting the other. Since the wage offers of the firms must be best responses to each other, accepting both must give the union exactly its continuation value, V, from rejecting both offers.

Note that V > $w_1^* L_{1c}(w_1^*,w_2^*) + w_2^* L_{2c}(w_1^*,w_2^*)$. For if V =( ) , then, (w_1^*,w_2^*) would be simultaneously accepted by the unison, and would be the firms' unique best response offers. (If firm i offers $w_i < w_i^*$ the union will reject it and accept w_j iff $w_j \geq w_j^*$. So firm j's best response is w_j^*. If $w_i > w_i^*$, , the union will simultaneously accept $(w_i,w_j), w_j \geq r_j(w_i)$. So firm j's best response is $r_j(w_i)$. See Davidson (1988) for details.)

For V to be a SPE payoff for the union in subgames where it makes offers, there must exist wages (w_1,w_2) that the firms simultaneously accept, s.t. $w_1 L_{1c}(w_1,w_2) + w_2 L_{2c}(w_1,w_2) = V$. Since the wage bill is increasing in the wages, in an agreement, this implies $w_i > w_i^*$, for at least one i=1,2. But then, by step 1, the firms won't simultaneously accept.

From steps 1 and 2, (w_1^*, w_2^*) is the union's unique best acceptable pair of offers in subgames in which it makes the offers.

REFERENCES

K. Binmore (1987), "Perfect Equilibria in Bargaining Models", in K. Binmore and P. Dasgupta (ed.), The Economics of Bargaining, Basil Blackwell Ltd.

K. Chatterjee and C. Kim (1998), " Strategic Sequencing", mimeo Penn State University

P. Cramton and J. Tracy (1992), " Strikes and Holdouts in Wage Bargaining : Theory and Data", *American Economic Review,* 82

C. Davidson (1988), "Mulitunit Bargaining in Oligopolistic Industries", *Journal of Labor Economics,* 6, 397-422.

A. Dixit and B. Nalebuff (1991), Thinking Strategically, Norton Inc.

R. Fernandez and J. Glazer (1991), "Striking for a Bargain Between Two Completely Informed Agents", *American Economic Review*, 81, 240-252

H. Haller and S. Holden (1990), "Non-Cooperative Wage Bargaining", *Journal of Economic Theory*

B. Jun (1989), "Non-cooperative Bargaining and Union Formation", *Review of Economic Studies,* 56, 59-76

A. Rubinstein (1982), "Perfect Equilibrium in a Bargaining Model", *Econometrica,* 50, 97-109

J. Sebenius (1991), "Thinking Coalitionally: Party Arithmetic, Process Opportunism, and Strategic Sequencing", in H.P. Young (ed.), Negotiation Analysis, U. Michigan Press

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