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KWOK H. CHEUNG

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Carl Davidson
Major professor

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By

Kwok H. Cheung

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ABSTRACT

THREE ESSAYS IN APPLIED GAME THEORY

By

Kwok H. Cheung

(1) Bargaining Structure and Strike Activity

The nature of the relationship between bargaining structure and strike activity is examined in the first essay. In particular, the paper focuses on the implications of the fact that the amount of information revealed by a union's actions depends on the bargaining environment in which it operates. This paper demonstrates that a union representing workers at more than one firm will face a greater incentive to reject offers than an independent union. This implies that a merger of two unions or the formation of bargaining coalitions will lead to a greater level of strike activity.

(2) Market Power and Vertical Restraint

In essay two, the doctrine of countervailing power is examined using a partial bilateral oligopolistic model. In contrast to Galbraith's original assertion, countervailing power does not improve consumer welfare and it may not reduce the profit of the firms. Although countervailing power reduces the market power of the oligopolists, it secures the position of the cartel as indicated by a collusive measure. This suggests that the effect of countervailing power is, in this respect, "coalescing" rather than "countervailing". This paper also indicates that the fears of applying supergame theory in industrial organization models are over-stated.

(3) Negotiation Process and Bargaining Tactics

Essay three investigates the ability of using the negotiation process as a kind of bargaining tactic in collective bargaining. Using a non-cooperative bargaining model with two firms and one industry-wide union, this paper show that an union always prefer to bargain with a big firm first if it can only choose one firm to begin with. There is a unique pooling equilibrium and no semi-separating equilibrium in this model. Surprisingly, this paper shows that, under some circumstances, equilibrium may not exist in a multi-lateral bargaining model.

Dedicated to my wife, Mei-sze.

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Any remaining errors are of course my own responsibility.

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CHAPTER ONE

(ESSAY 1)

Bargaining Structure and Strike Activity

1. Introduction

The theoretical literature on the determinants of strike activity is rather sparse. The major reason for this is that strikes are commonly viewed as an irrational action (from an economic point of view). Since both sides lose during a strike, it is difficult to build a model of rational, payoff maximizing agents that results in strike activity in equilibrium. In fact, until recently, most models of strike activity either viewed strikes as accidents (e.g., Reder and Neumann [1980], Kennan [1980] or Siebert and Addison [1981]) or simply took it as given that in order to extract a better settlement from management, workers had to strike (e.g., Hicks [1963], Cross [1965] or Ashenfelter and Johnson [1969]). In the latter case, the process by which the strike leads to an improved contract is never explicitly modelled.

Recently, however, there have been attempts to explicitly model the bargaining process in a manner that admits the possibility of strikes in equilibrium (see, for example, Hayes [1984], Morton [1983], Fudenberg, Levine, and Ruud [1983] and Tracy [1984]).[1] In these studies, firms and unions are imperfectly informed about the payoff function of their opponent and may therefore make equilibrium proposals that, in some instances, will be rejected. Such proposals and their subsequent rejections reveal information about the unknown parameters, which in turn influence the new proposals. Strikes are then interpreted as the failure to reach an agreement immediately.

In such a setting, factors that influence the amount of information revealed by bargaining behavior influence both the incidence and duration of strike activity. One such factor is the structure of the bargaining units for management and labor. In particular, if a union represents the employees of several different firms, the firms can collect information about the union's payoff function by observing its behavior in negotiations with other firms. Actions taken by industry-wide or conglomerate unions will therefore reveal a different amount of information than actions taken by independent unions. The purpose of this paper is to investigate how these differing levels information transmission affect strike activity.

Our results indicate that when a single union represents the interests of workers at more than one firm, incentives are created that lead to a greater expected level of strike activity. To understand the forces behind this result, consider a simple two period model in which two unionized firms bargain over wages with their union. Assume that the firms produce in distinct product markets so that their payoff functions are not interdependent and that the union's default level of utility is not known by the firms. Finally, assume that each firm makes one offer each period that its union may either accept or reject. If the first offer is accepted, the contract lasts two periods so that no further bargaining takes place in period two. If the first offer is rejected, a strike occurs and, in the second period, the firm makes a second offer.

There are two important properties of the agents' equilibrium strategies that lead to our result. First, in responding to the initial offer, the union will sometimes find it optimal to reject wage offers that lead to more than its default level of utility. In doing so, the unions leave the firm with the impression that it is relatively strong and therefore extracts a better settlement in the second period. By sacrificing utility in the first period, the union increases its utility in the next period. Second, as a firm contemplates increasing its offer, it realizes that higher wages increase the probability that a strike will be averted, but reduce its payoff if the offer is accepted. The optimal offer is the wage that just balances these two opposing forces.

Now, compare the unions' incentives to reject a given wage offer if they act as separate entities with their incentives if they merge and form one union. In the former case, each firm obtains information about its own union's default utility value by observing its behavior during negotiations. However, if the unions merge and form a conglomerate union, the firms may gather information by observing the negotiations between the union and the other firm. For example, General Motors may gather information about the UAW by observing them bargain with Ford or Chrysler. Any action taken by a conglomerate union will therefore have a bigger impact since it will affect the behavior of all firms it bargains with. This immediately implies that a conglomerate union is more likely to reject any given offer (since, in doing so, it can increase the future offers made by all firms it negotiates with). The firms, of course, realize this and take this fact into account in calculating their optimal offers. In fact, since increasing the wage now leads to a smaller increase in the probability of acceptance, the firms will offer lower wages. The lower wage offers coupled with the greater propensity to reject leads to the result that strike activity is greater in the presence of conglomerate unions.

The formal model, which closely mimics the model outline above, is introduced in the next section. In section 3, we solve for the equilibrium strategies under the assumption that the unions bargain independently and then calculate measures of expected strike activity. In section 4, we turn to the case of industry-wide or conglomerate bargaining and argue that the level of uncertainty about the union's payoff function is reduced when the unions join forces. To guarantee that the results derived in this section are independent of this assumption, we first calculate the equilibrium level of strike activity holding the level of uncertainty fixed at a level equal to that in section 3. We show that, in this case, a merger of two unions leads to a higher level of strike activity. We then allow the level of uncertainty to adjust and show that, while the overall level of strike incidence is still higher than when the unions bargain independently, strike duration may be reduced by the merger. This implies that the effect on total strike activity is ambiguous when the change in bargaining structure reduces the amount of uncertainty in the bargaining process. Finally, we close this section by discussing the degree to which our qualitative results depend upon some of the simplifying assumptions of the model.

2. The Model

Our two-period model consists of a pair of unionized firms that produce in separate produce markets.[2] Each firm bargains with its union over how to divide the firm's revenue which, without loss of generality, we assume to be equal to \$1 in each period that it produces.[3] In each period, if the negotiations have not already been completed, firm i makes an offer that its union may accept or reject. Once an offer of x is accepted, the firm earns 1-x and the union receives x in each remaining period. If an offer is rejected, the firm remains idle for that period and earns no income while the union receives a default level of utility denoted by s_i. Second period earnings are discounted by both parties by a common factor $\delta \in (0,1)$ and all agents are assumed to be risk neutral.

Incomplete information is introduced by assuming that the union's default level of utility is not known by the firm. For simplicity, we assume that the firm's initial prior for s_i is the uniform distribution on [0,1]. As the firm observes the behavior of its union, it updates its beliefs using Bayes' rule. Finally, all agents are assumed to be rational, expected payoff maximizers.

We solve for equilibrium by backwards induction. First we derive the agents' optimal strategies in the last period assuming that the first period offer has been rejected. We then solve for the equilibrium strategies in the first period taking these final period strategies as given.

A Bayesian Nash equilibrium consists of a set of strategies that maximize each agent's expected payoff taking the strategies and beliefs of all other agents as given. In this setting, firm i's strategy consists of a first period offer w_i and a second period offer $w_i(R)$ that will be made if the first offer is rejected. The strategy of a typical union consists of a reservation wage for each period. Any offer above the reservation wage for that period is accepted and any wage below that level is rejected. To rule out equilibria supported by non-credible threats, we require the equilibrium strategies to be sequentially rational (Kreps and Wilson [1982]). That is, given the agents beliefs, equilibrium strategies must be optimal at all stages of the game.

Before beginning the formal analysis, a few words concerning our modelling choices are in order. Since s_i is the only unknown parameter, we are analyzing a model with one-sided incomplete information. In a recent paper, Gul and Sonnenschein [1988] argue that if there is essentially no delay in the bargaining process (i.e., counter-offers can be made extremely quickly), then in this setting an agreement will be reached almost immediately and strikes will not occur (see also Ausubel and Deneckere, [1989]). Nevertheless, we have chosen to work in this framework for two reasons. First, we agree with Hart [1989] who argues that it is reasonable to assume <u>some</u> delay between offers (the Gul and Sonnenschein result requires that each counter-offer be made a split second after a rejection).[4] Second, models that have succeeded in explaining delay in reaching an agreement are in the early stages of development and are quite complex (see, for example, Admati and Perry, [1987]). By working with a particularly simple and tractable model, we are able to clearly highlight the forces that produce our results. We believe that it is very likely that the informational externalities at work in our model will produce similar results in more complex settings.

3. Independent Bargaining

Since we have assumed that the firms do not compete with each other in the product market and since, in this case, s_i and s_j are not related in any way, the equilibrium strategies in market i are not affected by the negotiations in market j. In solving for equilibrium, we may therefore focus on one market and ignore the actions of the agents in the other market. This will not be the case when the unions join forces. In that case, the outcome of the negotiations in market i will reveal information about the union that firm j will use in formulating its offers.

3.1. The Final Period

The union's problem in the last period is simple. If it accepts the firm's offer, it receives a payoff of $w_i(R)$. If it rejects the offer, it receives s_i. Therefore, in the last period the union's reservation wage is equal to its default level of utility.

To solve the firm's problem we must begin by describing its second period beliefs concerning the value of s_i. These beliefs depend upon the union's reaction to the first period offer. In general, the firm's first period offer will be rejected by the union if s_i is high and accepted if s_i is low. Let s^* denote the value of s_i that makes the union indifferent between accepting and rejecting the first period offer. Then, from Bayes' rule, whenever the firm's first period offer is rejected, its second period beliefs are represented by the uniform distribution over $[s^*,1]$.

If we let x denote any arbitrary offer in $[s^*,1]$ then we may write the firm's second period expected payoff as

$$(1) \qquad E\pi_i(x) = [(x - s^*)/(1 - s^*)] (1 - x)$$

The first term represents the probability of acceptance while the second term represents the firm's payoff if the offer is accepted. $w_i(R)$, the firm's optimal second period offer, is the value of x that maximizes this expression. From the first-order conditions we obtain

$$(2) \qquad w_i(R) = \tfrac{1}{2} (1 + s^*)$$

3.2. <u>The First Period</u>

Consider the problem of union i in the first period when the firm has made a wage offer of w_i. If the union accepts the offer, it earns w_i in both periods. Therefore, the value of accepting w_i is given by

$$(3) \qquad V(A) = (1 + \delta)\, w_i$$

If the union rejects the offer, it receives s_i in the first period and $\max[s_i, w_i(R)]$ in the second period (since it rejects any second period offer below s_i). Therefore, the value of rejecting w_i is given by

$$(4) \qquad V(R) = s_i + \delta \max[s_i, w_i(R)]$$

s^* is defined to be the value of s_i that equates V(A) and V(R). To solve for s^*, we begin by noting that from (2) it follows that max $[s^*, w_i(R)] = w_i(R)$. With this in mind, we use (2), (3), and (4) to obtain

$$(5) \qquad s^* = \max \{0, [2w_i (1 + \delta) - \delta]/(2 + \delta)\}$$

Since V(R) is increasing in s_i, it follows that if $s_i < s^*$, the union will accept the offer and if $s_i > s^*$, the union will reject w_i. That is, if $s_i < s^*$ the union's reservation wage is below w^i and if $s_i > s^*$ the unions' reservation wage is above w_i.

There are two properties of the union's equilibrium strategy that are worth noting. First, a union may reject a wage offer even if the offer is above its default level of utility (i.e., $s^* < w_i$ so that if the $s_i \in [s^*, w_i]$ the union rejects the offer even though the wage offered is above s_i). In doing so, the union leaves the firm with the impression that it is relatively strong and therefore extracts a higher wage in the second period. The second noteworthy property is that for extremely low wages $s^* = 0$. This implies that the union will reject w_i regardless of the value of s_i. In such a case, the firm learns nothing about the value of s_i by observing the union's reaction to the initial offer and enters the last period with its prior unchanged. This type of equilibrium is commonly referred to as a "pooling equilibrium." On the other hand, equilibria in which $s^* > 0$ are called "semi-separating" since the union's first period behavior will reveal some, but not all, information about the actual value of s_i.

Now, consider the firm's problem. Let y denote any arbitrary first period offer by the firm. Then the firm's expected profit as a function of y is

$$(6) \qquad E\pi_i(y) = \Pr\{y \text{ is accepted}\}\ (1 + \delta)\ (1 - y) + \delta\ \Pr\{y \text{ is rejected}\}\ E\tilde{\pi}_i\ (w_i(R))$$

The probability that y is accepted is equal to $s^*(y)$ and $E\tilde{\pi}_i(w_i(R))$, $w_i(R)$, and $s^*(y)$ are given by (1), (2), and (5). Substituting these values into (6) and optimizing, we obtain w_i, the optimal first period offer

$$(7) \qquad w_i = (4 + 6\delta + \delta^2)/[2(1 + \delta)(4 + \delta)]$$

In summary, in the first period the firm offers w_i (as given in (7)) and the union accepts if $s_i \le s_*$ (as given in (5)). If the offer is rejected, the firm makes a second period offer of $w_i(R)$ (as given in (2)) and the union accepts if $s_i \le w_i(R)$

3.3. Strike Activity

The three measures of strike activity that we wish to calculate are strike incidence, strike duration, and total strike activity. Strike incidence is measured by the number of strikes that occur during the two periods (a two period strike counts as one strike). Strike duration is equal to the average length of the strikes that occur and total strike activity is measured as the number of work days lost due to work stoppages.

A strike occurs at firm i in the first period if the firm's initial offer is rejected. This occurs with probability $1 - s^*(wi)$ which, from (5) and (7), is equal to $(2 + \delta)/(4 + \delta)$. Since s_i and s_j are independent, the probability that both firms are idle in the first period (and hence, two strikes occur) is $(1 - s^*)^2$. Expected strike incidence (ESI) per firm is therefore equal to

$$\text{ESI} = \tfrac{1}{2}\{2(1 - s^*)^2 + 2s^*(1 - s^*)\} = (2 + \delta)/(4 + \delta) \tag{8}$$

A strike occurs in the second period if the first period offer and $w_i(R)$ are both rejected. The probability that $w_i(R)$ is rejected if offered is equal to ½. Expected strike duration (ESD) is therefore equal to 1½ periods.

Finally, expected total strike activity per firm (ESA) is equal to the product of ESI and ESD; or,

$$\begin{aligned} \text{ESA} &= \Sigma_i \Pr\{i \text{ days of strike activity}\}\ i \\ &= [3(2 + \delta)]/[2(4 + \delta)] \end{aligned} \tag{9}$$

Expected strike incidence and expected strike activity are both increasing functions of δ. Intuitively, as the firm and union become more patient they both become less anxious to settle on a wage quickly. This leads the firm to offer a lower wage in the first period and results in more strike activity. The result that expected strike duration is always equal to one and one-half periods is an artifact of the two-period and uniform distribution assumptions. This fact will be discussed in greater detail in the next section.

4. Coalition Bargaining

In this section, we assume that the emloyees of both firms are represented by the same union. This implies that each time the union negotiates with one of the firms, information about its default level of utility will be revealed to both firms. This creates a link between the firms that would not exist otherwise.

The conglomerate union's utility is assumed to be equal to the sum of the utilities achieved in each of the two industries. We denote the union's default level of utility by s_m. This value represents the utility derived by the union in industry i if firm i is currently idle. Thus, if the union accepts one offer (w_i) and rejects the other (w_j) its utility is equal to $s_m + w_i$; if it rejects both it receives $2s_m$; and, if it accepts both it earns $w_i + w_j$.

In the previous section, we assumed that s_i and s_j were independent random variables uniformly distributed on [0,1]. In order to compare the levels of strike activity under the two bargaining structures holding the level of uncertainty constant, we begin by assuming that s_m is uniformly distributed on [0,1]. However, one reason that the unions might choose to merge is to reduce risk. For example, if we interpret s_i as the value of the independent unions' strike fund, the conglomerate union might combine s_i and s_j and then distribute the sum equally across industries.[5] This would imply that the firms' initial prior for s_m should be the triangular distribution on [0,1]. This would also be the case if the conglomerate union attempts to represent the preferences of its average member.[6] To understand the extent to which our results depend on our assumption that s_m has the same distribution as s_i and s_j, we also calculate measures of strike activity under the assumption that the level of risk is reduced by the merger.

4.1. Coalition Bargaining without Risk Sharing

4.1.1. The Final Period

The union's behavior in the last period does not reveal any valuable information to the firms since there are no subsequent periods in which to make use of the new information. Thus, as in section 3, in the last period, the union simply compares the wage offer with its default level of utility. The offer is accepted if and only if it is greater than s_m. The firms' problem in the last period differs in one fundamental way from the problem faced under independent bargaining. In particular, under coalition bargaining there are cases in which the unions' first period behavior will lead the firm to rule out values of s_m in the lower and the upper ends of the support. This will generally occur when one wage is accepted and the other is rejected. In such a case, the firm will enter the final period with beliefs concerning s_m represented by the uniform distribution on $[\underline{s},\bar{s}]$. If, on the other hand, both initial offers are rejected, the firms' problem is qualitatively identical to the problem faced when they bargain independently. In this case, the unions' first period behavior allows the firm to rule out extremely low values for s_m and their posterior distribution is uniform on $[\bar{s},1]$.

To determine the firm's last period offer we may write the firm's expected payoff as

$$(10) \qquad E\tilde{\pi}_i(x) = \Pr\{x \text{ is accepted}\}\ (1 - x)$$

where x is any arbitrary offer. The firm chooses x to maximize this expression. If both first period offers have been rejected and the optimal offer is

$$(11) \qquad w_i(R,R) = \tfrac{1}{2}(1 + \bar{s})$$

If, on the other hand, w_j has been accepted, $\Pr\{x \text{ is accepted}\} = (x - \underline{s})/(\bar{s} - \underline{s})$ and firm i's optimal second period offer is

$$(12) \qquad w_i(R,A) = \min\ \{\tfrac{1}{2}(1 + \underline{s}),\bar{s}\}$$

4.1.2. The First Period

Consider the problem of the conglomerate union in the first period when faced with offers of w_1 and w_2 with $w_1 \leq w_2$. If the union accepts both offers, it earns $w_1 + w_2$ each period. Therefore, the value of accepting both offers is

$$(13) \qquad V(A,A) = (1 + \delta)\ (w_1 + w_2)$$

If the union accepts w_i and rejects w_j, it receives $w_i + s_m$ in the first period and $w_i + \max\{s_m,w_j(R,A)\}$ in the final period. Therefore, the value of accepting one offer and rejecting the other is

$$(14) \qquad V(R,A) = (1 + \delta)w_i + s_m + \delta\ \max\{s_m,w_j(R,A)\}$$

Note that it is never in the union's interest to accept a wage lower than one that it rejects. This follows from the fact that $w_2 \geq w_1$ implies $V(R,A) \geq V(A,R)$.

Finally, if the union rejects both wage offers, it receives $2s_m$ in the first period and $2 \max(s_m, w_1(R,R))$ in the second period. The payoff From rejecting both offers is therefore

$$(15) \qquad V(R,R) = 2s_m + 2\delta \max(s_m, w_1(R,R))$$

It is important to note that $V(R,R)$ and $V(R,A)$ are increasing functions of s_m with $V(R,R)$ increasing at a faster rate. This implies that if the strategy (R,R) dominates (R,A) for some value of s_m, then it dominates it for all higher values of s_m as well. This will also be true if either (R,R) or (R,A) dominate (A,A) for some value of s_m (since $V(A,A)$ is independent of s_m).

A typical union will compare $V(A,A)$, $V(R,A)$, and $V(R,R)$ and choose the action that leads to the greatest payoff. The resulting equilibrium strategy depends, of course, on the values of s_m, w_1 and w_2. For $w_2 < 1$ there are four possibilities. The first is depicted in Figure 1.1. In this, the only possible pooling equilibrium, the wage offers are so low that the union rejects both offers regardless of the value of s_m.

In all other cases the optimal strategy depends upon the value of s_m. One possibility is depicted in Figure 1.2. In this case, all three strategies may be observed in equilibrium since a weak union would accept both offers, a strong union would reject both offers, and a union of intermediate strength would accept the high wage and reject the low. In the other types of semi-separating equilibria, one of the strategies is always dominated by the upper envelope of the two remaining

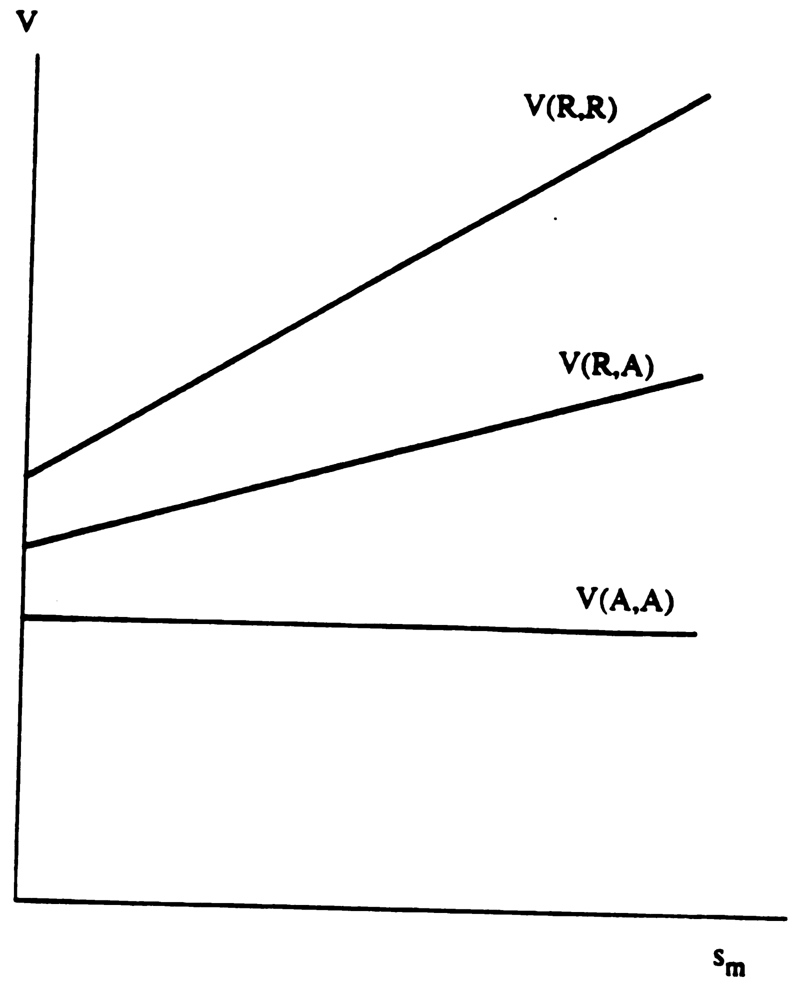

Figure 1.1

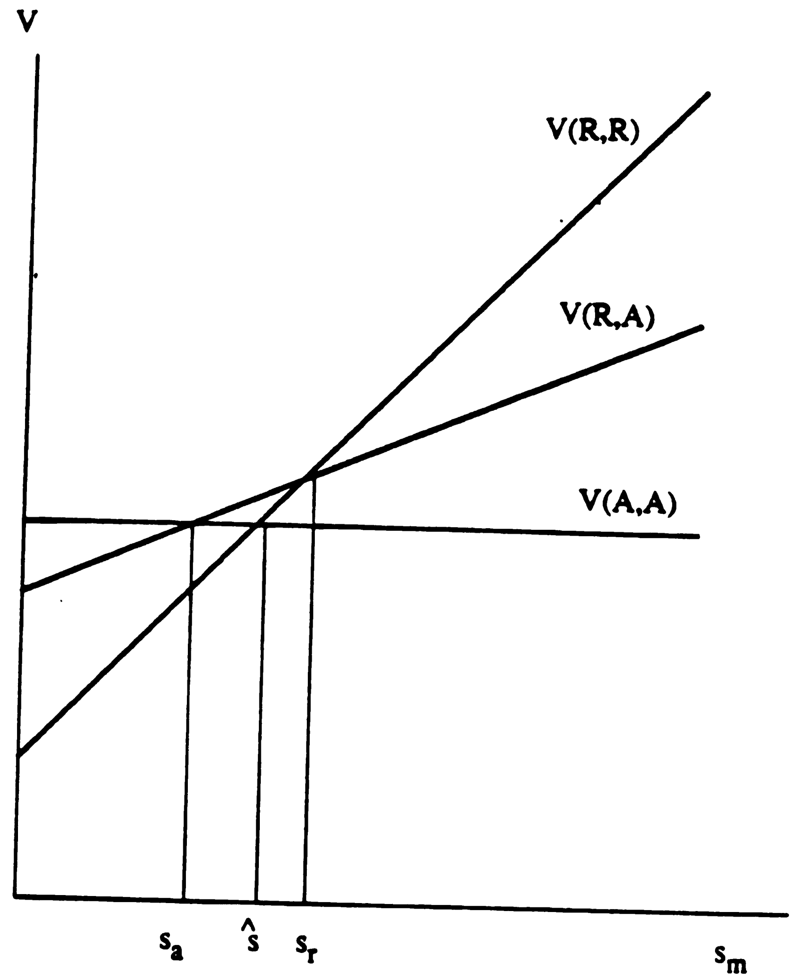

Figure 1.2

strategies and is therefore not expected to be observed in equilibrium. In order to guarantee that the union's reaction is optimal, it is necessary to specify beliefs for the firm if a dominated strategy is actually observed. For simplicity, we adopt the assumption that if an unexpected rejection (acceptance) is observed, the firm conjectures that $s_m = 1$ (0).[7]

The pooling equilibrium is appropriate when $V(R,R) \geq \max\{V(A,A),V(R,A)\}$ for all s_m. Due to the monotonicity of V(R,R) and V(R,A) in s_m, this inequality is least likely to hold when $s_m = 0$. Using (11)-(15) we find that the inequality reversed if $w = w_1 + w_2 \geq \delta/(1+\delta)$.[8] Therefore, a pooling equilibrium in which the union rejects both offers exists if and only if $w \leq \delta/(1 + \delta)$.

To determine which of the possible semi-separating equilibria is appropriate for a given wage vector, define s_a to be the value of s_m that equates V(A,A) and V(R,A); s_r, the value that equates (R,R) and (R,A); and $\hat{s}$, the value that equates (R,R) and (A,A). These values can be calculated using equations (11)-(15). Provided that the values are positive (and less than one), their ordering then tells us which type of semi-separating equilibrium applies. For example, if $s_a < \hat{s} < s_r$ (as in Figure 1.2) all three strategies will be observed in equilibrium. In this case, if the union accepts the high wage and rejects the low, the firm will enter the second period with beliefs represented by the uniform distribution on $[\underline{s},\bar{s}]$ with $\underline{s} = s_a$ and $\bar{s} = s_r$. If both wages are rejected, the firms' posterior distribution will be uniform on $[\bar{s},1]$ with $\bar{s} = s_r$. On the other hand, if $0 < s_r < \hat{s} < s_a < 1$ then V(R,A) is dominated by the upper envelope of V(A,A) and V(R,R) (see Figure 1.3). In this case, if the firm observes that both first period offers have

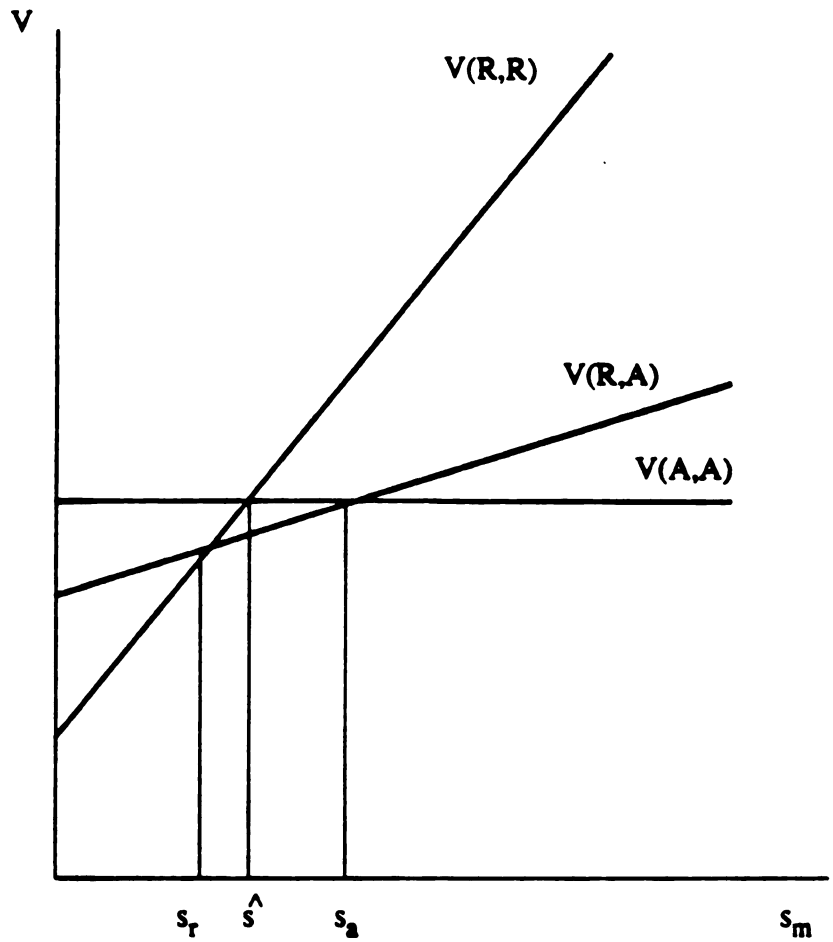

Figure 1.3

been rejected its posterior distribution will be uniform on [s,1] with $\bar{s} = \hat{s}$. The wage offers under which each type of equilibrium apply are derived in section 1 of the appendix. Figure 1.4 summarizes the case $\delta = .5$. Region a represents the wage vectors that lead to the pooling equilibrium. In this region both wages are so low that the union rejects them both regardless of its default level of utility. In region b, w_1 is so low that it is never optimal to accept it (i.e., V(A,A) is dominated). Therefore, if $s_m < s_r$ the union accepts w_2 and if $s_m > s_r$ both wages are rejected. Throughout this region s_r is increasing in w_2. In region c, the firms' offers do not differ much and it is therefore never optimal to accept one while rejecting the other. This is, in fact, the case depicted in Figure 1.3 and discussed above. $\hat{s}$ is increasing in both wages throughout the region. Finally, region d represents those wage vectors that generate the type of semi-separating equilibrium depicted in Figure 1.2. In this region, s_r is increasing in w_2 and s_a is increasing in w_1 and decreasing in w_2. The qualitative features of Figure 1.4 remain the same for other values of the discount factor. However, little insight would be gained by explicitly calculating the boundries of the regions and the critical values of s_m in the text. This information is provided in the appendix for the interested reader.

There are two key features of the union's optimal first period strategy that are worth mentioning. First, as in the case of independent bargaining, each firm can increase the probability that its wage will be accepted by increasing its offer. This follows from the fact that s_a (s_r) is increasing in w_1 (w_2) in regions b and d and that $\hat{s}$ is increasing in both wages in region c. Second, and most important, if the offers are similar (but not necessarily identical) it is never optimal

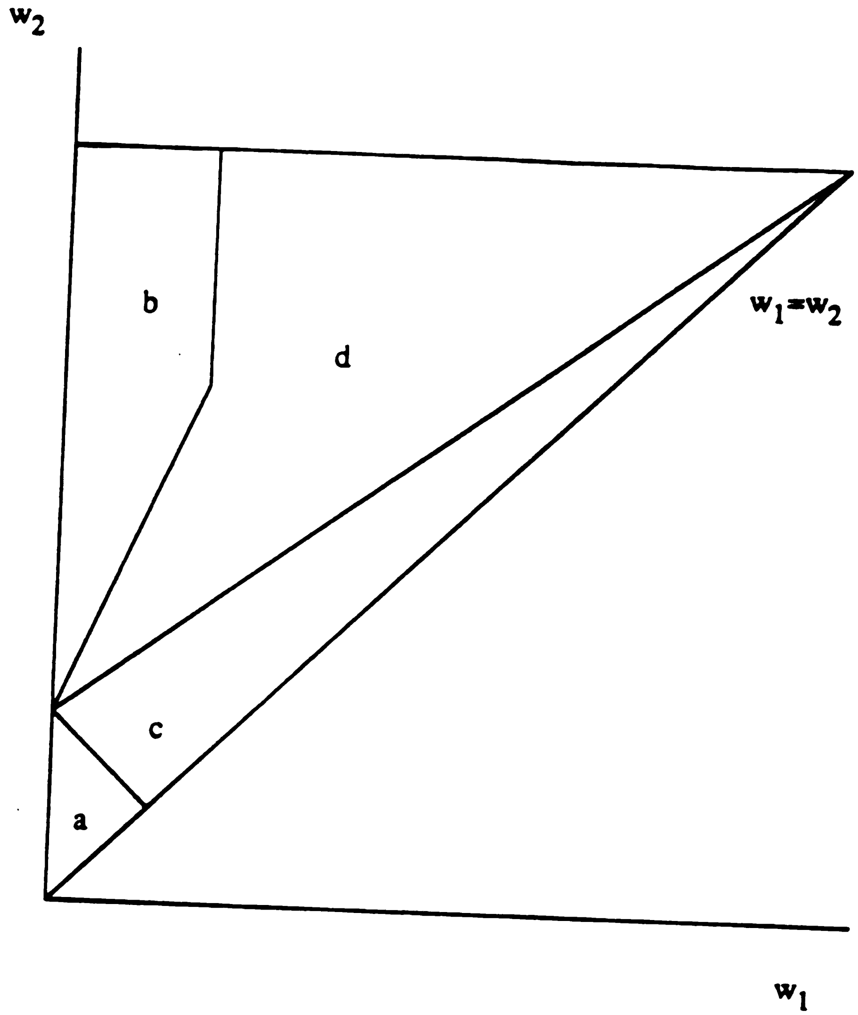

Figure 1.4

for the union to reject one wage and accept the other. The reason for this is simple. Accepting a wage offer is essentially a sign of weakness (a low default level of utility) while rejections are made either to feign strength or because the union is actually strong. Therefore, if the union accepts one offer it reveals itself to be relatively weak and the value of rejecting the other offer is significantly reduced (firm j's second period offer falls from $w_j(R,R)$ to $w_j(A,R)$ when w_i is accepted). Thus, unless the offers are significantly different, (R,A) will not be an optimal response. As we will see shortly, it is this feature of the union's strategy that will lead to the increased strike activity.

We are now in position to describe the firms' first period problem. Let $Pr_i(A,R)$ denote the probability that the union accepts firm i's first period offer and rejects firm j's. Define $Pr_i(A,A)$, $Pr_i(R,A)$, and $Pr_i(R,R)$ in an analogous manner. Then the expected profit for firm i as a function of y, its own offer, and z, the offer firm i expects firm j to make, can be expressed as

$$E\pi_i(y|z) = [Pr_i(A,A) + Pr_i(A,R)]\ (1 + \delta)\ (1 - y) + \delta\ Pr_i(R,A)\ Pr_i\{w_i(R,A) \text{ is accepted}\}\ (1 - w_i(R,A)) + \delta\ Pr_i(R,R)\ Pr_i\{w_i(R,R) \text{ is accepted}\}\ (1 - w_i(R,R)) \quad (16)$$

The probability of acceptance depends on the position of (y,z) in Figure 1.4. For example, if (y,z) lies in region a, then $Pr_i(R,R) = 1$ and all other probabilities are equal to zero. If, on the other hand, (y,z) lies in region d with $y > z$ then $Pr_i(A,A) = s_a$, $Pr_i(A,R) = s_r - s_a$, $Pr_i(R,A) = 0$, and $Pr_i(R,R) = 1 - s_r$ (if $y < z$, $Pr_i(A,R)$ and $Pr_i(R,A)$ are reversed and if $y = z$, $Pr_i(A,R) = Pr_i(R,A) = ½$). The other cases are handled in a similar manner. Therefore, since s_a, s_r, $\hat{s}$, and the boundries that define the regions in Figure 1.4 depend on both wages, firm i's expected payoff depends on the wage it expects firm j to propose. This is not the case when the unions bargain independently since, in that case, firm i learns nothing about its union's strength from observing the negotiations at firm j.

In a Nash equilibrium both firms must be maximizing their expected payoff given their conjecture about their opponent's wage offer and both firms' conjectures must be correct. If we let $w_i^*(w_j)$ denote the value of y that maximizes (16) when $z = w_j$, then the equilibrium first period offers, $\hat{w}_i$ and $\hat{w}_j$, must satisfy $w_i^*(\hat{w}_j) = \hat{w}_i$ and $w_j^*(\hat{w}_i) = \hat{w}_j$. $w_i^*(w_j)$ is simply firm i's reaction curve and $\hat{w}_i$ and $\hat{w}_j$ represent the wages defined by the intersection of the two reaction functions. These reaction curves are depicted in Figure 1.5. They are downward sloping and cross only once so that the equilibrium is unique. Moreover, they cross at the 45° line so that the equilibrium is symmetric.

The negative slope of the reaction function is a direct result of the informational externality that exists in the presence of coalition bargaining. To see this, consider firm i's problem when it expects firm j to offer w' instead of w with w' > w. When w' is offered firm i knows that it will learn more about the likelihood that the union is strong than when w is offered (by observing the union's reaction). This reduces the incentive for firm i to offer a high wage and increases the value of the information provided by a low offer. Firm i's response is to therefore lower its wage offer. In a sense, this results from the fact that firm i is able to free ride off of the information provided by the

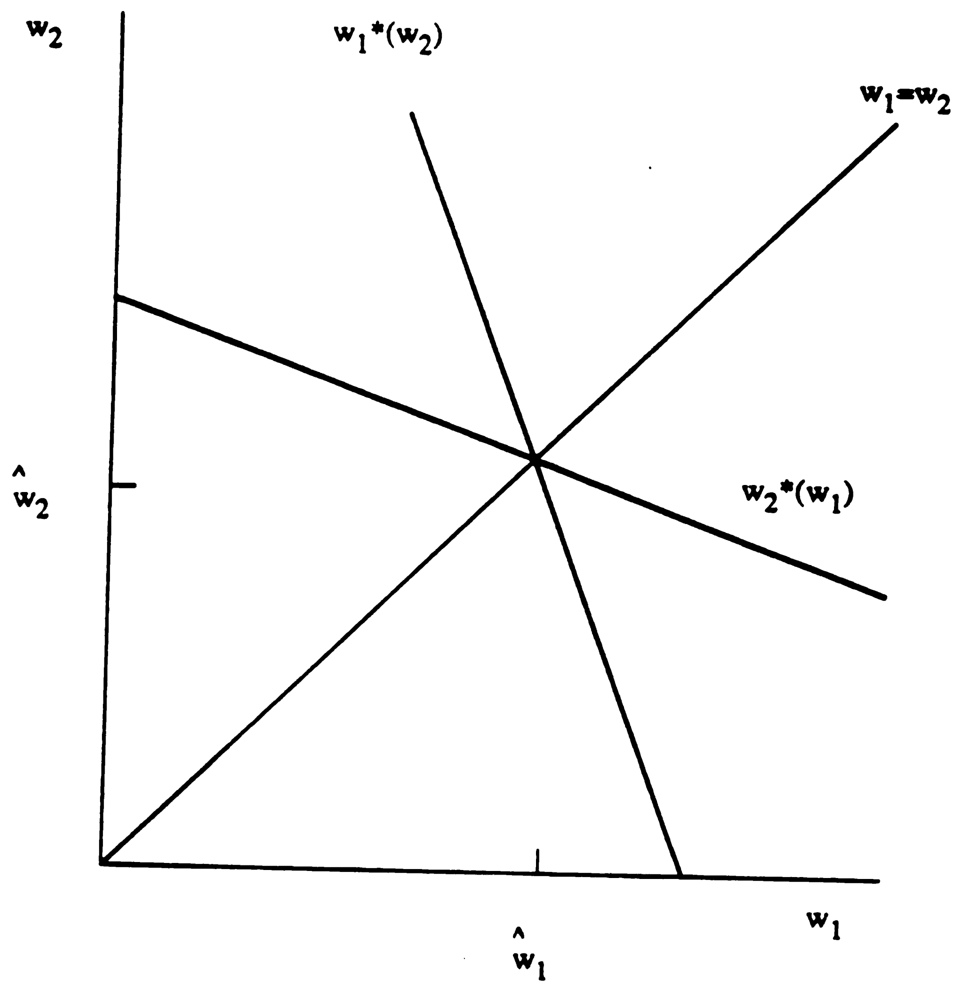

Figure 1.5

union's reaction to firm j's offer.

Since the equilibrium is symmetric, an analytic solution for the equilibrium wages can be derived by examining the expected payoff functions in the neighborhood of the 45° line. From Figure 1.4 it is apparent that when the offers do not differ by much only regions a and c are relevant. However, it is clearly not optimal for the firm to offer a wage in region a since wages in this region are rejected with probability one. Moreover, such rejections provide the firm with no new information concerning the union's strength. This leaves us with region c. In this region, the union accepts both offers if $s_m \leq \hat{s}$ and rejects both if $s_m \geq \hat{s}$ where, from section one of the appendix, $\hat{s} = [w(1 + \delta) - \delta]/(2+\delta)$. Using (11) expected profit over region can now be simplified to

$$(17) \qquad E\pi_i(y|z) = \hat{s}(1 + \delta)(1 - y) + \delta(1 - \hat{s})^2/4$$

If we set the derivative of (17) equal to zero and solve for the equilibrium wage we obtain

$$(18) \qquad \hat{w}_i = (2 + 4\delta + \delta^2)/[2(1 + \delta)(3 + \delta)].$$

Comparing (18) with (7) we find that the first period wage offers are lower in the presence of coalition bargaining. To understand the forces behind this result, we begin by comparing the union's reaction to a given wage vector under the two bargaining structures. In particular, suppose that the firms make identical first period proposals and that the offered wage vector lies in region c of Figure 1.4. From section 3 we know that such a wage offer would be accepted by an independent union if $s_i < s^*$ with $s^* = [2w_i(1 + \delta) - \delta]/(2 + \delta)$. Therefore, from the firm's point of view, the offer will be accepted with probability s^*. Turn next to the case of coalition bargaining. From above, such a proposal would accepted by a conglomerate union if $s_m < \hat{s}$ with $\hat{s} = [(w_1 + w_2)(1 + \delta) - \delta]/(2 + \delta)$ and, from the firm's point of view, $\hat{s}$ represents the probability that its proposal will be accepted. When the initial offers are identical it is interesting note that $s^* = \hat{s}$. Thus, at first glance, it appears that the union's behavior is independent of the bargaining structure. However, appearances can be deceptive and, in this case, they are. The union's behavior begins to differ as soon as the proposals begin to diverge. To see this, simply note that s^* increases at a faster rate than $\hat{s}$ as w_2 rises above w_1. Intuitively, as w_2 increases, union two is free to accept the better offer without fear of harming the workers at firm one <u>only</u> when the unions bargain independently. In the case of coalition bargaining, an acceptance of w_2 would signal weakness and would lead to a lower second period offer by firm one. The union would like to accept firm two's offer but cannot do so without hurting firm one workers. This would not be the case if the unions bargained independently since, in that case, an acceptance by union two provides no information concerning the strength of union one. An industry-wide or conglomerate union therefore faces a stronger incentive to reject proposals. This implies that the information a firm might gain by increasing its offer is greatest when the unions bargain independently. Finally, since the only reason that firms increase their wage offers is to gain information and increase the probability of acceptance, the firms will offer lower wages in the presence of coalition bargaining.

4.1.3 Strike Activity

We are now in a position to calculate the three measures of strike activity and compare them with their counterparts under independent bargaining. Under coalition bargaining, the probability that both firms are idle in the first period is equal to $1 - \hat{s}$ the probability that the initial offers are rejected. Expected strike incidence per firm is therefore equal to

$$\text{(19)} \qquad ESI = \tfrac{1}{2}\{2(1 - \hat{s})\} = (2 + \delta)/(3 + \delta).$$

Comparing (19) and (8) we find that strikes are more frequent under coalition bargaining. This result follows from the fact that the firms, knowing that a conglomerate union is more likely to reject their proposed wages, offer lower wages in the presence of coalition bargaining.

A strike occurs at both firms in the second period if the first period offers and $w_i(R,R)$ are both rejected. If offered, $w_i(R,R)$ will be rejected with probability ½. Expected strike duration is therefore equal 1 to 1½ periods; just as it is under independent bargaining. The fact that strike duration is independent of the bargaining structure is misleading, however, since it is an artifact of the two-period model and uniform distribution assumptions. Since there are no subsequent periods in which to learn about the true value of s_m and since it is equally likely that s_m lies anywhere in the interval the optimal second period offer lies half [s,1], way between s and 1. If we had a more elaborate n-period model, there would still be a value to shading the second period offer towards the lower end of the support in an effort to gather information and in the hopes that the lower offer would be accepted. The same forces that led to the result that strike incidence is greater under coalition bargaining would then lead the firms to shade more when facing a conglomerate union that when facing independent unions. In a more elaborate model then, we would expect strike duration to be greater under coalition bargaining.

Since expected strike incidence is increased by industry-wide bargaining and since expected strike duration is independent of the bargaining structure, it follows that expected total strike activity per firm is greater under coalition bargaining. This is confirmed by comparing (9) with (20), the appropriate measure when the unions have a common bargaining agent.[9]

(20) $$ESA = (3/2)\ [(2 + \delta)/(3 + \delta)].$$

4.2. Coalition Bargaining with Risk Sharing

It was argued in the introduction to this section that a merger between two unions might alter the distribution of the union's default level of utility and reduce the amount of risk inherent in the bargaining process. If this is the case, we might expect the merger to reduce the amount of strike activity in the industry. In this sub-section we show that, at least in one important case, this may not be true. We do so by assuming that the firms' initial prior for s_m is triangular on [0,1]. Two cases in which such as assumption might be appropriate were outlined at the beginning of Section 4. The uniform distribution on [0,1] may be obtained by a mean preserving spread of this distribution and therefore, this assumption captures the notion that the merger reduces uncertainty.

The analysis is carried out exactly as in sub-section A above except, of course, a different initial prior is used. The form of the triangular distribution leads to expressions considerably more complicated than their counterparts in the case of the uniform distribution. The details of the equilibrium strategies are therefore relegated to section two of the appendix. For our present purposes, it is sufficient to report that the nature of the equilibrium strategies remains the same although the firms' first period offers tend to be higher and their second period offers lower. This follows from the fact that the triangular distribution has more of the mass of the distribution centered around the mean. Both offers are therefore drawn closer to the mean after the merger.

The measures of expected strike incidence and expected strike activity as a function of the discount factor are provided in Figure 6. The thick lines represent the measures under coalition bargaining and the thin line, the case of independent bargaining. The total number of strikes increases due to the change in bargaining structure while total strike activity falls. The first result remains true even though the total amount of uncertainty present in the bargaining process has been reduced. We argue below that the latter result would be reversed in a model with more than two periods of bargaining.

In the appendix, we demonstrate that expected strike duration decreases to one and one-third periods when the unions join forces. This is a by-product of the fact that the triangular distribution has more mass centered around the mean. Since there is so little mass in the upper end of the distribution, the probability that the firms' second period offers will be rejected is significantly reduced. In our two period model, this reduction in expected strike duration more than compensates for the increase in expected strike incidence as evidenced by the fact that total strike activity falls (see Figure 1.6). In a more elaborate n-period model the forces that lead to greater strike incidence in the first period would cause an increase in the number of strikes expected in every period but the last. Therefore, we strongly suspect that in a model with more than two periods of bargaining, total strike activity will be increased due to the merger even if the merger reduces the level of uncertainty inherent in the bargaining process.

4.3. Extensions

There are at least two important simplifying assumptions embodied in this model that might limit its applicability. We have assumed throughout that the amount of revenue to be divided between the firm and union (i.e., the "size of the pie" in bargaining terminology) is independent of the wage. In reality, when the wage increases, a profit maximizing firm responds by reducing output which, of course, alters its level of revenue. This model could be extended to allow for such effects by making the size of the pie a decreasing function of the wage. Such an extension would, however, greatly complicate the analysis without adding any new insights. Clearly, the primary economic force driving our results is that in the presence of coalition bargaining the incentive to deceive increases. This force would not disappear or even be diminished by allowing the wage to affect revenue.

The second simplifying assumption is that the wage paid by firm i does not affect the size of the pie to be divided between firm j and its

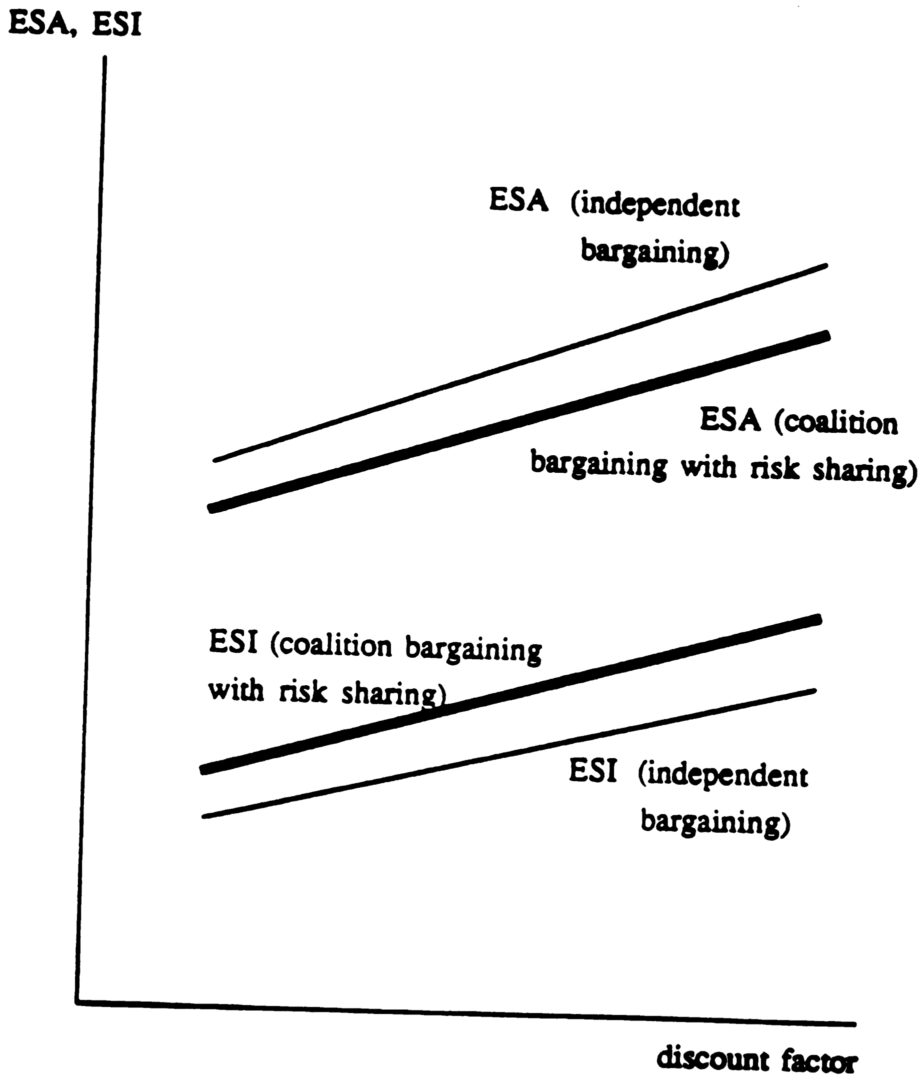
ESA, ESI
ESA (independent bargaining)
ESA (coalition bargaining with risk sharing)
ESI (coalition bargaining with risk sharing)
ESI (independent bargaining)
discount factor

Figure 1.6

workers. This assumption might be especially troublesome if we want out theory to apply to mergers or coalitions formed by unions in the same industry. We wish to argue, however, that the inclusion of such effects will actually strengthen our results. To see this, consider two unionized firms that compete in the same product market and bargain over wages with their respective unions. In such a setting, increases in the wage paid by firm one will enhance the competitive position of firm two in the product market. If, for example, the workers at firm i manage to secure a higher wage for themselves a positive externality is created in that the size of the pie to be divided by firm j and its workers is increased. When the unions bargain independently they ignore this externality and are too willing to settle for any given wage. If the unions merge or form a coalition this externality is internalized and the unions will hold out for higher wages. This implies that an industry-wide union is more likely to reject any given offer (see, Davidson [1985] for a more detailed argument). But, this is precisely the same incentive that results in increased strike activity in our model! Therefore, our results are far more general than might be readily apparent.[10]

5.Conclusion

In this paper, we examined the nature of the relationship between bargaining structure and strike activity. In particular, we focused on the implications of the fact that the amount of information revealed by a union's actions depends upon the bargaining environment in which it operates. We demonstrated that a union that represents workers at more than one firm will face a greater incentive to reject offers than an independent union. This implies that a merger of two unions or the formation of bargaining coalitions will lead to a greater level of strike activity.

FOOTNOTES

1. These studies were made possible by recent advances in noncooperative game theory. In particular, they follow approaches developed in recent papers concerned with abstract bargaining problems in the presence of incomplete information. Among the path breaking papers are Fudenberg and Tirole [1983], Sobel and Takahashi [1983], Cramton [1984], and Rubinstein [1985]. The model presented in this paper is similar in spirit to Cramton's.

2. We discuss the importance of this assumption in section 4.C below.

3. In section 4.C, we discuss the importance of the assumption that the revenue to be divided is independent of the wage.

4. Hart argues that while limited delay between offers is enough to some strike activity, it is not sufficient to explain the magnitude of strike activity we actually observe. He therefore adds another assumption to his model - strikes reduce the future probanility of firms (due to, say, a loss in goodwill during the strike).

5. This assumes that the unions are of equal size.

6. As in note 5, this assumes that the unions are of equal size.

7. These off the equilibrium path conjectures are the only conjectures that satisfy the Intuitive Criterion recently introduced by Cho and Kreps [1987].

8. If the union accepts either wage the firms' will enter the last period believing that the union's default level of utility is zero. The firms' last period offer then becomes zero. On the other hand, rejecting both wages leaves the firms' prior unchanged and leads to a second period offer of one half. Therefore, if $s_m = 0$, $V(A,A) = (w_1 + w_2)(1 + \delta)$; $V(R,R) = \delta$; and, $V(R,A) = w_2 (1 + \delta)$.

9. At this point, before considering the case of coalition bargaining with risk sharing, we wish to offer a comment concerning the interpretation of our model. Up to this point we have focused on the effects of coalition bargaining when the coalition consists of unions that represent workers at different firms. However, workers in many industries are organized by their craft, with unions cutting across firms. In such a case, coalitions may form in order to coordinate the bargaining activities of the many craft unions in a given industry. Our model is clearly flexible enough to handle such a situation. Rather than interpreting our model as a model of unionized firms bargaining with their unions, interpret it as a model of firms bargaining with two craft unions. When the coalition forms, the firm may learn about the union's payoff function by observing the union's behavior each time it represents one set of workers. Therefore, coalition bargaining by craft unions at a given firm (or a given industry) will lead to an increase in strike activity.

10. In a recent paper, Rose [1986] found that coalition bargaining on the employers' side led to an increase in strike activity in Canada. This is consistent with our theory. To see this, suppose that some parameter of the firm's profit function is unknown but that there is complete certainty concerning the union's payoff function. In such a setting, low (high) wage offers will be taken by the union as a sign that the size of the pie to be split in small (large). It will obviously be in the firm's interest to mislead the union into believing that the pie is small. Since offers by a coalition of firms will affect the payoff received by all firms, it is clear that under coalition bargaining the incentive to deceive (offer low wages) is greater. Therefore, the same forces that lead to greater strike activity in our model would lead to greater strike activity in the presence of multi-unit bargaining on the employers side.

APPENDIX

I. The Uniform Case

We begin by assuming $w_1 \leq w_2 < 1$. As discussed in the text, this leaves us with four possibilities:

(a) $V(R,R) \geq \max\{V(A,A), V(R,A)\}$ for all $s_m \in [0,1]$

This is a pooling equilibrium in which the union rejects both wages regardless of the value of s_m. This inequality is least likely to hold when $s_m = 0$. Therefore, suppose that $s_m = 0$. If the union rejects both wages, the firm enters the last period with its prior unchanged. Therefore, $w_1(R,R) = \frac{1}{2}$ and $V(R,R) = \delta$. If the union accepts either wage, the firm enters the last period with $\underline{s} = \bar{s} = 0$. Therefore, $w_1(R,A) = 0$ and
$V(A,A) = (1+\delta)(w_1+w_2) \geq V(R,A) = (1+\delta)w_2$. If the inequality holds for all $s_m \in \{0,1\}$ it must therefore be the case that $\delta/(1+\delta) \geq w_1 + w_2$.

(b) $V(R,A) \geq \max\{V(A,A), V(R,R)\}$ for all $s_m \in [0,s_r]$
$V(R,R) \geq \max\{V(A,A), V(R,A)\}$ for all $s_m \in [s_{r,1}]$

This is a semi-separating equilibrium in which the union rejects w_1 regardless of the value of s_m and accepts w_2 only if it is sufficiently weak. If the union rejects both wages the firm's second period beliefs are uniform on $[s_r,1]$. If the union plays (R.A) the firm's second period beliefs are uniform on $[0,s_r]$. Therefore, s_r solves

$$V(R,R) = 2\, s_r + \delta(1+s_r) = w_2(1+\delta) + s_r(1+\delta) = V(R,A)$$

or, $s_r = w_2(1+\delta) - \delta$.

For this equilibrium to be appropriate it must be the case that $0 < s_r < 1$ and $V(R,A) \geq V(A,A)$ for $s_m = 0$. $s_r \in (0,1)$ if $w_2 \in [\delta/(1+\delta), 1]$ and the latter inequality holds if $w_1(1+\delta) \leq \delta w_1(R,A) = \delta \min(\frac{1}{2}, w_2(1+\delta) - \delta)$. The values of w_1 and w_2 satisfying these constraints are depicted in Figure 4 of the text.

(c) $V(A,A) \geq \max\{V(R,A), V(R,R)\}$ for all $s_m \in [0,\hat{s}]$
$V(R,R) \geq \max\{V(R,A), V(A,A)\}$ for all $s_m \in [\hat{s},1]$

In this semi-separating equilibrium (A,R) is never optimal and both wages are accepted if the union is sufficiently weak. If the union plays (R,R) the firms' second period beliefs are uniform on $[\hat{s},1]$. Therefore, $\hat{s}$ solves $V(A,A) = (w_1 + w_2)(1+\delta) = 2\hat{s} + \delta(1 + \hat{s}) = V(R,R)$ or,

$$\hat{s} = [(w_1+w_2)(1+\delta)-\delta]/(2+\delta)$$

There are two cases to consider, depending on the relative ranking of V(R,R) and V(R,A) when $s_m = 0$. Suppose first that $V(R,R) \geq V(R,A)$ when $s_m = 0$. This occurs if $w_2 \leq \delta/(1+\delta)$. If this is the case, $\hat{s} \in (0,1)$ whenever $w_1 + w_2 \in [\delta/(1+\delta), 2]$.

Now, suppose $V(R,R) \leq V(R,A)$ when $s_m = 0$. This occurs when $w_2 \geq \delta/(1+\delta)$. In this case, we must have $V(A,A) \geq V(R,A)$ at $s_m = 0$ and $s_m = \hat{s}$ or, $w_1 \in [0,\hat{s}]$. The values of w_1 and w_2 satisfying these constraints are depicted in Figure 4 of the text.

(d) $V(A,A) \geq \max\{V(R,A), V(R,R)\}$ for all $s_m \in (0,s_a)$
$V(R,A) \geq \max\{V(A,A), V(R,R)\}$ for all $s_m \in (s_a,s_r)$
$V(R,R) \geq \max\{V(A,A), V(R,A)\}$ for all $s_m \in (s_r,1)$

For this case to be valid, we must have

(i) $V(A,A) \geq V(R,R)$ at $s_m = 0$
(ii) $V(R,A) \geq V(R,R)$ at $s_m = 0$
(iii) $V(R,R) \geq V(R,A)$ at $s_m = 1$
(iv) $V(R,R) \geq V(A,A)$ at $s_m = 1$

The first condition requires $w_1 + w_2 \geq \delta(1+s_r)/(1+\delta)$.
The second condition requires $w_2(1+\delta) + \delta\min[\frac{1}{2}(1+s_a),s_r] \geq \delta(1+s_r)$.
The third condition requires $w_1 + w_2 < 2$.
The fourth condition requires $w_1 < 1$.

Finally, in solving for s_a and s_r we require $s_a < s_r$ (this guarantees $s \in (s_a,s_r)$). s_r solves $V(R,R) = V(R,A)$ or $2s_r + \delta(1 + s_r) = w_2(1 + \delta) + s_r(1 + \delta)$ or

$$s_r = [w_2(1 + \delta) - \delta]/(1 - \delta).$$

s_a solves $V(A,A) = V(R,A)$ or $(w_1 + w_2)(1 + \delta) = w_2(1 + \delta) + s_a + \min[\frac{1}{2}(1 + s_a), s_r]$. As before, the values of w_1 and w_2 satisfying (i)- (iv) and $s_a < s_r$ are depicted in Figure 4.

For the case $w_2 = 1$, the union always accepts the high wage. The problem of whether or not to accept $w_1 < 1$ is analogous to the union's problem discussed in section 3 and is therefore left to the interested reader.

II. The Triangular Case

The original prior is of the form

$$f(x) = \begin{cases} 4x & \text{if } 0 \le x \le ½ \\ 4(1-x) & \text{if } ½ \le x \le 1 \end{cases}$$

The firms' optimal second period offers become:

$$w_1(R,R) = \begin{cases} 1 - \sqrt{[6(1 - 2\bar{s}^2)]}/6 & \text{if } 0 \le x \le ½ \\ 1 - (1 - \bar{s})/\sqrt{3} & \text{if } ½ \le x \le 1 \end{cases}$$

and

$$w_1(R,A) = \begin{cases} \bar{s} & \text{if } \underline{s} \le \bar{s} \le ½ \\ \min\{1 - \sqrt{[6(1-2\underline{s}^2)]}/6,\ \bar{s}\} & \text{if } \underline{s} \le ½ \le \bar{s} \\ \min\{1 - (1 - \underline{s})/\sqrt{3},\ \bar{s}\} & \text{if } ½ \le \underline{s} \le \bar{s} \end{cases}$$

The union's optimal first period response is dervied in the same manner outlined in section I of the appendix. For completeness, we report the conditions under which each cas is appropriate. Detailed computations may be obtained from the authors, if desired.

(a) $V(R,R) \ge \max\{V(A,A),\ V(R,A)\}$ for all $s_m \in [0,1]$

This case applies if $w_1 + w_2 \le 2(1-1/\sqrt{6})\delta/(1+\delta)$.

(b) $V(R,A) \ge \max\{V(A,A),\ V(R,R)\}$ for all $s_m \in [0,s_r]$
$V(R,R) \ge \max\{V(A,A),\ V(R,A)\}$ for all $s_m \in [s_{r,1}]$

where

$$s_r = \begin{cases} m_1(w_2) & \text{if } w_2 \in [1.18\delta/(1+\delta),\ (.5+.925\delta)/(1+\delta)] \\ m_2(w_2) & \text{if } w_2 \in [(.5+.925\delta)/(1+\delta), (.59+.94\delta)/(1+\delta)] \\ m_3(w_2) & \text{if } w_2 \in [(.59+.94\delta)/(1+\delta), 1] \end{cases}$$

with $m_1(w_2) = \{3(1-\delta)[w_2(1+\delta)-2\delta]+\delta\sqrt{[6(1-\delta)^2-40\delta^2-48\delta(1+\delta)w_2+12w_2^2(1+\delta)^2]}\}/[3(1-\delta)^2+4\delta^2]$,

$m_2(w_2) = [w_2(1+\delta)-.8453\delta]/(1+.1547\delta)$, and

$m_3(w_2) = [w_2(1+\delta)-.2535\delta]/(1+1.1547\delta)$.

This case applies if $w_1 \le \delta/s_r(1+\delta)$ when $w_2 \in [1.18\delta/(1+\delta), (.59+.94\delta)/(1+\delta)]$ or $w_1 \le .59\delta/(1+\delta)$ when $w_2 \in [(.59+.94\delta)/(1+\delta), 1]$.

(c) $V(A,A) \geq \max\{V(R,A), V(R,R)\}$ for all $s_m \in [0,\hat{s}]$
$V(R,R) \geq \max\{V(R,A), V(A,A)\}$ for all $s_m \in [\hat{s},1]$

where

$$\hat{s} = \begin{cases} m_4(w_1+w_2) & \text{if } (w_1+w_2)\in[1.18\delta/(1+\delta),\ (1+1.42\delta)/(1+\delta)] \\ m_5(w_1+w_2) & \text{if } (w_1+w_2)\in[(1+1.42\delta)/(1+\delta),2] \end{cases}$$

with $m_4(w_1+w_2) = \{3[(1-\delta)(w_1+w_2)-2\delta]+\delta\surd[6(6-10\delta^2+12\delta^2(1+\delta)(w_1+w_2)-3(w_1+w_2)^2(1+\delta)^2]\}/[2(3+\delta^2)]$, and

$m_5(w_1+w_2) = [(w_1+w_2)(1+\delta)-.8453\delta]/[2(1+.1547\delta)]$.

This case is appropriate if $w_2 \leq 1.18\delta/(1+\delta)$ or $w_2 \geq 1.18\delta/(1+\delta)$ and $w_1 \geq \hat{s}$.

(d) $V(A,A) \geq \max\{V(R,A), V(R,R)\}$ for all $s_m \in (0,s_a)$
$V(R,A) \geq \max\{V(A,A), V(R,R)\}$ for all $s_m \in (s_a,s_r)$
$V(R,R) \geq \max\{V(A,A), V(R,A)\}$ for all $s_m \in (s_r,1)$

where $s_r = \min\{m_6(w_2),\ [(1+\delta)w_2-.8453\delta]/(1+.1547\delta)\}$
and

$$s_a = \begin{cases} m_7(w_2) & \text{if } w_1(1+\delta)-\delta s_r \geq \tfrac{1}{2} \text{ and } f(w_1,s_r) \leq 0 \\ m_8(w2) & \text{if } w_1(1+\delta)-\delta s_r \leq \tfrac{1}{2} \text{ and } g(w_1,s_r) \leq 0 \\ w_1(1+\delta)-\delta s_r & \text{otherwise} \end{cases}$$

with $m_6(w_2) = \{3[(1-\delta)(1+\delta)w_2-2\delta]+\delta\surd[6(1-\delta)^2-40\delta^2-48\delta(1+\delta)w_2+3(1+\delta)^2w_2^2(1+\delta)^2]\}/[3(1-\delta)^2+4\delta^2]$,

$m_7(w_2) = \{6[w_1(1+\delta)-\delta]+\delta\surd[6-10\delta^2+24w_1(1+\delta)\delta-12w_1^2(1+\delta)^2]\}/[2(3+\delta^2)]$,

$m_8(w_2) = [w_1(1+\delta)-.4226\delta]/(1+.5774\delta)$,

$f(w_1,s_r) = 2s_r^2(3+\delta^2)-4s_r[3+\delta(1+\delta)w_1]+5+2w_1^2(1+\delta)^2$,

$g(w_1,s_r) = [.58(1+\delta)w_1+.42](1+.15\delta)-[((1+\delta)w_2-.85](1+.58\delta)$.

This case applies if $w_2 \in [1.18\delta/(1+\delta),\ 2]$ and $w_1 \in [\delta\min(.59,s_r)/(1+\delta),\ s_r]$.

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CHAPTER TWO

(ESSAY 2)

Market Power and Vertical Restraints

1. Introduction

Oligopolistic collusion is a major concern for economists and policy makers. While explicit cartels are prohibited by the anti-trust laws, collusion in a tacit form may still exist. Although some economists have previously questioned the stability problem of tacit cartels, recent studies (Friedman (1971), Green and Porter (1984), Abreu (1986), Fudenberg and Maskin (1986)) indicate that self-enforcing agreements among cartel members can be implemented with the use of credible threats of retaliation. Moreover, Salop (1986) found that some business practices that seem to enhance competition, such as matching the lowest price, serve to facilitate coordination in tacit cartels. Consequently, anti-trust advocates urge the government to secure effective anti-trust laws in order to inhibit such tacitly collusive behavior.

In contrast, Galbraith (1952) argued that state intervention would not be necessary. Although competitive forces from the same side of the market may not be present (due to practical barriers to entry), they are replaced by other self-regulating forces. In fact, he argued that abnormal profits due to excessive market power will stimulate the formation of opposing market power in vertically related industries. He coined the term "countervailing power" to describe this phenomenon and argued that it would neutralize the detrimental effect of big business.

This idea is appealing, however, its validity has, for the most part, been ignored. Some studies have focused on how fast and how extensively these opposite forces emerge in vertically related markets (especially in labor markets). Ashenfelter and Johnson (1972), among others, found that unionization is more likely to develop in concentrated industries. Rosen (1969) suggested that union coverage has a spillover effect on non-union firms' wages and probabilities of unionization within an industry. Martin (1984) provided further empirical evidence that spillover effects of union coverage exist even across industry boundaries.

But, the validity of Galbraith's assertion, that the existence of vertical restraints such as the presence of trade unions will reduce the market power of giant enterprises, remains questionable. Adams and Brock (1983) suggest that management and labor share a common interest in market dominance and market control because the greater the market control the larger the pie to be shared by both parties. Thus, countervailing power tends to be undermined by "coalescing power" through vertical cooperation between management and labor. Coalescing power, however, tends to support a larger degree of collusion in the product market in order to capture a larger surplus for both parties.

As stressed by Galbraith, his theory of countervailing power should not be considered as a theory of bilateral-monopoly. Instead, it is more appropriate to look upon it as a bilateral oligopoly in which firms collude in their product markets and workers team together to form trade unions. The major difference between these two frameworks is that in the latter, one does not assume perfect coordination of collusive behavior. In fact, this is a legitimate concern. Without binding contracts, the enforcement of a tacit agreement relies on credible threats of retaliation against cheaters. In most situations, tacit collusion may not have the full strength of market control that a legal cartel or monopolist would have unless the threat, measured by the present value of the credible punishment, is sufficiently large. However, even under an implicitly collusive agreement supported by the harshest credible punishment (that is, Abreu's (1986) stick-and-carrot strategy), the discounted value of punishment is quite likely to remain small because the detection of cheating takes time. To prevent secret deviations by any individual firm, the cartel has to reduce the incentive to cheat by increasing the output quota of each firm. Under this scenario, the market power of the oligopolists should be represented by their ability to collude and can be measured by some collusive indexes.

Organized downstream firms or trade unions exercise their market power through price or wage negotiations. Such price or wage negotiations, according to Rubinstein's (1983) bargaining model and Davidson's (1988) multi-unit bargaining model, will raise the input prices or wages of the cartel above competitive levels. Thus, to the tacit cartel, a change in the market power of downstream firms and/or trade unions affects them by altering their costs. It is the aim of this paper to investigate the impact of this cost-push effect on the strength of an implicit agreement in order to determine whether market power from vertically related industries is countervailing or coalescing.

The paper is organized as follows In section II, we develop a partial bilateral oligopoly model and discuss some issues related to the modelling of dynamic, imperfectly competitive markets. In section III, the issue of countervailing power is then examined. As we shall see, in contrast to Galbraith's original assertion, countervailing power does not work on the behalf of consumer welfare. Although countervailing power reduces the profit and market power of the oligopolists, it increases the level of collusion that can be supported in equilibrium. This suggests that the effect of countervailing power is, in this aspect, "coalescing" rather than "countervailing". Discussions and extensions are in section IV.

2. A Partial Bilateral Oligopoly Model

In this paper, we wish to model two bilateral oligopolies in which horizontal collusion, if possible, is the norm. Initially, we investigate a situation with an upstream labor market and a downstream oligopolistic industry. The labor market can be competitive, unionized at the firm level or subject to industry-wide unionization. The oligopolistic sector, on the other hand, is modelled as a cartel with various degrees of collusion so that monopoly, pure oligopoly or purely competitive market structures can be derived parametrically. Compared to a setup with two opposing oligopolies, this structure is not only more interesting in its own right, but also allows us to examine issues of collusion in a simpler manner.

The oligopolistic sector in this model consists of n identical firms, which are indexed by i. These firms produce a homogenous good which has no close substitutes. The good has a downward sloping inverse demand curve $P(Q,\alpha)$, where Q is quantity demanded and α is a vector of demand parameters. Firm i has a cost function $C(q_i,\Omega)$, with $C(0,\Omega) = 0$, where q_i is the output of firm i and Ω is a vector of cost parameters. Finally, since we are interested in industries with practical barriers to entry, we assume no entry or exit so that n remains fixed over time.

Given the existing technology, the values of Ω come from either the competitive labor market or collective bargaining between the union(s) and firms. The market price of the good, however, is determined by the total output of the cartel. Clearly, the total market output depends on how we model the cartel. Thus, the modelling approach chosen is critical to our analysis and deserves more careful discussion.

Basically, we have two different,. and not complementary, approaches. First, we can model the cartel in a static setting, hypothesizing that each firm chooses a production plan to maximize profit based on a constant conjecture as to how other firms will react to slight changes in its level of output. Although this (conjectural variations) approach has been criticized as static, informal, and misleading in its own terminology, it underlies a great deal of industrial organization literature. Its advocates argue that conjectural variations models are mathematically simple and allow one to easily parameterize a whole spectrum of market structures which the supergame approach cannot.

This paper will demonstrate, among other things, the fallacy of such arguments. In fact, supergame models are not only able to represent a spectrum of market structures, but are also more formal, mathematically simple and provide a more accurate representation of dynamic environments. More importantly, the comparative static results generated by the supergame model in this paper can be used to compare with those obtained by conjectural variations models (c.f. Seade (1983), Dixit (1986) and Quirmbach (1988)).

Consequently, we have chosen to model the oligopolistic sector in a dynamic environment where firms play an infinite horizon quantity setting game with perfect recall. In this game, firms act in discrete time and time periods are indexed by t. At any period t, firms choose quantities simultaneously at any period. Frictions obstructing the coordination of the cartel, such as imperfect detection of cheating, are implicitly assumed in this discrete time model since players cannot move within periods.

Two kinds of strategies are available in this setting. In an open-loop strategy, the decisions of a firm at any time are independent of their rivals' past behavior. This mimics a situation in which firms can commit themselves to binding agreements. On the other hand, closed-loop strategies allow behavior to be conditioned on history and they resemble cases in which firms can collude but are bounded by their abilities to coordinate. Thus, we will utilize closed loop strategies and assume that firms possess the abilities of perfect recall. The current production decision of a firm, therefore, will depend upon all observable information about the past behavior of rival firms.

As stressed by Stigler (1964), firms may not be able to observe each others' output directly. We assume that the only information observable to all firms is the market price of the good. Thus, firms' production decisions in any period depend on the price history of the game. This is <u>equivalent</u> to assuming that firms can observe other firms' outputs but are bound to select non-discriminating (i.e. asymmetric) strategies. To be precise, a typical strategy available to a firm is a sequence of decision rules, one for each period. The t-th element of this sequence specifies the action of this firm in the t-th period. This action is conditioned on the outputs of all firms in the past t-1 periods. Moreover, since firms can only use non-discriminating strategies, the firm's output decision depends on the total output of all firms but is independent of the share of total output produced by individual rivals. Given the strategies of all other firms, a firm chooses the strategy which maximizes the sum of its discounted future profit using a common discount factor, δ ($0 \leq \delta < 1$). Since the value of δ is determined by the length of a period, δ measures how fast firms can detect cheating.

We have already created an environment which enables oligopolists to form a stable cartel. Since binding agreements among firms are prohibited, the stability of the cartel can only be maintained through self-enforcing agreements. An agreement is self-enforcing if it is supported by a collection of strategies in which, at any time t and after any possible history, no firm has any unilateral incentive to deviate from its prescribed strategy. In other words, self-enforcing agreement must be supported by a sub-game perfect equilibrium. In such an equilibrium, firms use mutual, credible threats and promises in supporting their agreements. Collusion is then achieved by players responding aggressively and credibly to information that not all players are honoring the implicit agreement.

Unfortunately, as indicated by the so called "folks theorem", such a self-enforcing agreement is not unique. Our next step is to select a self-enforcing agreement for the tacit cartel. Our selection is based on two objective criteria: symmetry (equity) and pareto efficiency. Symmetry stems from the fact that all firms in our model are identical and, therefore, we would expect that the total quota will be equally divided among all firms. The pareto efficiency requirement is based on two considerations. First, it is natural. Second, since our ultimate concern is the change in the strength of this tacit cartel under different regimes, the most collusive self-enforcing equilibrium agreement provides a good reference point for comparative static analysis.

Therefore, the tacit cartel in this model represents a situation in which each firm produces the same output q and (q,..,q) leads to the largest profit level that can be supported by any symmetric punishment scheme. This symmetric extremal sub-game perfect equilibrium can be derived by using Abreu's (1986) stick-and-carrot strategy. Before we examine his strategy, three facts have to recognize: (1) the most collusive agreement can be supported by the harshest punishment, (2) the harshest punishment can be supported by the most promising agreement, and (3) in an extremal equilibrium, punishments and rewards in subsequent period must be stationary.

These features of the extremal equilibrium can be captured in a stationary, two-stage symmetric punishment strategy. In the first stage of the punishment, all firms are required to produce a high output q^s (nq^s is the market total) in one period so that they all suffer tremendously. This painful "stick" process is, in turn, enforced by consecutive threats and promises. Deviating from the first stage punishment scheme results in the re-imposition of the stick in the next period, successful execution of the first stage by all firms leads to a promising second stage. In the second stage, referred to as a "carrot", all firms return to the most collusive output agreement, q^c (nq^c as market total). Finally, the second stage is enforced by the same consecutive threats and promises as the first stage. That is, if no firm cheats, all firms are expected to produce q^c units of output in the next period; otherwise, each firm will produce q^s units. Since total market output, not individual rivals' output, triggers the punishment and thus determines the stage of the game in the next period, the stick-and-carrot strategy is a non-discriminating (symmetric) strategy.

The values of q^s and q^c are carefully chosen so that the threats and promises are credible in both stages while the stick-and-carrot strategy remains harshest. Let $\pi^c(q)$ be the per period profit of a firm if all firms produce the same output level q; and let $\pi^{ch}(q)$ be the instantaneous optimal profit of a firm if the firm cheats unilaterally and produces more than q. During the first stage of the punishment, all firms are required to produce q^s. The benefit of cheating on q^s is $\pi^{ch}(q^s) - \pi^c(q^s)$ while the cost is $\delta[\pi(q^c) - \pi(q^s)]$. In the second stage, firms are expected to produce q^c. The benefit and costs of cheating in this stage are $\pi^{ch}(q^c) - \pi^c(q^c)$ and $\delta[\pi^c(q^c) - \pi^c(q^s)]$, respectively. The stick-and-carrot punishment is credible and harshest if the following conditions hold (see Abreu):

(1) $\pi^{ch}(q^s) - \pi^c(q^s) = \delta[\pi^c(q^c) - \pi^c(q^s)]$ and

(2) $\pi^{ch}(q^c) - \pi^c(q^c) = \delta[\pi^c(q^c) - \pi^c(q^s)]$ if $q^c > q^m$

$\pi^{ch}(q^c) - \pi^c(q^c) \leq \delta[\pi^c(q^c) - \pi^c(q^s)]$ if $q^c = q^m$.

where q^m (= arg max π) is the "monopoly" output. These conditions are clear with the following considerations. In (1), Left hand side (LHS) > right hand side (RHS) indicates that the stick is not large enough to be credible, while LHS < RHS suggests that a larger stick can be used to support a larger carrot. Similarly, in (2), RHS ≤ LHS implies that no firm will cheat on the agreement unilaterally. Equation (2) also requires that a better agreement be chosen whenever possible.

With an abuse of terminology, the stick-and-carrot strategy is denoted as the vector (q^s, q^c) which satisfies both (1) and (2). Under the assumptions of linear demand and constant average costs, Abreu (1986) showed that there exists a stick-and-carrot strategy representing the harshest punishment of the game among all possible symmetric punishment strategies. As claimed by Abreu and proved in our appendix, existence, uniqueness and optimality (globally under our context) of (q^s, q^c) remains under more general demand and cost functions.

Since punishments are carried out in the future, the power of the threats depend on how fast firms can detect cheating. Thus, the strength of the threats can be measured by the loss of the present value of the firm after cheating. Let the present value of the firm evaluated at the beginning of the punishment be V^{ch} and, according to stick-and-carrot strategy, $V^{ch} = \pi^c(q^s) + \pi^c(q^c)/(1-\delta)$. Therefore, given an implicit quota, the power of the threat, which is equal to $- V^{ch}$, increases with the value of δ.

With $\delta = 0$, firms put no weight on future profits, making all possible threats ineffective. In this cases, the unique equilibrium outcome is characterized by every firm producing the one-period Cournot-Nash output (q^{cn}).

If $\delta > 0$ but very small, according to (1) and (2), then the costs of cheating on both q^s and q^c (RHS of both equations) will be small after discounting. This implies that the benefits from cheating in both phases should also be small, indicating that both q^s $(>q^{cn})$ and q^c $(<q^{cn})$ are close to q^{cn} (see figure 2.1). In this situation, V^{ch} is close to

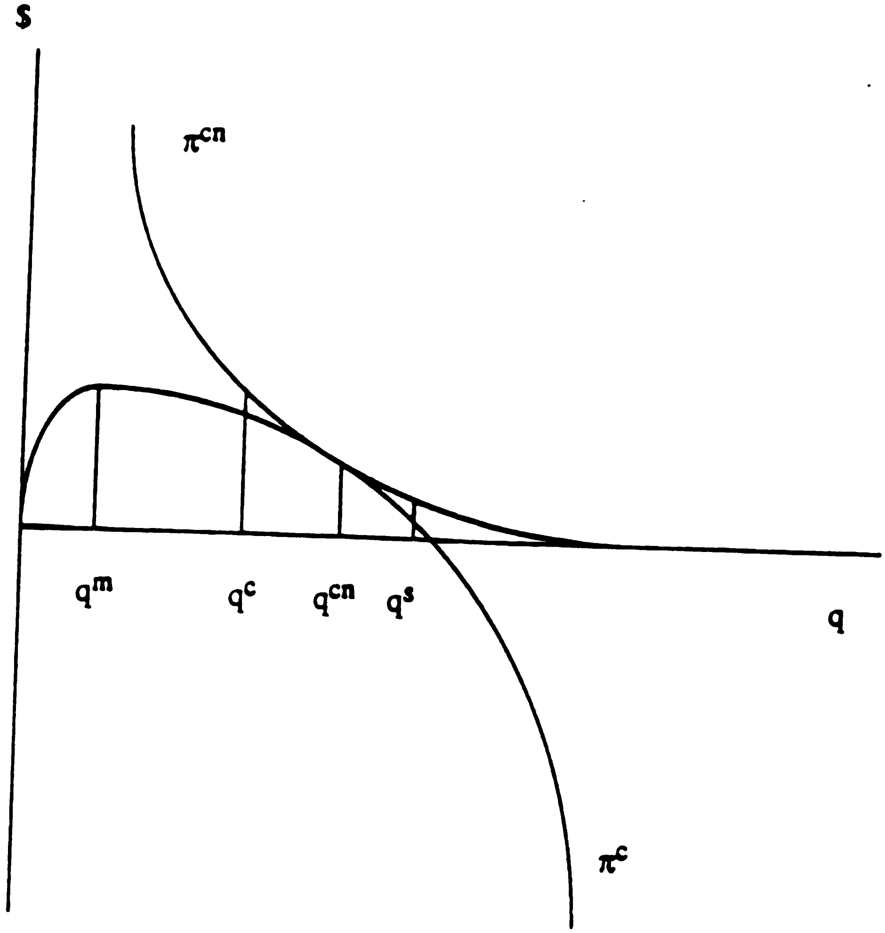

Figure 2.1

$\pi^c(q^{cn})/(1-\delta)$ and is greater than zero.

As δ becomes larger, the costs of cheating on both stage increase as indicated by equations (1) and (2). A more collusive agreement (smaller q^c) supported by a larger stick (larger q^s) is then possible. This implies that V^{ch} falls as δ rises. However, since firms can choose not to produce, the present value of the firm, at any time period, cannot fall below zero even when δ is very large. We can define a critical value of discount factor, δ^1, such that, if $\delta \geq \delta^1$, $V^{ch} = 0$ (see figure 2.2). In fact, this additional restriction $\delta \geq \delta^1$ can be used to simplify the problem of solving for the value of q^c. To see this, substitute $V^{ch} = 0$ into (2) to obtain:

(3) $\pi^{ch}(q^c) = \pi^c(q^c)/(1-\delta)$.

Equation (3) implies that, if the present value of the firm goes to zero after cheating, the benefit of cheating on q^c should equal to the present value of the firm if no cheating occurs. Thus, if $\delta \geq \delta^1$, we can obtained the quota of a firm by solving equation (3).

Now, rearrange (3) so that $\pi^c(q^c)/\pi^{ch}(q^c) = 1 - \delta$. Since a limiting value of q^c is q^m, $\pi^c(q^c)/\pi^{ch}(q^c)$ is bounded by $1 - \delta^*$, where $\delta^* = 1 - \pi^c(q^m)/\pi^{ch}(q^m) < 1$. Thus, if $\delta \geq \delta^*$, $q^c = q^m$, the monopoly output. It is then clear that the quota of this cartel falls into four regions, depending on the value of δ. In summary, q^c is equal to

$$(4)\quad q^c = \begin{cases} q^c & \text{if } \delta = 0 \\ q' & \text{if } 0 < \delta \leq \delta^1 \\ q'' & \text{if } \delta^1 \leq \delta \leq \delta^* \\ q^m & \text{if } \delta^* \leq \delta < 1 \end{cases}$$

where q' solves (1) and (2) simultaneously and q'' solves (3).

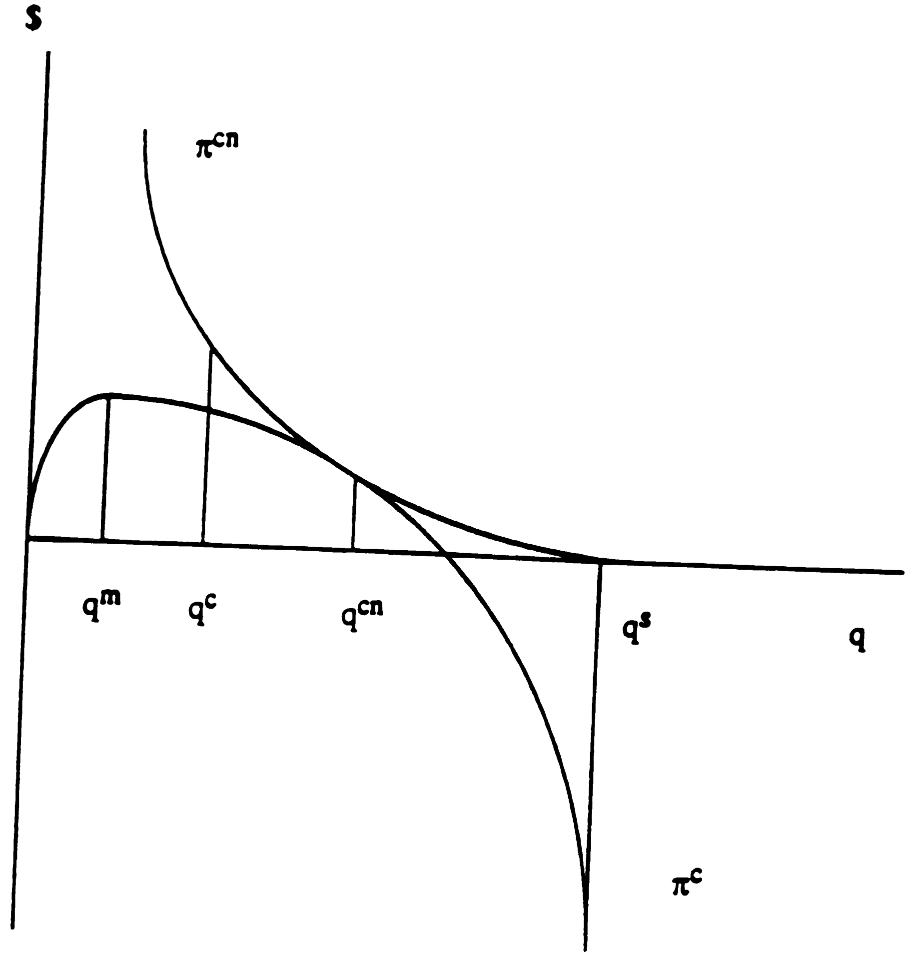

Figure 2.2

By altering the value of δ, we can generate a spectrum of market structures. Clearly, if $\delta = 0$ and $n \to \infty$, the cartel resembles a competitive market. If $\delta = 0$ and n is small, the cartel generates a pure oligopoly. If $\delta \in (0,\delta^*)$, we have a cartel with imperfect coordination. If $\delta \in [\delta^*,1)$, we have a perfect cartel.

Our goal is to derive the per firm quota as a function of the parameters: δ, Ω, α and n. Because of the non-linearity of equations (1), (2) and (3), it is virtually impossible to obtain a closed form solution for q^c when using general demand and cost functions. Since the purpose of this paper is mainly to examine how the market power of a cartel is influenced by the strength of the vertically related market (rather than to provide a general comparative static analysis for a dynamic oligopoly), we will assume linear demand and marginal cost functions for the rest of our analysis.

Now, we can solve for the value of q^c where q^c denotes the per firm cartel output. An algebraic exercise (as shown in the appendix) gives us the following lemma.

Lemma 1. If $P(Q) = \max\{0,\ a - bQ\}$ and $C(q) = wq^2$ where a, b and $w > 0$, then

$$(5)\quad q^c = \begin{cases} \dfrac{a}{b(n+1)+2w} & \text{if } \delta = 0 \\[2ex] \dfrac{a}{b(n+1)+2w}\cdot\left[1-\dfrac{8b(n-1)(b+w)\delta}{[b(n+1)+2w]^2}\right] & \text{if } 0 < \delta \le \delta^1 \\[2ex] \dfrac{a(1-\sqrt{\delta})}{b[(n+1)-(n-1)\sqrt{\delta}]+2w} & \text{if } \delta^1 \le \delta \le \delta^* \\[2ex] \dfrac{a}{2bn+2w} & \text{if } \delta^* \le \delta < 1 \end{cases}$$

where $\delta^1 = 1 - 8b(n-1)^2(b+w)^2/\{[b(n-3)-2w][n(2w-b)+b]\}$ and

$\delta^* = [b(n-1)/2(bn+w)]^2$.

3. The Effect of Countervailing Power.

There are two basic arguments involved in the theory of countervailing power. First, there is the notion that original power and countervailing power grow together. Second, when strong buyers face strong sellers, they will neutralize each other, holding each other's power in check.

While the former issue is an empirical one, the latter argument can be examined with the model developed here. According to Galbraith, an emergence of countervailing power will neutralize the market power of both parties. Yet he does not provide a clear explanation of how, and through what channels, countervailing power will operate.

Clearly, an improvement in the bargaining position of unions will increase total worker compensation (in terms of an increased wages or an improved working conditions) and increase the firms' costs of production. Unionization (or more highly concentrated bargaining) has two effects on the firms. First, because of raising labor costs, they may be forced to raise price and may suffer a reduction in profits. Second, such an increase in costs will change the cost and benefit of cheating and thus upset the internal stability of the cartel under the original quota scheme, leaving cheating a viable option to the firms. To restore the stability of this cartel, firms will have to honor a new quota scheme which, under the new environment, may entail a change in prices and profits. In the light of these effects, we will investigate the overall impact of countervailing power.

The expected effects of countervailing power may not be as clear as people may think. In fact, Galbraith himself changed his position on the impact of countervailing power. In his book, American Capitalism, he implies that countervailing power works on the behalf of consumer welfare. Later, in his 1954 AEA presidential address, he seems to stress that the primary objective of countervailing power is to reduce social tension in the sense of redistributing the profit margins among labor and firms. We will examine both of these perspectives and provide an additional measure of how "countervailing" this type of power is.

Clearly, consumer welfare increases as long as the price of the good decreases. Countervailing power may, by raising marginal costs, increase the price of the goods. It also may lower price to the consumers by weakening the collusive ability of the tacit cartel. The ultimate effect on price can be obtained by looking at the sign of $dP(q^c)/dw$ for all possible value of $\delta \epsilon [0,1)$. A straight forward exercise implies that $dP(q^c)/dw > 0$ (see appendix).

Proposition 1. In our model, consumer welfare falls as countervailing power grows.

Of course, the trade union will benefit from an increase in wages. Whether social tension can be reduced by the presence of countervailing power depends upon how this power affects the profit of the tacit cartel. Clearly, as cost increases, the profit of the tacit cartel will decrease if $d\pi^c(q^c;w)/dw < 0$. Differentiating π^c with respect to w, we have $d\pi^c/dw = d\pi^c/dw|_{q=constant} + [d\pi^c/dqc|_{w=constant}][dq^c/dw]$. The first term is the direct cost effect on profit while the second one is the indirect effect on profit. Clearly, $d\pi^c/dw|_{q=constant}$ and $d\pi^c/dqc|_{w=constant}$ are both negative and, according to proposition 1, dq^c/dw is also negative. As shown in the appendix, $d\pi/dw$ can be positive or negative, depending on the values of n, b, w and δ. Therefore, the profit of the tacit cartel may rise or fall as countervailing power grows.

Proposition 2. In our model, the growth of countervailing power does not necessarily reduce social tension in the sense that the trade union will gain and the tacit cartel will lose.

Although Galbraith fails to offer a definition of the optimal allocation of power, we can still examine the influence of countervailing power on the original power of the cartel. Market power is usually measured by the ability of the firms to raise prices above marginal cost. In our model, such a measurement is not appropriate because the industry is shielded from the threat of entry. The most competitive situation, in this case, is the Cournot-Nash outcome where every firm produces q^{cn} units of output. Thus, a proper measure of market power is the ability of the firms to raise their prices above the Cournot-Nash price. The market power of the cartel can be measured by the index, μ, where $\mu = [p(q^c)-p(q^{cn})]/p(q^{cn})$. Note that μ resembles a Lerner index for markets with practical barriers of entry. Since $d\mu/dw < 0$ for all $\delta \in [0,1)$ (see appendix), we have the following proposition:

Proposition 3. In our model, the growth of countervailing power will decrease the market power of the tacit cartel.

To dig deeper, let's decompose μ as follows:

$$(6) \qquad \mu = \frac{P(q^m)-P(q^{cn})}{P(q^{cn})} \cdot \frac{P(q^c)-P(q^{cn})}{P(q^m)-P(q^{cn})}.$$

The first term measures the power of the perfect cartel (a cartel that acts like monopoly). The second term, denoted as ϕ, measures the collusive ability of the tacit cartel. Note that $\phi \in [0,1]$ increases with the degree of collusion of a cartel. In our model, if $\delta = 0$, $q^c = q^{cn}$ and $\phi = 0$. If $\delta \to 1$, $q^c = q^m$ and $\phi = 1$.

Of particular interest in equation (6) is the derivative of ϕ with respect to w. Although the market power of the tacit cartel falls as countervailing power increases, such an increase does not necessarily make the cartel less collusive. It is hard to argue that countervailing power is really "countervailing" if its expansion makes the original cartel more collusive. In our model, this is shown by the fact that the derivative of ϕ with respect to w. An algebra exercise gives $d\phi/dw > 0$ (see appendix), for all δ.

Proposition 4. In our model, the growth of countervailing power improve the collusive ability of the tacit cartel.

Proposition 4 indicates that countervailing power, under the collusive index, ϕ, is "coalescing". This result is important because it shatters the far-reaching ideological presumption that under conditions of countervailing power, markets can be self-regulating in a anti-collusion manner even though market power persists.

4. Conclusion and Extension

We have developed a supergame model which can generate a spectrum of market structures while preserving an essential dynamic environment. We then used the model to examine the theory of countervailing power. We found that countervailing power does not work on the behalf of consumer welfare. Moreover, the growth of countervailing power does not necessarily reduce social tension in the sense that the trade union will gain and the tacit cartel will lose. Although countervailing power reduces the market power of a cartel as a whole, we found that countervailing power does not benefit consumers. By using a collusive measure, we also found that countervailing power is "coalescing" rather than "countervailing" in this respect.

There are many possible extensions in this paper. Firstly, the cartel-union framework can easily be extended to a cartel-cartel framework or a sequence of cartels. To do so, we have to derive the demand curve of the upstream industry from the behavior of the downstream cartel. Since the total output of the cartel is a function of input prices, the factor demand curve can be obtained with knowledge of production function. The upstream cartel can then be characterized in the same way as its downstream opponent. The model will be completed by modelling a bargaining mechanism between this two group of oligopolists.

Secondly, the comparative static analysis on prices, profits and welfare of our model based on general demand and cost functions is possible. These results can be compared with those obtained by conjectural variations models.

Thirdly, we focus on sub-game perfect equilibria because we only consider individual rationality in our cartel formation. In fact, group rationality should also be important. Using concepts such as re-negotiation proof equilibrium instead of sub-game perfection will reduce the size of the equilibrium set and may generate new insight into our understanding of bilateral oligopoly.

FOOTNOTES

1. According to Stigler (1964), oligopoly theory should be a theory of cartel. Our model of the oligopolistic sector is, therefore, a general characterization of oligopoly theory.

2. Besides, Galbraith did emphasis the importance of trade unions as a principle source of countervailing power in his 1952 book.

3. Our attention on modelling approaches is not unique. In fact, Schmalensee (1988) complains "[m]ost central questions in industrial organization have by now received considerable game-theoretic attention; the problem is not too little theory but too many different theories. It would appear the research on the theoretical front should be aimed, at least in part, at unification of diverse models and identification of particular non-robust predictions."

4. As we shall see, these two approaches are conjectural variations and supergame approaches. Friedman conjectures that these two approaches may be complementary in the sense that, for any non-trivial conjectural variation strategies equilibrium, there may exist a corresponding sub-game perfect equilibrium in a supergame setting. This long-standing hope has been shattered by Stanford (1986). He showed that only trivial conjectural variation equilibria are subgame perfect in the sense that they must coincide with the repeated one-shot Cournot-Nash game.

5. For example, Dixit (1986) admitted that conjectural variations suffer some well-merited criticisms such as "static, .. and concepts like reactions, conjectures and their consistency have no meaning. Stability conditions, which help to fix many sign in comparative static, are equally without foundations".

6. For example, Quirmbach (1988) argued that "conjectural variations ... provides us with a convenient way to parameterize the spectrum of oligopoly outcomes. This is an advantage since, as the "folk theorem" literature demonstrates, little, if any, of this spectrum can yet be ruled out by formal, dynamic game theory."

7. See Selten (1975).

8. Sometimes, this process, following Schelling (1960), is called focal point selection. For a detail discussion on the criteria for selecting focal equilibrium, see Myerson (1985).

9. Since Abreu's stick and carrot strategy is optimal relative to the class of symmetric punishment, it is globally optimal in our setting since asymmetric punishment is not enforceable in our model. In fact, this simplifies things greatly. Namely, if asymmetric punishments have to be considered, then the stick-and-carrot strategy will not be globally optimal if δ is small enough. Moveover, there is no successful characterization of globally optimal asymmetric punishment.

10. We will not provide the solution for q^s because, in equilibrium, no firm will cheat and q^s will not be observed in the market.

11. We are not be the first to recognize the power of applying supergame theory in an oligopolistic setting. For example, Davidson (1984), Davidson and Martin (1985) and Rotemberg and Saloner (1986) characterize cartel structures using Friedman's trigger strategy.

12. Under this situation, the cartel resembles to a setting study by Novshek and Sonnenschein (1978).

13. This belief is further confirmed by bargaining models based on both cooperative bargaining solution and non-cooperative bargaining equilibrium.

14. There are several other suggestions and speculations. Some economists argue that trade unions have positive effect on productivity. The validity of this argument, by and large, remains empirical. Another argument, which is not so convincing, is based on the assumption that oligopolists are not profit maximizers. For a detail discussion, see Hamermesh and Rees (1984).

15. See, for example, Galbraith (1954).

16. See, for example, Farrell and Maskin (1987).

APPENDIX

1. Optimality of stick and carrot strategy

For brevity, we adopt Abreu's notation and his results (whenever appropriate) here. Interested reader should refer to Abreu's (1983) paper for details. To show that Abreu's stick-and-carrot strategy is unique and optimal (in the sense of harshest) for linear demand and marginal cost functions, we only have to redo the prove of lemma 2 in Abreu's (1986) paper.

Lemma 2 (Abreu). If $P(Q) = \max\{0, a - bQ\}$ and $C(q) = wq^2$, then $\pi^{ch}(q_1) \leq \pi^{ch}(q_2)$ or $\pi^{ch}(q_1) = \pi^{ch}(q_2) = 0$ if $q_1 > q_2 \geq 0$.

[Proof] Consider firm i. If it produces q_i units of output while its rivals produce q units each, firm i's instantaneous profit, $\pi(q_i;q)$, is $P[q_i+(n-1)q]q_i - C(q_i) = [a-b(n-1)q-bq_i]q_i-(b+w)q_i^2$. Let r(q) be the reaction function of firm i when its rivals produce q units each in a one-shot companion game. That is, $r(q) \equiv \arg\max \pi(q_i;q) = \max\{0, [a-b(n-1)q]/[2(b+w)]\}$.

Thus, $\pi^{ch}(q) \equiv \pi(r(q);q) = \max\{0, [a-b(n-1)q]^2/[4(b+w)]\}$ Q.E.D.

2. Proof of Lemma 1:

Consider firm i. If it produces q_i units of output while its rivals produce q units each, firm i's instantaneous profit, $\pi(q_i;q)$, is $P[q_i+(n-1)q]q_i - C(q_i) = [a-b(n-1)q-bq_i]q_i-(b+w)q_i^2$. Let r(q) be the reaction function of firm i when its rivals produce q units each in a one-shot companion game. That is, $r(q) \equiv \arg\max \pi(q_i;q) = \max\{0, [a-b(n-1)q]/[2(b+w)]\}$. Thus,

$$\pi^{ch}(q) \equiv \pi(r(q);q) = \max\{0, [a-b(n-1)q]^2/[4(b+w)]\}$$

and $\pi^c(q) \equiv \pi(q;q) = aq-(bn+w)q^2$.

For $\delta \in [\delta^*,1)$, $q^c = q^m = \arg\max \pi(q;q) = a/[2(bn+w)]$.

For $\delta \in [\delta^1,\delta^*]$, q^c solves $\pi^{ch}(q) = \pi^c(q)/(1-\delta)$. In this case, $\pi^{ch}(q) = [a-b(n-1)q]^2/[4(b+w)]$ for $q \in (qm, q^{cn})$. Solving for q^c, we have

$$q^c = \frac{a[b(n-1)(1-\delta)+2(1-\sqrt{\delta})(b+w)]}{[b^2(n-1)^2(1-\delta)+4(b+w)(bn+w)]}$$

$$= \frac{a(1-\sqrt{\delta})}{b[(n+1)-(n-1)\sqrt{\delta}]+2w}.$$

For $\delta \in (0,\delta^1]$, $\pi^{ch}(q) = [a-b(n-1)q]^2/[4(b+w)] \geq 0$ for all admissible values of q^c and q^s. In this cases, q^c can be obtained by solving equations (1)' and (2)' below simultaneously:

(1)' $\{a-[b(n+1)+2w]q^c\}^2/[4(b+w)] = [aq^c-(bn+w)q^{c2}]-[aq^s-(bn+w)q^{s2}]$ and

(2)′ $\{a-[b(n+1)+2w]q^s\}^2/[4(b+w)] = [aq^c-(bn+w)q^{c2}]-[aq^s-(bn+w)q^{s2}]$.

Since the left hand side of both equations are identical, their right hand sides should also be equal. This gives us that $q^s = 2a/[b(n+1)+2w] - q^c$. Substituting it into equation (1)′ and solve for q^c, we obtain:

$$q^c = \frac{a}{b(n+1)+2w}\cdot\left[1-\frac{8b(n-1)(b+w)\delta}{[b(n+1)+2w]^2}\right].$$

If $\delta = 0$, $q^c = q^{cn}$ and q^{cn} solves $r(q) = r(r(q)) = [a-b(n-1)r(q)]/[2(b+w)]$. This gives us $q^{cn} = a/[b(n+1)+2w]$.

Finally, let's derive δ^1 and δ^*. Note that, for $\delta \in [\delta^1,\delta^*]$, $V^{ch} = 0$. Substituting this zero present discount value condition into equation (1), we have $\pi^{ch}(q^s) = 0$. Therefore, when $\delta = \delta^*$, $q^s = \min\{q$ such that $\pi^{ch}(q^s) = 0\} = a/[b(n-1)]$ since q^s is positively related to δ. Also, $q^c = 2a/[b(n+1)+2w]-q^c$. Thus $q^c = 2a/[b(n+1)+2w]-a/[b(n-1)] = a[b(n-3)-2w]/\{b(n-1)[b(n+1)+2w]\}$. By equation (3), $\delta^1 = 1 - [\pi^c(q^c)/\pi^{ch}(q^c)] = 1 - 8b(n-1)^2(b+w)^2/\{[b(n-3)-2w][n(2w-b)+b]\}$.

Using equation (3) again, $\delta^* = 1 - [\pi^c(q^m)/\pi^{ch}(q^m)]$. Substituting $q^m = a/[2(bn+w)]$ and $q^{cn} = a/[b(n+1)+2w]$ into δ^*, we have $\delta^* = [b(n-1)/2(bn+w)]^2$. Q.E.D.

3. Proof of Proposition 1:

Clearly, from equation (5), q^c is a decreasing function of δ for $\delta = 0$, $\delta \in [\delta^1,\delta^*]$ and $\delta \in [\delta^*,1)$. For $\delta \in (0,\delta^1]$, rewrite q^c by using the following notations: $e = a/[b(n+1)+2w]$, $m = a/[2bn+2w]$ and $x = \{4(e/m)[2-(e/m)]\}^{-1}$. Then, we obtain $q^c = e - [(e-m)/x]\delta$. Differentiating q^c w.r.t. 2w, we have $dq^c/d(2w) = de/d(2w) - [xd(e-m)/d(2w) - (e-m)dx/d(2w)]/x^2$.

Since $dm/d(2w) = -m^2/a < 0$, $de/d(2w) = -e^2/a < 0$, $d(e-m)/d(2w) = (e-m)(e+m)/a > 0$ and $dx/d(2w) = -8e[(e/m)-1]^2x^2 < 0$, $dq^c/d(2w) < 0$. Q.E.D.

4. Proof of proposition 2:

For $\delta = 0$, using (5) and the fact that $\pi^c(q^c) = aq-(bn+w)q^2$, we obtain $\pi^c(q^c) = a^2(b+w)/[b(n+1)+2w]^2$. Differentiating π^c w.r.t. w, we have $d\pi^c/dw = a^2[b(n-3)-2w]/[b(n+1)+2w]^3$. Clearly, the sign of $d\pi^c/dw$ depends on the sign of b(n-3)-2w which, depending on the values of b, n and w, can be positive or negative.

For $\delta \in (0,\delta^1]$, consider the following facts:

(i) $d\pi^c/dw = d\pi^c/dw|_{q=constant} + [d\pi^c/dqc|_{w=constant}][dq^c/dw]$

(ii) $d\pi^c/dw|_{q=constant} = -q^{c2}$

(iii) $d\pi^c/dqc|_{w=constant} = a-2(bn+w)q$, and

(iv) $dq^c/dw = a\{-2b^2(n+1)^2-8w^2-8b(n+1)w+32b(n-1)w\delta+48b^2(n-1)\delta-8b^2(n^2-1)\delta\}/[b(n+1)+2w]^4$.

Substituting (ii)-(iv) into (i), after simplification, we have

$$d\pi^c/dw = -a^2[A+B\delta+C\delta^2]/[b(n+1)+2w]^7,$$

where $A = [b(n+1)+2w]^5-[-2b^2(n+1)-8w^2-8b(n+1)w]b(n-1)[b(n+1)+2w]^2$

$B = -16b(n-1)(b+w)[b(n+1)+2w]^3+b(n-1)[b(n+1)+2w]^2[32b(n-1w+48b^2(n-1)-8b^2(n-1)-8b^2(n^2-1)] +[2b^2(n+1)^2+8w^2+8b(n+1)w][16b(n-1)(b+w)(bn+w)]$, and

$c = [32b(n-1)w+48b^2(n-1)-8b^2(n^2-1)][16b(n-1)(b+w)(bn+w)]$.

Clearly, the sign of $d\pi^c/dw$ depends on the sign of $A+B\delta+c\delta^2$ which, depending on the values of b, n, δ and w, can be positive or negative. To see this, consider the value of π^c when a=b=1 and n=9. If w=1, then $\pi^c = .01389+1.333\delta-.05487\delta^2$. If w=2, then $\pi^{c\prime} = .01531+.03998\delta-.05386\delta^2$. Define $\pi = \pi^c - \pi^{c\prime}$. Then, $\pi = -.00142+.9335\delta-.00101\delta^2$. The facts that π has two roots, .00352 and 657, and $d^2\pi/d\delta^2 < 0$ indicates that π can be positive or negative, depending on the value of δ.

For $\delta \in [\delta^1,\delta^*]$, substituting q^c from (5) into $\pi^c = aq^c-(bn+w)q^{c2}$ and simplifying, we obtain $d\pi^c/dw = a^2(1-\sqrt{\delta})[b(n-3)-2w-2(b+w)\sqrt{\delta}-6(n-1)\delta]/\{b[(n+1)-(n-1)\sqrt{\delta}]+2w\}$. It is clear that the sign of $d\pi^c/dw$ equal to the sign of $[b(n-3)-2w-2(b+w)\sqrt{\delta}-6(n-1)\delta]$. Since $[b(n-3)-2w-2(b+w)\sqrt{\delta}-6(n-1)\delta]$ can be positive or negative, $d\pi/dw$ can be positive or negative, depending on the values of b, n, w and δ.

Finally, for $\delta \in [\delta^*,1)$, substituting q^c from (5) into $\pi^c = aq^c-(bn+w)q^{c2}$ and simplifying, we obtain $\pi^c = \frac{1}{2}a^2/(2bn+2w)$. Clearly, $d\pi^c/dw < 0$. Q.E.D.

5. Proof of proposition 3:

For $\delta \in (0,\delta^1]$, using the notations developed in the proof of proposition 1, $\mu = bn(e-m)\delta/[x(a-bne)]$ after substitutions. Furthermore, by differentiating μ w.r.t. 2w, after simplification, we obtain $d\mu/d(2w) = -x[2a(e-m)^2-bne(3e^2-6em+2m^2)]/[a(2m-e)]$. Thus, the sign of $d\mu/d(2w)$ equals to the sign of $-[a(5m-3e)+bne(4e-7m)]$. Since $5m-3e > 0$ and $4e-7m>0$, we obtain $d\mu/dw < 0$.

For $\delta \in [\delta^1,\delta^*]$, after substituting q^c into μ and simplifying, we obtain $\mu = 2bn\sqrt{\delta}[(b+w)/(b+2w)]\{1/[b(1+\sqrt{\delta})+b(1-\sqrt{\delta})n+2w]\}$. Since $d[(b+w)/(b+2w)]/dw = -b/(b+2w)^2 <0$ and $1/[b(1+\sqrt{\delta})+b(1-\sqrt{\delta})n+2w]$ is a decreasing function of w, we have $d\mu/dw < 0$.

Since $d\mu/dw < 0$ for $q^c = q^m$ as proved above, we have $d\mu/dw < 0$ for $\delta \in [\delta^*,1)$. Q.E.D.

6. Proof of proposition 4:

For $\delta \in (0,\delta^1]$, after substituting q^c into ϕ by using the notation developed in the proof of proposition 1, we have $\phi = \delta/x$. Since $dx/dw > 0$, we have $d\phi/dw > 0$.

For $\delta \in [\delta^1,\delta^*]$, after substitutions and simplifications, we have $\phi = 4(b+w)(bn+w)/\{[b^2(n^2-1)/\sqrt{\delta}]-b^2(n-1)^2+[2b(n-1)/\sqrt{\delta}]w\}$. Differentiating ϕ w.r.t. w and simplifying, we obtain sign $(d\phi/dw)$ = sign $\{[(w+b)^2+(w+bn)^2]/\sqrt{\delta} - b(n-1)[(w+b)+(w+bn)]\}$. Let $f = [(w+b)^2+(w+bn)^2]/b(n-1)[(w+b)+(w+bn)]$. Clearly, the sign of $(d\phi/dw)$ is positive if $f > \sqrt{\delta}$. Since δ is bound by δ^*, $f > \sqrt{\delta}$ if $f > \sqrt{\delta^*} = b(n-1)/[(b+w)+(bn+w)]$. Thus, $f > \sqrt{\delta}$ if $(w+b)^2+(w+bn)^2-b^2(n-1)^2 = 2w^2+2wb(n+1)+2b^2n > 0$. Therefore, $d\phi/dw > 0$. Q.E.D.

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CHAPTER THREE

(ESSAY 3)

Negotiation Process and Bargaining Tactics

1. Introduction

Although sequential bargaining models have received a great deal of attention in this decade, the choice of bargaining sequences in these models, by and large, remains ac hoc and, in many occasions, depends on the individual tastes of researchers. A possible explanation stems from the presumption that the traditional axiomatic and the recent non-cooperative approaches to bargaining are complementary. Since the axiomatic approach undermines the importance of the details of the bargaining process, most of the papers follow the strategy that the selection of bargaining process could be ac hoc but should be "natural". This approach is further reinforced by the fact that some cooperative bargaining solution concepts can be supported by the non-cooperative equilibrium in a sequential bargaining model with an appropriately chosen bargaining process. For instance, Binmore, Rubinstein and Wolinsky (1986) show that the unique equilibrium outcome generated by an alternating offer/counteroffer bargaining game between a buyer and a seller approaches the Nash bargaining solution as the time between periods goes to zero. Gul (1989) demonstrates that the equilibrium of a dynamic bargaining game with many buyers and sellers competing both in price and location approaches the Shapley value.

Not only is endogenizing the bargaining process as part of the bargaining game a logical extension of previous work, but its importance becomes evident in more complex bargaining situations. For example, Herrero generalized Rubinstein's brenchmark bilateral bargaining model to a 3-person bargaining game and showed that every possible outcome can be supported by a sub-game perfect equilibrium. However, Jun (1988) indicated that uniqueness could be obtained for some particular bargaining mechanisms.

Recently, there have been several attempts to model the bargaining mechanism as part of the bargaining process. Mechanism design is one of the approaches that studies the properties (especially efficiency) of equilibrium outcomes in simple dynamic settings by allowing agents to bargain over the mechanism under an externally specified bargaining rule. There exists a problem with this approach. If one should include the choice of bargaining process, the selection of the rules governing this choice should be included as well. The argument can extend ad-infinitum. In order to overcome this obstacle, one must impose some restriction somewhere in the sequential game. Crawford (1985), among others, took the first route by letting the hierarchy of selecting bargaining rule to be stopped at some specified level. Lagunoff (1988) followed an alternative path. He allowed any possible level of bargaining hierarchy but restricted the class of mechanisms at all levels to satisfy what he called the "free choice condition". By doing so, he avoided the problem of the infinite regress because, under the free choice restriction, selection of a mechanism ends after a finite number of iterations.

There are some shortcomings with these two approaches as well. Crawford's approach, to some degree, remains ad hoc while Lagunoff's free choice condition appears to violate the condition of unrestricted domain. Moreover, in order to reduce the complexity of this game and to arrive at some general conclusions, these studies focus on either two-person bargaining games with incomplete information or N-person bargaining games with complete information. Thus, the inclusion of the bargaining mechanism as part of the N-person bargaining game with incomplete information is ignored. The aim of this paper is to shed some light on a subset of these games. Of course, with its anticipated complexity, one would not expect a general treatment of the problem at the present time. In this paper, simple models and examples will be used instead. Our objective in this paper is to focus on the games relating to the choice of bargaining process that would increase our understanding of some of the bargaining tactics discussed in the collective bargaining literature.

To be specific, consider an industry with two non-identical firms and an industry-wide union. The union, representing all employees at both firms, bargains separately over wages with each firm. Since we are interested in the incentive of the players to choose a particular bargaining process, to simplify matters, we assume that the union has the power to set up the bargaining schedule. We further restrict our attention to two alternative bargaining processes which the union can choose from. Mechanism one (two) dictates that the union bargains with firm one (two) in the first period and then bargains with both firms simultaneously in the latter periods. If the union can not reach an agreement in a period with the firm bargained with, a strike will occur and future negotiations may resume in the next period but both parties are penalized by discounting their future earning by a discount factor δ ($0 < \delta < 1$). The question is: Given that the goal of the industry-wide union is to maximize a well defined utility function of all workers, which bargaining process will the union choose?

This problem is a simplified version of a problem that a union or a firm might face in a collective bargaining situation when either the union or the firm has the power to control the bargaining agenda. For example, UAW could schedule to bargain with GM first and delay negotiations with Ford to some specified date in the future. By threatening to strike the target firm, UAW forces GM to take into account the fact that during a strike it will lose market share to its competitors. Other examples can easily be found in the industrial relations literature. For instance, during the decade of 1940, there were many competing unions representing workers at different operation plants of GE and this provided GE with the power to determine the schedule for individual bargaining. GE picked one of the plant unions as a target to bargain with and tried to establish a pattern for latter negotiations with other unions. Phrases like "picking a strike target", "whipsaw tactics", "Boulwarism", "pattern bargaining" and "pattern-plus bargaining" have been used to describe such bargaining tactics. To understand how these kind of tactics work and to solve the above problem, we need to know more about the interdependencies of the pair of bilateral negotiations.

There are two kinds of product market interactions of interest. First, as demonstrated by Davidson (1988) in a bargaining model with complete information where firms bargain with the union simultaneously, a firm will always take into account the fact that, if the other firm can not reach an agreement with the union in a period, it could increase its market share by settling immediately. This additional temptation for the firm to agree forces them to give better offers to the union. Thus, by selecting either one of the alternative bargaining processes the union grants the first mover adventage or disadvantage to the firm it chooses to bargain with first.

Of particular interest is the second kind of interaction. Even if we ignore the possible product market interaction (imagine a situition in which the firms successfully seperate their markets or these two firms produce two non-competing goods but require the same type of skilled workers), in the presence of incomplete information, important interactions may still exist. In particular, consider a simple case of one-sided incomplete information in which the union possesses private information (as discussed in Chapter one). The union might use the selection of the bargaining schedule to serve one of two possible purposes. First, it could be used as a signalling device. This conjecture could be confirmed by detecting the existence of any separating or semi-separating equilibrium in the model. Second, the union would prefer to bargain with firm i first if, by establishing an early pattern with firm i, it could lead to better overall settlements. Such a mechanism, if it exists, could be traced by showing that a unique pooling equilibrium exists.

The rest of this paper uses a model to explore the above factors as potential forces that affect the selection of mechanism. Section 2 presents a model of continuous uncertainity. As we will see, there are a couple of difficulties associated with this type of model. Section 3 focuses on the mechanism selection problem. Section 4 discusses the source of difficulties found in this paper. Section 5 is the conclusion.

2. The Basic Model

The model consists of two unionized firms and a trade union. These firms operate in seperate markets and have to bargain over wages with the same trade union. Firm i (j) demands α_i (α_j) units of labor services inelastically. Without loss of generality, the union is assumed to have one unit of total labor service so that $\alpha_1 + \alpha_2 = 1$. Moreover, we assume $\alpha_1 > \alpha_2$ and call firm 1 the big firm and firm 2 the small firm. Each firm bargains seperately with the union over how to divide the firms revenue per worker which is normalized to be $1.

Before the contract negotiations begin, the union has to select one of the two alternative bargaining processes. If process i is selected, the union starts to bargain with firm i in the first period. Meanwhile, workers at firm j continue their production, without a contract, in the first period and receive predetermined compensation of $r ($r < 1$) per worker. As we will see later, the value of r will only affect the choice of the mechansim by the union and has no effect on the latter part of the game. Negotiations between the union and firm j will start in the second period.

In each period, if the negotiation have not already been completed, firm i makes an offer that the union may accept or reject. Once an offer of w_i is accepted, a binding contract is made which lasts forever. Firm i then earns $\alpha_i(1-w_i)$ and the union receives $\alpha_i w_i$ in each period thereafter. If the offer is rejected, a strike will occur in that period and the firm earns nothing. The union, however, receives a default level of utility denoted by $\alpha_i b_i$ at that period. Earnings in the latter periods are discounted by both parties by a common discount factor $\delta \in (0,1)$. All players are assumed to be risk neutral.

Incomplete information is introducted by assuming that the union's default level of utility is not known by the firms. For simplicity, we assume that the firms' initial prior is the uniform distribution on [0,1]. All the above aspects are common knowledge to all players. In order to reduce the complexity that arises in an infinite horizon model, we further assume that, if agreements can not be reached in the second period, the union will reveal its private information so that bargainings will be terminated after the third period.

As the firms observe the actions taken by the union, they update their beliefs using Bayes' rule. Finally, firms are assumed to maximize profit per worker (although, here, maximizing total profit is equivalent to maximizing profit per worker for a firm) and the union is assumed to maximize the total wage bill.

We are looking for Bayesian Nash equilibria which, if it exists, consists of a set of strategies that maximize each player's expected payoff by taking the strategies and beliefs of all other players as given. In this setting, a strategy of a typical union b consists of four decision rules, one for each period. The first rule specifies which firm the union will select to bargain with in the first period. The rest of the decision rules specifies whether the offer(s) made by the firm(s) will be accepted or rejected. On the other hand, the structure of a strategy of firm i depends on which process the union selected. If process i is chosen, a strategy of firm i is an ordered triple; otherwise, it is an ordered pair. Each element in these ordered pair and ordered triple specifies, whenever it is the turn of the firm to move, an offer made by the firm at a period, given the current history (a history is a collection of past actions of all players) of the game.

To rule out equilibria supported by non-credible threats, we require the equilibrium strategies to fulfill the sequentially rationality requirement posed by Kreps and Wilson (1982). Thus, we have to solve for equilibria by backward induction. First, we derive the players' last period optimal strategies by solving for the subgames starting from the third period. We then proceed to solve for the subgames starting from the second and the first periods respectively. Finally, we solve for the union's schedule problem.

2.1. The Third Period

In the beginning of this period, the union reveals its private information to both firms. If a contract has not been made by a firm at that time, the firm will then offer b, the union's default value of utility, and the union has to accept. The firm earns an exact value of 1-b in every period thereafter.

But, before this information is revealed, the expected per period profit per worker of the firm would not be 1-b. In order to determine the firm's expected profit per worker at the beginning of the third period, we must begin by describing its third period beliefs concerning the value of b. These beliefs depend on the union's reactions to all the previous offers. At the present moment, let us suppose that the third period beliefs are represented by the uniform distribution over $[\underline{b}_3, \bar{b}_3]$. Note that the support $[\underline{b}_3, \bar{b}_3]$ is a subset of the interval [0,1] since every previous rejection truncate part of the lower tail of the prior support while an acceptance cuts off the upper end of the original support. In this case, the expected profit of the firm at the beginning of the third period is

$$(1) \qquad E\pi_1^3(\underline{b}_3, b_3) = \frac{\int_{\underline{b}_3}^{\bar{b}_3} (1-b)/(1-\delta)\,db}{\int_{\underline{b}_3}^{\bar{b}_3} db}$$

$$= [1-\tfrac{1}{2}(\underline{b}_3+\bar{b}_3)]/(1-\delta)$$

2.2. The Second Period

The union's problem in this period remains simple. Since the net gain of delaying an agreement is zero, the union will accept any offer greater than or equal to its default level of utility. Thus, if the support of the second period belief is $[\underline{b}_2, \bar{b}_2]$, then the expected third period profit of the firm after rejection is $E\pi_i^3(w, \bar{b}_2)$.

The firm's problem is also straight-forward: it chooses w to maximize its expected profit in this period which is given by

$$(2) \quad E\tilde{\pi}_i^2(w) = \text{Prob}(w \text{ is accepted}) \cdot [(1-w)/(1-\delta)] + \text{Prob}(w \text{ is rejected}) \cdot \delta \cdot E\pi_i^3(w, \bar{b}_2)$$

where Prob(w is accepted) = $(w-\underline{b}_2)/(\bar{b}_2-\underline{b}_2)$ and Prob(w is rejected) = $(1-w)/(\bar{b}_2-\underline{b}_2)$. The first order condition of the maximization problem gives

$$(3) \quad w_2^* = \min \{\bar{b}_2,\ (1-\delta-\underline{b}_2)/(2-\delta)\}.$$

The optimal second period profit of firm i is then given as

$$(4) \quad E\pi_i^2(\underline{b}_2, \bar{b}_2) = \begin{cases} \dfrac{1-\bar{b}_2}{1-\delta} & \text{if } \dfrac{1-\delta+\underline{b}_2}{2-\delta} > \bar{b}_2 \\[2ex] \dfrac{(1-\bar{b}_2)^2 - \delta(2-\delta)^2(1-\underline{b}_2)^2}{2(1-\delta)(2-\delta)(\bar{b}_2-\underline{b}_2)} & \text{otherwise.} \end{cases}$$

2.3. The First Period

We begin our analysis by assuming that the union chooses bargaining process i, that is, the union is going to bargain with firm i in this period. Suppose that the beliefs about the strength of the union in this period has a support of [0,1].

2.3.1 <u>The Union's Problem</u>

If firm i offers $1 per worker to the union, the union will always accept. So lets suppose the firm's offer, w_1, is less than $1. Obviously, a union with b greater than w_1 will definitely reject this offer.

In respond to a firm's offer, the union chooses an equilibrium action and this action, in equilibrium, can be classified into the following three groups: (1) the union rejects w_1 regardless of its type, (2) the union accepts the wage offer if $b \in [0,b^*]$ and rejects it if $b \in [b^*,1]$, and (3) any equilibrium response by the union other than the first two group belong to this third category.

Before analyzing the union's action, we need to know the expected utility of the union if it chooses to reject, $U_1(R,b)$, and the expected utility of the union if it chooses to accept, $U_1(A,b)$. Let $w_2(A)$ and $w_2(R)$, respectively, be the expected second period offer by a firm if acceptance and rejection has been observed in the first period. Then, we can write

(5) $$U^1(A,b) = \alpha_i \cdot w_1/(1-\delta) + \alpha_j \cdot \delta \cdot \max\{w_2(A),b\}/(1-\delta) + \alpha_j \cdot r$$

and

(6) $$U^1(R,b) = \alpha_i \cdot b + \delta \cdot \max\{w_2(R),b\}/(1-\delta) + \alpha_j \cdot r.$$

Note that the first term of equation (5) represents the union's utility in the contract made with firm i and the second term is the discounted expected utility of the union from bargaining with firm j if the union chooses to accept w_1. Also note that the first term in equation

(6) represents the default return of the union in the first period and the second term is the expected return from bargaining with both firms in the second period after discounting if the union chooses to reject w_1. The third term, which appears in both equations, is the first period predetermined compensation from firm j to the union.

It is important to note that both $U_1(R,b)$ and $U_1(A,b)$ are piecewise linear and, in fact, have one kinked point (see figures 3.1 and 3.2). Interestingly, $U_1(R,b)$ has a slope of α_i when $b < w_2(R)$ and has a slope of $\delta/(1-\delta)$ otherwise. The slope of $U_1(A,b)$ is 0 if $< w_2(A)$ and is $\alpha_j \cdot \delta/(1-\delta)$ otherwise. Thus, the minimum slope of $U_1(R,b)$ is greater than the maximum slope of $U_1(A,b)$ if and only if $\alpha_i > \alpha_j \cdot \delta/(1-\delta)$, or equivalently, $\alpha_i > \delta$.

The fact that the slope of $U_1(R,b)$ is not always greater than that of $U_1(A,b)$ may lead to the non-existance of equilibrium in some cases.

Theorem 1. If $\alpha_i < \delta$ and $w_1 > (1-\delta)/(2-\delta)$, there exists no equilibrium for the union in the subgame(s) starting at period one.

Proof: Suppose $\alpha_i < \delta$. Then, $\alpha_i > \alpha_j \cdot \delta/(1-\delta)$. That is, the slope of the first segment of $U_1(R,b)$ is greater than the slope of the second seqment of $U_1(A,b)$. Recall that any equilibrium responses, if exists, can be classified into three groups. With these given conditions, we want to show that there exists no equilibrium in any of these three groups.

Consider the first group that the union always rejects regardless of its type. In this case, according to equation (3), $w_2(R) = \min\{1,(1-\delta)/(2-\delta)\} = (1-\delta)/(2-\delta)$. Since the union will always reject, acceptance of the offer is not expected. Here, we need to specify the of

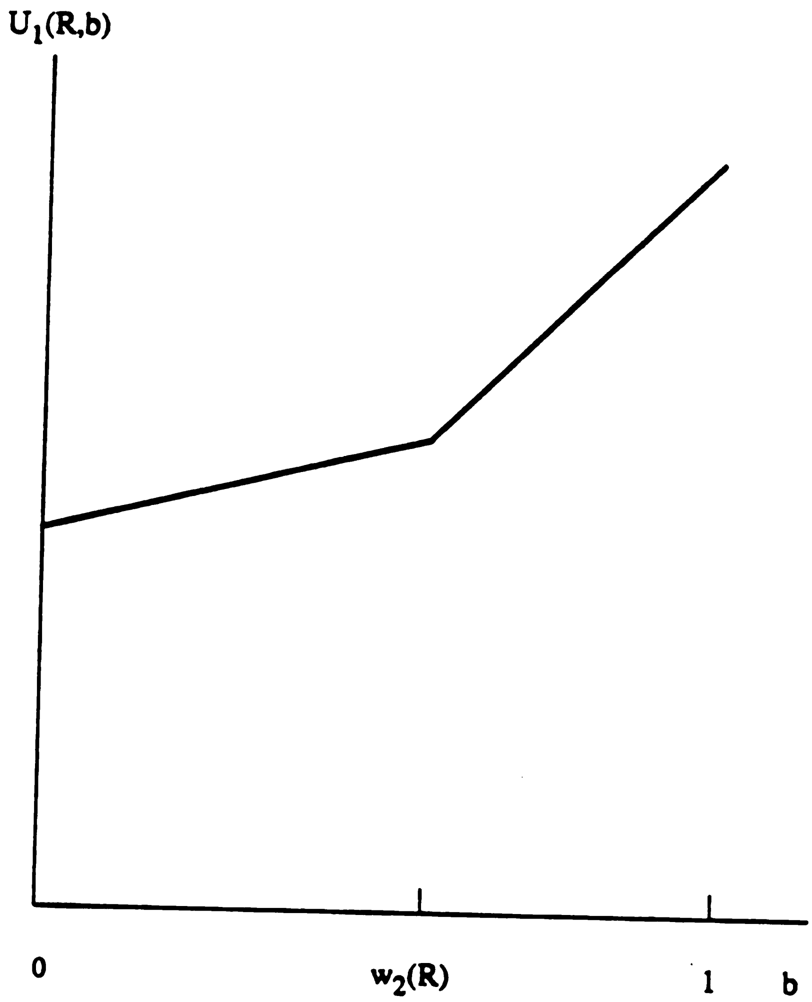

Figure 3.1

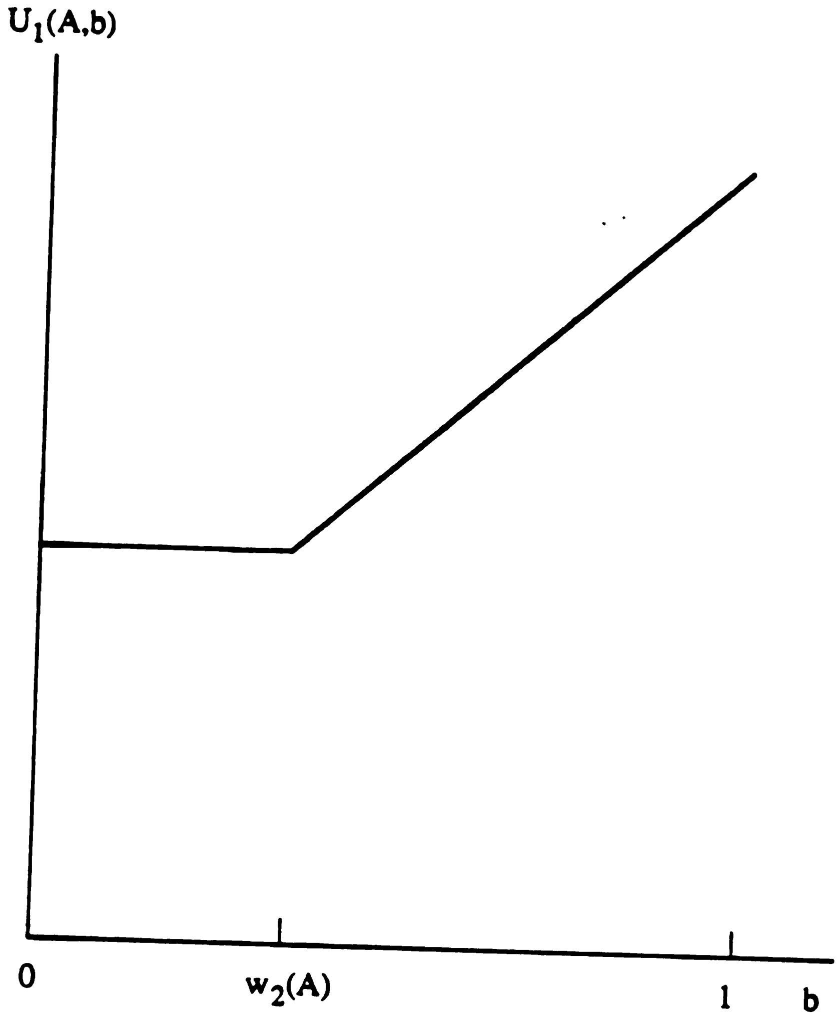

Figure 3.2

out-of-equilibrium beliefs for this case as required by any sequential equilibrium. For the sake of simplicity, we adopt the assumption thoughout this paper that if an unexpected acceptance (rejection) is observed, the firms conjecture that $b = 0$ (1). Thus, $w_2(R) = 0$ and $U_1(A,b)$ is a straight line. As depicted in figure 3.3, this case is least likely to happen when $b = w_2(R) = (1-\delta)/(2-\delta)$. Therefore, suppose $b = (1-\delta)/(2-\delta)$. Substituting $w_2(R)$ and $w_2(A)$ into equations (1) and (2), we obtain: $U_1(R,b) > U_1(A,b)$ if and only if $(1-\delta)/(2-\delta) > w_1$. Since $(1-\delta)/(2-\delta) < w_1$, there is no equilibrium responds of the union in this category.

Next, consider the second possible group of equilibrium responses by the union. In this case, there exists a b^* such that $U^1(R,b) > U^1(A,b)$ if $b > b^*$ and $U^1(R,b) < U^1(A,b)$ if $b < b^*$. Lets focus on the value b^*. Since the firm believes that, after observing an acceptance of offer in the first period, it would face a union with types ranging from $[0,b^*]$, its second period offer, $w_2(A)$, will not be greater than b^*. Thus, according to equation (5),

$$(7) \quad U_1(A,b^*) = \alpha_i \cdot w_1/(1-\delta) + \alpha_j \cdot \delta \cdot b^*/(1-\delta) + \alpha_j \cdot r.$$

Similarly, equation (6) and the fact that $b^* \le w_2(R)$ give us

$$(8) \quad U_1(R,b^*) = \alpha_i \cdot b^* + \delta \cdot w_2(R)/(1-\delta) + \alpha_j \cdot r.$$

Equations (7) and (8) indicate that the slope of $U_1(A,b)$ at point b^* is $\alpha_j \cdot \delta/(1-\delta)$ while the slope of $U_1(R,b)$ at point b^* is α_i. Therefore, b^* should lies on the first segment of $U_1(R,b)$ and the second segment of $U_1(A,b)$. Since $U_1(R,1) > U_1(A,1)$, these two curves must at least intercept

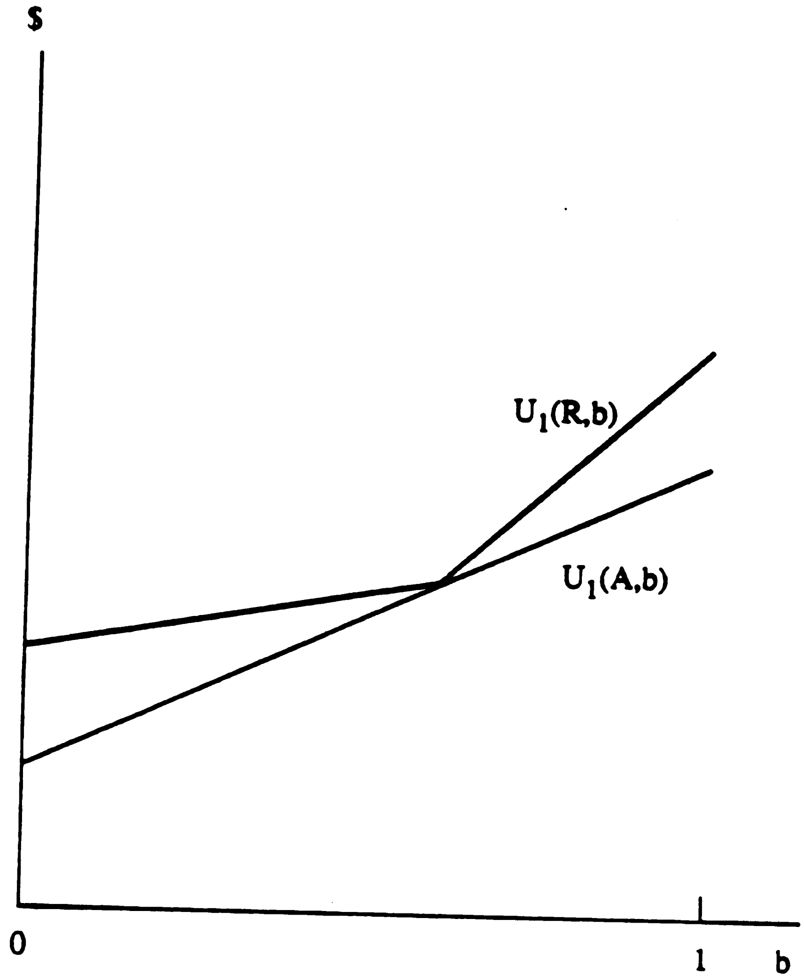

Figure 3.3

twice (see figure 3.4). This contradicts the orginal assertion that they only intercept once at b^*. Therefore, there exists no equilibrium responses in this case either.

Finally, we want to show that no other form of equilibrium responses by the union exists. Since both $U_1(R,b)$ and $U_1(A,b)$ contain two linear segments and the fact that $U_1(R,1) > U_1(A,1)$, other than the above possibilities, there are three more possible configurations about the interception(s) of these two curves. They are shown in Figures 3.5, 3.6 and 3.7. However, none of these configurations represents an equilibrium response. In figure 3.5, the fact that $w_2(A)$ belongs to a rejection region violent the rationality assumption of the firm since, in this case, the firm could offer less, say b^* ($< w_2(R)$), without decreasing the chance of its offer being accepted in the next period. Similarly, since $w_2(A)$ in figure 3.6 falls into a rejection region and $w(A)$ in figure 3.7 lies on an acceptance region, they both can not represent a possible equilibrium. Q.E.D.

Theorem 1 indicates that if the size difference between these two firms is too large relative to the discount factor, equilibrium fails to exist. This result, although discouraging, is quite surprising. It indicates how fragile this kind of models is. We leave the dicussion of this issue to the next section and continue to solve for equilibrium for the remaining case. To guarantee that an equilibrium exists, we require

(C1) $\min\{\alpha_i,\alpha_j\} > \delta.$

One should be aware that condition (C1), in fact, is quite strong. Since $\alpha_i + \alpha_j = 1$, $\min\{\alpha_i,\alpha_j\}$ is bounded above by ½. Condition (C1) then implies

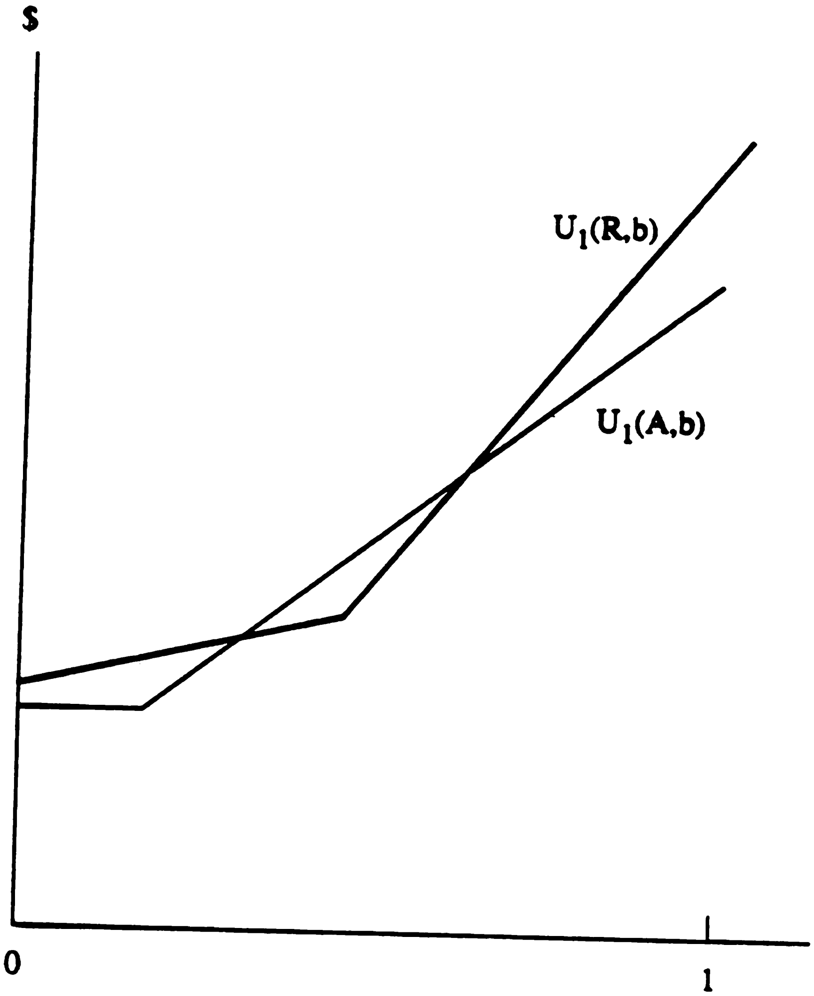

Figure 3.4

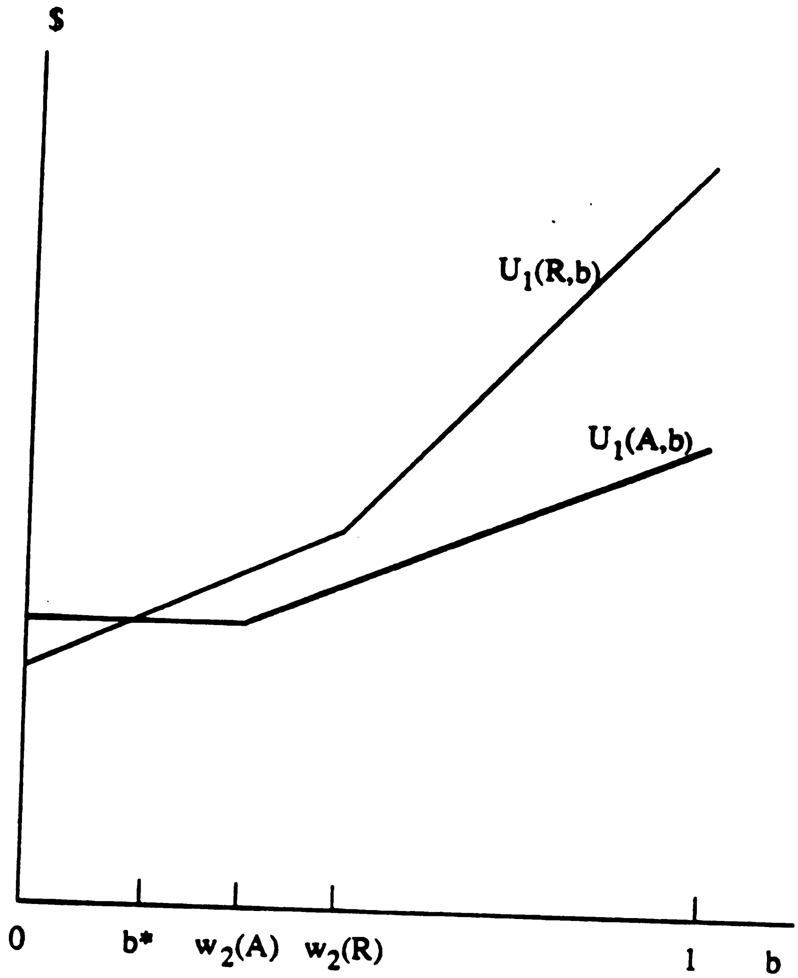

Figure 3.5

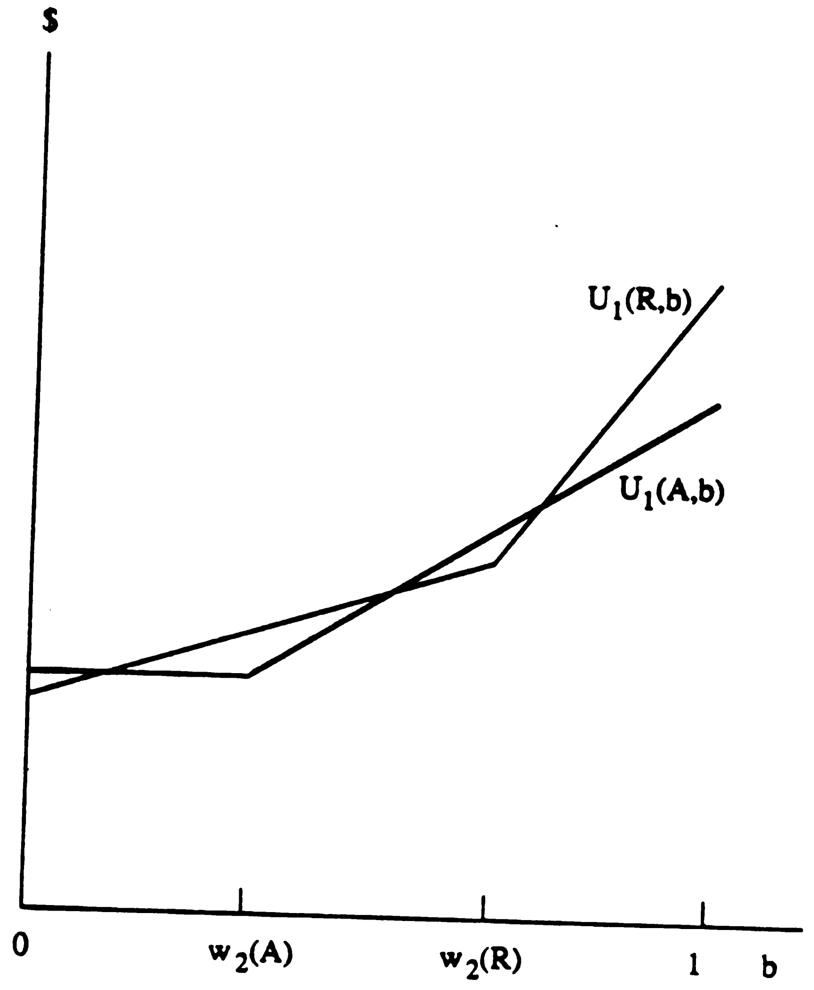

Figure 3.6

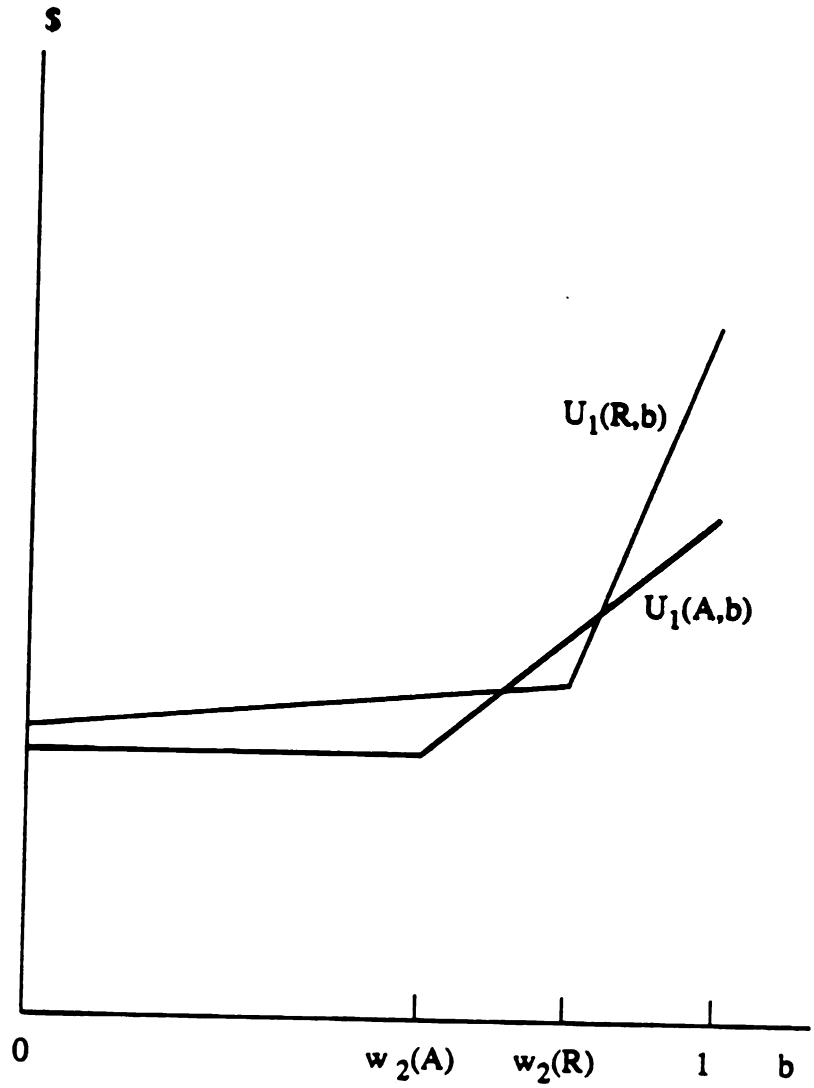

Figure 3.7

that δ must be less than ½.

Interestingly, condition (C1) corresponds to the "single crossing property" of Cramton (87) which ensures that $U_1(R,b)$ and $U_1(A,b)$ intercept each other at most once. This is beacuse, under condition (C1), the first segment's slope of $U_1(R,b)$ is greater than the maximum slope of $U_1(A,b)$. Thus, equilibrium actions of the union in this period can be characterized by a reservation wage, b^*. Any offer above the reservation wage for this period is accepted and any wage below that level is rejected.

Of course, the value of b^* depends on the offer of the firm. If w_1 is too low, the union will reject regardless of its type. Knowing that the union always rejects w_1, rejection of the first period offer will not increase the information possessed by the firms and, therefore, the second period offers, according to equation (3), are $(1-\delta)/(2-\delta)$. If acceptance is observed unexpectedly in this period, the firm would conjecture that the union's type is $b = 0$ leading to \$0 offers in the next period. Since the marginal case for this to happen is that $U_1(R,0) \geq U_1(A,0)$, by putting $w_2(R)$ and $w_2(A)$ into the above inequality, we conclude that the union will always reject w_1 if and only if

(9) $\quad w_1 \leq \sigma$

where $\sigma = (\delta/\alpha_1)\cdot[(1-\delta)/(2-\delta)]$.

If w_1 is large enough so that inequality (9) does not hold, then we should be able to find the union's reservation wage, b^*. If rejection occurs in this period, the firms' belief in the next period has a support of $[b^*,1]$ and, according to equation (3), $w_2(R)$, the second period offers, will be $(1-\delta+b^*)/(2-\delta)$. Since b^* solves $U_1(R,b^*) = U_1(A,b^*)$, by putting

$w_2(R)$ into equation (8) and solving for b^* by using equating equations (7) and (8), we have

$$(10) \quad b^* = (w_1-\sigma)/(1-\sigma).$$

Note that b^* is an increasing function of α_i. This suggests that the union is more reluctant to reveal its weakness (the information that the union is weak) when it faces a smaller firm because the information leakage in this period imposes a larger cost for the union when it has to face the bigger firm in the next period. Combining equation (9) and (10), we summarize the union's equilibrium action as:

$$(11) \quad b^* = \begin{cases} 0 & \text{if } w_1 < \sigma \\ (w_1-\sigma)/(1-\sigma) & \text{otherwise.} \end{cases}$$

2.3.2 The Firm's Problem

We are now in the position to describe the firms' first period problem. Let $Pr_i(w_1 \epsilon A)$ and $Pr_i(w_1 \epsilon R)$ denote, in respect, the probability that the union accepts and rejects firm i's first period offer, w_1. Then the expected profit for firm i is a function of its own offer and can be expressed as

$$(12) \quad E\bar{\pi}_i(w_1) = Pr_i(w_1 \epsilon A)\cdot[(1-w_1)/(1-\delta)] + Pr_i(w_1 \epsilon R)\cdot\delta\cdot E\pi_2(b^*,1).$$

where b^* is a function of w_1 as described in equation (11).

As shown in the appendix, the optimal offer by firm i is given as

$$(13) \qquad w_1^* = \frac{1-(1+\sigma)(1-\sigma)(2-\delta)}{1-2(1-\sigma)(2-\delta)}.$$

Note that w_1^* is a decreasing function of α_i (see Appendix). The intuition is as follow. Since the union is more reluctant to reveal its information that it is (relatively) weak to the smaller firm, this smaller firm has to give a better deal to the union in the first period, after carefully balancing its own costs and benefit of doing so.

3. The Mechanism Selection Problem

Having solved the bargaining game, we now procced to the mechanism selection problem. In general, if equilibrium exists in this stage, it could either be semi-seperating or pooling.

3.1. Semi-seperating equilibrium

Of particular interest is the semi-seperating equilibrium in which the union uses the scheduling decision to signal some information to the firms. For instance, in equilibrium, a stronger union would prefer mechanism i while a weaker union would perfer mechanism j. However, such a conjecture does not hold up to our expectation. We start our discussion of this problem by constraining r, the predetermined compensation to the workers of firm j, in order to highlight its importance.

Lemma 1. If $r = 0$, there exists no semi-seperating equilibrium in this model.

Proof: Suppose not. Define a_i as the number that (1) if $b < a_i$, union b, in equilibrium, would prefer mechanism i to mechanism j and (2) if $b > a_i$, b would choose mechanism j. Consider union $\hat{b} = a_i - \epsilon$ where ϵ is an arbitrary small positive number. We claim that, given the equilibrium choices of other types of the union, union $\hat{b}$ is better off to choose mechanism j. Since a_i is the toughest union that the firms would face if mechanism i is selected, during the bargaining process, no firm will give an offer greater than a_i (see figure 3.8). Thus, by choosing mechanism i, this union get no more than its default value (recall that ϵ is very small). If mechanism j is chosen, the offers given by the firms must be greater than a_i since the firms would believe that the weakest type of union they could ever face is a_i. Thus, by choosing mechanism j, union $\hat{b}$ can obtain a return greater than its default value. This contradicts the definition of a_i. Q.E.D.

The above proof depends critically on the fact that, when r = 0, a strong union (union with b close to 1) remains indiffernt between the two alternative mechanisms. It is because, under both mechanisms, a strong union gets nothing more or nothing less than its own default value. In contrast, a union with b close to its lower end of support always get more than its default value. Thus, there exists an incentive for a union in the high end of the support (in a partition) to pertain union of the low end of another support (in another partition) whenever such a possibility exists. Such an possibility clearly exists in a semi-seperating equilibrium for union with b that are smaller but close enough to the cut off value. This incentive destorys the existance of semi-seperating equilibrium.

One could then conjecture that with, r > 0, a semi-sperating equilibrium would exist. The intuition runs as follow. If r takes a value close to one, unions with a default value greater than r would prefer to bargain with the big firm first, that is, they always prefer mechanism

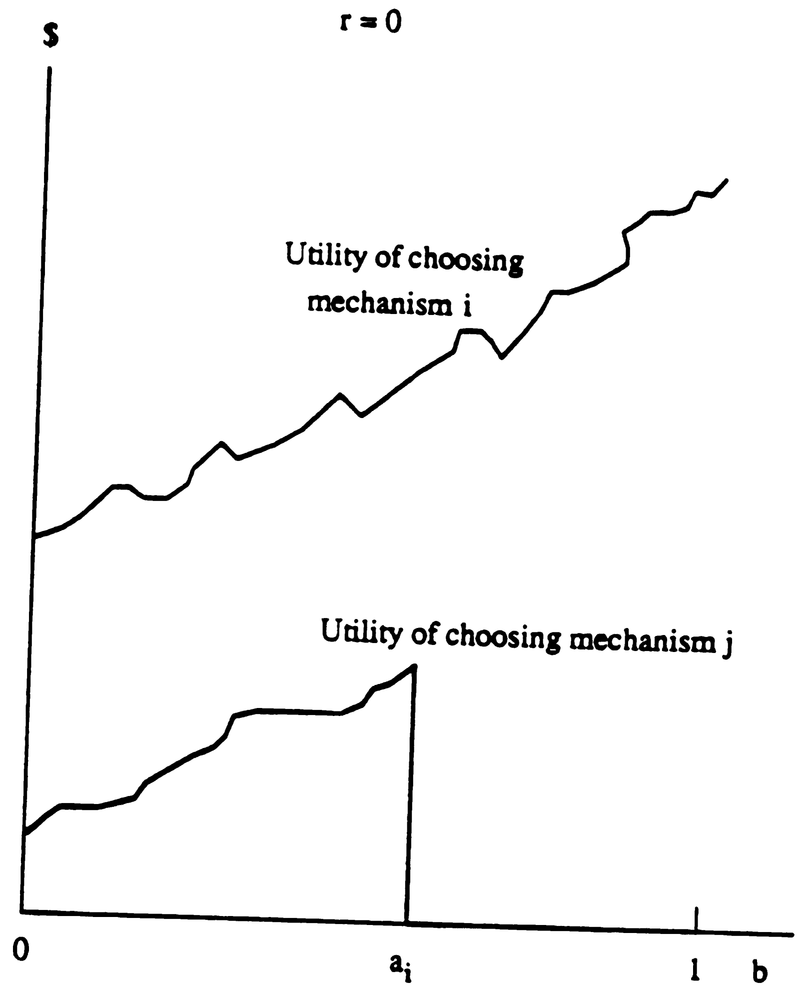
r = 0
$
Utility of choosing mechanism i
Utility of choosing mechanism j
0
a_i
1
b

Figure 3.8

1. For those unions, it is better off to strike than to be under-paid by a big firm. On the other hand, *ceteris paribus*, a union with default value slightly smaller than r (say $r-\epsilon$) would prefer to bargain with a small firm because the majority of its members are over-paid by the big firm. However, this unions would choose to bargain with the big firm first if there exists a seperating equilibrium in which the cut off value is smaller than $r-\epsilon$ but not far away. In this case, the union may find it profitable to by-pass the above advantage so that it can send a strong signal to the firms that the union is real strong and recieve a big offer that would not be obtained without the signal. This trade-off may ensure the existance of such a cut-off value and support a possible partition equilibrium.

Unfortunately, this nice intuition does not work out in our setting.

Lemma 2. There exists no semi-seperating equilibrium in this model.

Proof: It suffices to prove the nonexistance when $r > 0$. Consider $U_1(R,b)$ and $U_1(A,b)$, as defined in equations (7) and (8). For any possible prior support and any given wage offer, the utility of the union with b close to the low end of the support has a slope of zero. In fact, this utility can be represented by a piecewise linear curve as in figure 3.9.

Now, suppose a semi-seperating equilibrium exists and has a cut off value b* as represented in Figure 3.10. On the right hand side of b*, the union prefers to bargain with the big firm first while on the left hand side, the union chooses to bargain with the small firm first. If the union selects the big firm to bargain in the first period, the firms will have beliefs that the union is uniformly distributed on [b*,1]. Based on this information, we could graph the equilibrium payoff of the union in

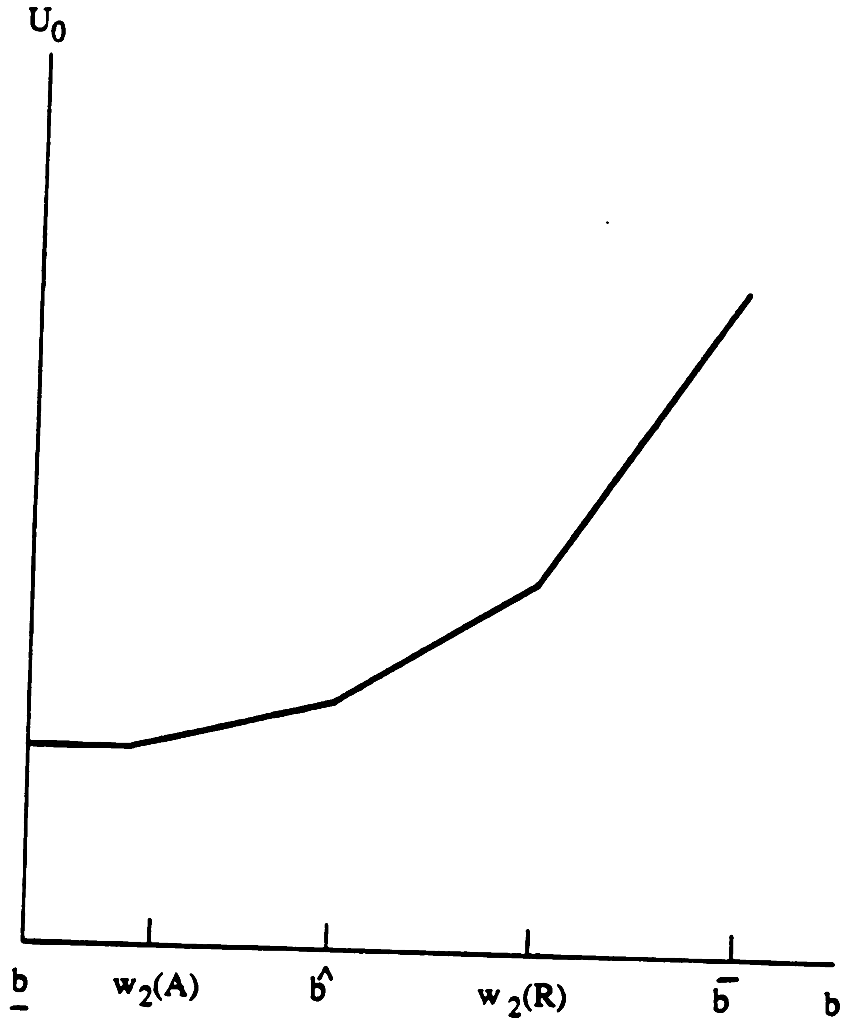

Figure 3.9

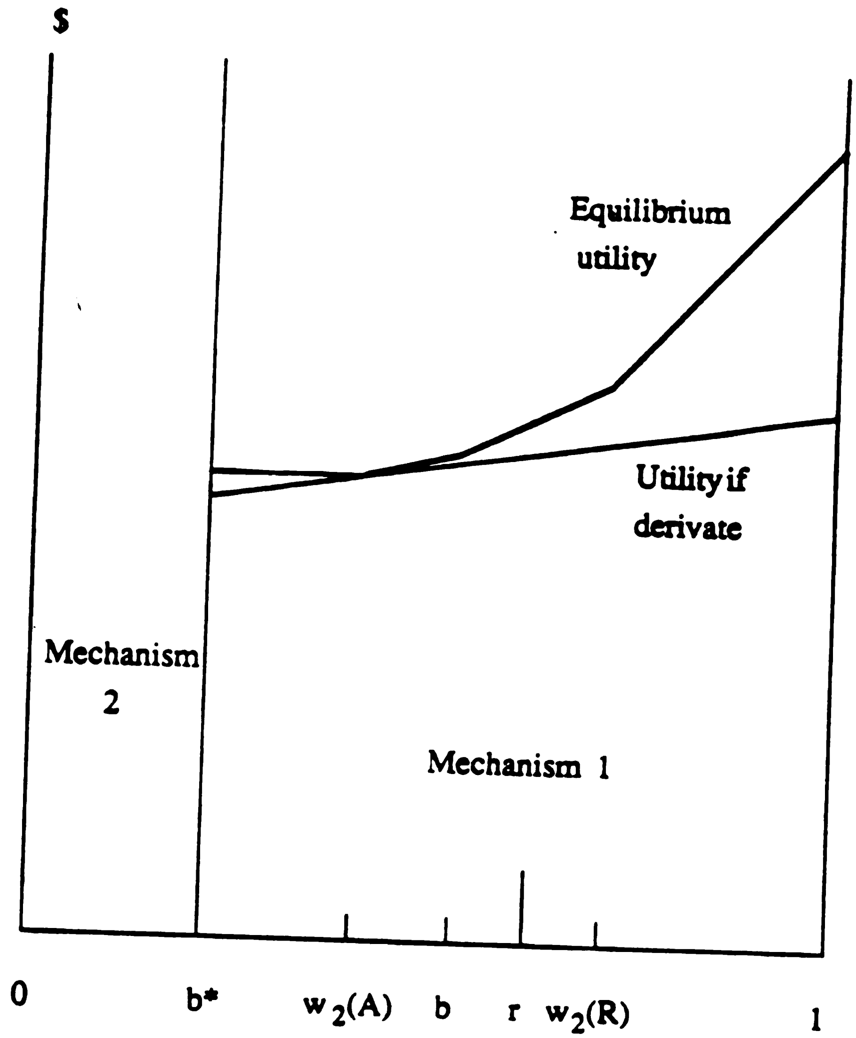
$
Equilibrium utility
Utility if derivate
Mechanism 2
Mechanism 1
0
b*
w2(A)
b
r
w2(R)
1

Figure 3.10

the first period. We call this curve equilibrium utility curve.

If a union with b ϵ [b*,1] derivates by choosing to bargain with the small firm first, this union should not expect to reach any agreement with any firms because firms simply will not offer anything above b*. The expected utility of this union recieves its default value plus the predetermined compensation from the big firm. Note that the utility of such a choice can be represented by a straight line with a positive slope. Lets call this curve the derivated utility curve.

Here comes the contradiction. There is no ways that these two curves (the equilibrium utility curve and the derivated utility curve) can intercept at b* since one curve has a slope of zero near b* and it lies above a straight line with a positive slope. Thus, there is no semi-seperating equilibrium. Q.E.D.

As we can see in the proof above, the problem lies on the shape of the utility curves. We will leave the discussion of this issue to the next section and continue to search another type of equilibrium.

3.2. The Pooling Equilibrium

It is fairly easy to show that pooling equilibrium exists in this model. We need an additional assumption on the conjecture of the firms for the possibility that an off-equilibrium mechanism selection may occur. We assume that, if an unexpected mechanism selection occurs, firms will conjecture that the type of union they face is $b = 0$.

Clearly, if $r > 0$, bargaining with the small firm first would not be an equilibrium. Thus, the only candidate here is that the union choose to bargain with the big firm first. Suppose this selection common to all types of unions. It is obvious that no union has any incentive to deviate from this choice because firms will always offer $0 during the negotiation if such a derivation occur. We summarize our finding in this section as follow:

Theorem 2. Under condition (C1), there exists a unique pooling equilibrium but no seperating or semi-seperating equilibrium in this game.

4. Discussions

Ironically, the model in this paper provides more negative results than positive results. However, those undesired findings are interesting in many aspects. In this section, we focus on these negative aspects and their association with other literitures.

(a) On Theorem 1

Theorem 1, indeed, is a very surprising result. Clearly, it indicates how fragile the bargaining models with continuous uncertainity are, despite the fact that a continuous probability function is a close description of reality. One should also be aware that the modelling approach employed here is not a particular one. Instead, it is one of the two possible alternatives one could start with in modelling bargaining under uncertainy. It has not been known that these models would end up with no equilibrium, although historically multiple equilibria seems to the only problem. One of the reasons that such problem does not surface in the early literiture is because of the fact that most of these bargaining models concern with only two players while in this model, we have three players bargain bilaterally in an interrelated fashion.

One would also suspect that the non-existance phenomena could go away if we relex some of the restrictive assumptions such as the time horizon that these parties can bargain with each other, the end game modelling strategy and the functional form of the probability prior, etc. In fact, it can be shown that, even with the propose modifications, the problem remains.

The non-existance problem here is not alone in economics. Similar situitions arise in the area of informational economics as denoted by footnote 7 of Rothschild and Stiglitz (1976) on competitive insurance market:

> "one curious result of these investigation should be mentioned. In other areas of economic theory where existance of equilibrium has been a problem, smoothing thing by introducing a continuum of individual of different type insure existance, not so here. If there is a continuous distribution of accident probability, this equilibrium never exists."

In fact, Riley (1979) prove that non-existance of Nash equilibrium with a continuum of classes.

The problem we encountered here seems to be the same as that of Rothschild and Stiligz's (1976): "when there is a continue probability, there always are individual with close probability whom it pays to pool."

(b) On Lemma 2

Could we obtain semi-seperating equilibrium by using another model? My speculation is yes. Despite previous negative results from the information literiture, recent studies on models of strategic information transmission such as Crawford and Sobel (1982) and Stern (1989) indicate that semi-seperating equilibrium could be obtained under some circumstances. Their models show that partition equilibria exist when players can use noisy signal to inform their types to uninformed agents. Structurally, our model different to their in two aspects. First, we do not have noisy signal available for the players. Second, they requires some qualifications of the payoff functions that our model does not accomplish. This particular requirement appears to be responsible for the non-existances of partition equilibrium in our model.

For future research, there are two things to note in order to avoid some of the difficulties presented here. It is better off to have a model that uses discrete distribution than continue distribution. It is because, in such a model, players use mixed strategies and mixed strategies provides noisy instead of pure signals. Futhermore, in a continuous distribution model, individual player has no infleuence to the subsequent actions of their oppenent (only collective action matter) while, in a discrete distribution model, actions of a single player can directly affect other players actions. Second, since there are many ways to introduce bargaining costs, it is possible to find an appropiate way of defining the payoff functions which can aviod some of the our problems.

5. Conclusion

We present a simple mechanism selection model with two firms and a union bargain seperately over wages. We found that the union will always choose to bargain with the big firm first. Although there is no partition equilibrium in this model, we do not rule out the existance of a model that could do so. In fact, a model which has an adequate payoff function with discrete uncertainity is a good candidiate to start with. The major contribution of this paper is that it points out the difficulties and the potential problem of modelling complicated bargaining game.

FOOTNOTES

1. See Nash (1950) and Sutton (1986).

2. Natural is the term I used and it may have many different interpretations. It could mean nearly generic, simple or symmetric. In Sutton's view (1986), natural here means nearly generic. He argued that "the detailed process of bargaining differ so widely from one case to another that any useful theory of bargaining must involve some attempt to distil out some simple principles which will hold over a wide range of possible processes". In Binmore's (1988) paper, it could mean simple or symmetric.

3. See Sutton (1986).

4. The function of "Free Choice Condition", according to Lagunoff (1988), "is to restricts the class of mechanisms at all levels in the regress to those which prevent any agent from being "locked-in" to an equilibrium outcome." This assumption, although reasonable in symmetric models, is quite restrictive in asymmetric models because to be able to "locked-in" a particular mechanism should be a kind of power possessed by some players. Nevertheness, the assumption restricts the choice set of the players in any level. This appears to violent the condition of unrestricted domain used in social choice literiture.

5. In a two-person non-cooperative bargaining game, there are two analytical equivalent interpretations of δ: δ can be regarded as the discount factor or δ can be seemed as the probability that the next round of bargaining may resume. It is interesting to note that, upon some reflexions, the probability interpretation of δ is different to the discounting intrepretation in a N-person bargaining game as in our context because, ex post, bargainings between the union and a firm may terminate without agreement, and that will change the structure of the other subgames.

6. According to the Dictionary of Modern Economics, whipsawing is a "technique e,ployed by some unions to extract a concession from an employer by threatening to strike while his competetors continue to operate, and, after he has conceded, to attempt to force a second employer to grant the same or even enhanced terms and conditions of employment or face a strike."

7. According to the Dictionary of Modern Economics, "Boulwarism is the process of collective bargaining over terms and conditions of employment is normally one of compromise and concession; the two bargain and approach one another until a point somewhere between their original or opening positions is attained that is mutually satisfactory to them". Although "Boulwarism has been declared as contracy to the legal requirement of bargaining in good faith, ... bargaining sequences within the US public sector show that Boulwarism is not yet dead".

8. According to Craypo (1986), in pattern bargaining, "unions tried to extend contract settlements in concentrated industries from large

producers to suppliers and fabricators. Once established, key bargains were pattern targets in negotiations with secondary companies".

9. Pattern plus bargaining, according to Craypo (1986), is similar to pattern bargaining except that union demands exceed the recently negotiated gains at other firms and become the new pattern for sebsequent economic settlements.

10. We assume that all contracts, once signed, are binding. Moreover, the information revealed by the union can be verified. This assumption is a little bit odd since private information should be information that can not be verified by communications but only by actions. Nevertheness, one should take these assumptions as instrumental.

11. The union could be modelled to maximize some other well-defined utility function. The current objective function is used because of its simplicity. However, the utility function seems to be responsibile for some of the non-existance problems. See section 4 for details.

12. Since all offers are made by the firms, the union has no other alternatives but to accept any offer equal to or above its default value in the third period. Although the assumption that the uninformed agents give all the offers is unrealistic, it is typical in bargaining models with one-sided incomplete information in order to rule out the possibility that informed agents use offers to signal their own types to other players.

13. As we will see in the next section, there exists no semi-seperating or seperating equilibria in this model. Thus, for the sake of exposition and to aviod unnecessarily algebraic complexity, we assume that the support of the first period belief is [0,1].

14. See appendix (b) for the case that the support is equal to [0,1].

15. This is a strong but simple assumption. However, there exists some other conjectures which would generate the same result.

16. That's why Rothschild and Stigitz used a two point distribution to model their insurance problem.

APPENDIX

(1) Derivation of the firm's first period offer

Firm i's problem in the first period is to maximize equation (12) with respect to w_1. Since b^* is piecewise linear in w_1 as indicated by equation (11), $E\pi_2(b^*,1)$ is also piecewise linear in w_1.

If $w_1 \in [0,\sigma]$, $Pr_i(w_1 \in R) = 1$ and $Pr_i(w_1 \in A) = 0$. In this case, $E\pi_2(w_1,1) = [2(1-\delta)(2-\delta)]^{-1}$.

If $w_1 \in [\sigma,1]$, $Pr_i(w_1 \in R) = (1-w_1)/(1-\delta)$ and $Pr_i(w_1 \in A) = (w_1-\sigma)/(1-\delta)$. In this case, $E\pi_2(w_1,1) = (1-w_1)\cdot[2(1-\delta)(2-\delta)(1-\sigma)]^{-1}$. Putting $E\pi_2(b^*,1)$ into equation (12) and optimizing equation (12) with respect to w_1, we obtain

$$w_1^* = \frac{1-(1+\sigma)(1-\sigma)(2-\delta)}{1-2(1-\sigma)(2-\delta)}.$$

Note that $1 > w_1^* > \sigma$.

Since $w_1^* = \sigma$ is available, w_1^* is the global optimal offer by firm i.

(2) The union's equilibrium utility in a pooling equilibrium

By using equations (3), (5), (6), (11) and (13), we can derive the unions utilities as follow:

$$U_0(i) = \begin{cases} \alpha_i\dfrac{(1-\sigma^2)(2-\delta)}{2(1-\sigma)(2-\delta)} + \dfrac{\delta(1-\delta)(\alpha_i-\delta)(1-\alpha_i)}{(1-\delta)(3-2\delta)\alpha_i-2\delta(1-\delta)^2} & \text{if } b \in [0,A] \\[2ex] \alpha_i b + \dfrac{2\delta(2-\delta)\alpha_i-\delta^2(3-2\delta)}{(2-\delta)(3-2\delta)\alpha_i-2\delta(1-\delta)^2} & \text{if } b \in [A,B] \\[2ex] (\alpha_i + \dfrac{\delta}{1-\delta})b & \text{if } b \in [B,1] \end{cases}$$

where $A = (1-\delta)(\alpha_i-\delta)/[(3-2\delta)\alpha_i-2\delta(1-\delta)]$ and
$B = [(1-\delta)/(2-\delta)]\cdot\{[2(2-\delta)\alpha_i-\delta(3-2\delta)]/[(3-2\delta)\alpha_i-2\delta(1-\delta)]\}$.

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