Timing of endogenous bargaining over costs and firms' locations

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Abstract

This work analyzes a duopoly in which firms choose their locations and then bargain over wages with their unions. The timing of the bargaining process is endogeously determined. We obtain that bargaining is simultaneous if and only if both firms decide when negotiations take place. Otherwise negotiation takes place sequentially. Under simultaneous or sequential negotiations, the market is equally shared and both firms have the same price-cost margins and profits. When bargaining is sequential firms have higher profits, the leader locates closer to the market than in the simultaneous case, the follower locates further away and the distance between the two firms is greater.

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1 Introduction

The consideration of costs as endogenous in spatial competition models is quite exceptional. One of the few examples is a recent paper by Brekke and Straume (2004), who analyze bilateral monopolies and location choice in a duopoly model in which firms can choose their locations simultaneously or sequentially, but always bargain over their input prices simultaneously. Their model can also be useful for studying the negotiations between a firm and its union. In our paper we follow the path of Brekke and Straume (2004), so we bring together two separate literatures: spatial competition and wage bargaining. We consider that locations are chosen simultaneously but we extend their analysis by assuming that not only wages but also the timing of wage negotiations are endogenously determined. As a result, input costs can be negotiated either simultaneously or sequentially. This is an important issue since firms' locations crucially depend on input costs and these costs differ from the simultaneous case to the sequential case.

In spatial competition models (see, e.g., d'Aspremont et al., 1979) firms are usually restricted to locating within city limits. In our paper, as Brekke and Straume (2004) do, we adopt the approach of Lambertini (1994, 1997) and Tabuchi and Thisse (1995), who allow locations outside city limits. They show that if firms can locate outside the city limits they will do so. In this setting, if costs are exogenous, the firm with the lower exogenous marginal cost locates closer to the center of the market, sets a higher price, and obtains greater market share and profits. As we will show below these results change if costs and the timing of the bargaining stage are endogenous.

The literature on wage negotiations has studied how production costs are determined, and has analyzed extensively the bargaining structure in which firms negotiate with independent unions at firm level (see, for example, Malcomson (1987), Farber (1986), Oswald (1985) and McDonald and Solow (1981)).[1] A branch of this literature has focused on the role played by the order of movements when negotiations take place.[2] This analysis is relevant since empirical evidence shows that bargaining structures in developed countries differ. In the U.S. and the E.U. countries contracts are typically staggered; i.e. different groups bargain at different times (see Freedman and Fulmer, 1982; Layard et al., 1991; Flanagan, 1993; Addison and Siebert, 1993). In Japan, wages are negotiated simultaneously in the 'Spring offensive' (see Sasajima, 1993).

[1] Literature on wage bargaining has analyzed the effects on price-cost margins of different bargaining powers from both theoretical and empirical points of view. For example, Neven et al. (2002) treat input prices as endogenous and investigate their effect on market power. Their empirical implementation uses data from the European airline industry from 1976 to 1994. An important difference between their theoretical model and ours is that they consider the variety of the product as exogenously given. They find that *"input market imperfection has rather little impact on prices and margins relative to output market imperfection"* (See Neven et al., 2002, p. 3).

[2] De Fraja (1993), Corneo (1995) and Bárcena-Ruiz and Campo (2000) show that when wage bargaining is decentralized at firm level, workers prefer sequential negotiation; however, owners of firms prefer simultaneous bargaining.

In the model analyzed below we consider that the time when firms and unions bargain over wages is not exogenously imposed but decided by the different agents once both firms are located and before the stage in which firms set prices. By this means we can study whether negotiations take place simultaneously or sequentially. Our findings confirm that negotiations over wages (or input prices) are conducted simultaneously if and only if both firms decide the timing of the bargaining process: it does not matter whether they are the sole decision makers or whether they decide jointly with a union. But if the timing of bargaining is established only by the two unions, by the unions and only one firm or by one union and the rival firm, the negotiation over wages takes place sequentially.

Brekke and Straume (2004) show that when production costs are endogenously determined and wage negotiation is simultaneous, firms locate further from the market than when costs are exogenously given. Moreover, the firm facing the stronger union locates closer to the market. We get that under sequential negotiations, the firm that negotiates first may be closer to the market than the follower even if its bargaining power is higher than that of the follower. Then, the range of values of the bargaining power of the leader firm for which it is closer to the market is greater than in the simultaneous case. Independently of the bargaining power of the firms, when wages are negotiated sequentially the leader locates closer to the market than in the simultaneous case while the follower locates further away. We also obtain that firms' locations are the same whether the decision is taken by the owners of the firms or by the unions.

The different timing of negotiation alters some results concerned with the degree of product differentiation but, surprisingly, does not affect market shares, which remain the same under simultaneous and sequential bargaining. In our model firms produce differentiated products, have different costs for their inputs, might set different prices but both have the same price-cost margins, they sell half of the demand and make the same profits. The same results are obtained if firms bargain over their input cost with their suppliers, or their wages with their unions, simultaneously or sequentially, although profits differ from one setting to the other.[3]

Comparing the simultaneous and sequential equilibrium choices, both the owners of the firms and the unions are better off if wages are negotiated sequentially. From firms' point of view this is due to the fact that under both sequential and simultaneous negotiations the firms share the market equally and that the price-cost margin is greater in the sequential case as the distance between the two firms is greater. Therefore, both firms are better off if wages are negotiated

[3] What can be said about performance in this market? It seems that firms are in some way colluding: they may have reached an agreement to get the same price-cost margins and market shares and thus profits, regardless of the different prices they set and the different costs they have. Moreover, it seems that different prices could be used to hide a collusive agreement from the cartel monitoring authorities. In fact, as this paper shows, the real situation could have nothing to do with collusion: these results can be properly obtained in a non collusive framework if we allow firms to choose their location or, in other words, decide not only on prices but also on the variety of the good they produce before they bargain over wages. In this setting firms anticipate their future costs and prices before choosing their locations.

sequentially.[4]

The rest of the paper is organized as follows: first we study the model, second the main results and, finally, we draw conclusions.

2 The model

Consumers are distributed uniformly with unitary density along a linear market: the interval $[0, 1]$. They buy one unit of the good at the lowest delivered price, considered as the mill price plus transportation cost. Consumers transport their purchase home at a cost td^2, where t is a positive constant and d is the distance between the consumer and the firm.

The are two firms indexed by i $(i = 1, 2)$ competing in the market. They can decide to locate inside or outside the city boundaries. Let a denote the location of firm 1 and $1 - b$ denote the location of firm 2. When a is 0 firm 1 is located at the $[0, 1]$ city's left boundary. If $a > 0$, firm 1 is located to the right of this point. If $a < 0$, firm 1 is located to the left of the $[0, 1]$ city. From the point of view of firm 2, if $b = 0$, firm 2 is located on the right border of the $[0, 1]$ interval. If $b > 0$, firm 2 is located to the left of this point, and finally, if $b < 0$, firm 2 is located to the right of this point. For the sake of simplicity, we assume that firm 1 is located to the left or on the same point as firm 2: $1 - a - b \geq 0$. Once the firms choose their locations they cannot be changed in the future.

Labor is the only factor of production. Firm i hires L_i workers and pays a uniform wage rate w_i. There is a separate, independent union in each firm. All workers are unionized and the uniform wage rate is the result of wage bargaining between unions and firms. The utility of each union is its wage bill: $U_i(w_i,L_i)=L_i w_i, i = 1, 2$. Technology exhibits constant returns to scale such that output of firm i is $q_i=L_i$. We consider a variant of the "right-to-manage" model of Nickell and Andrews (1983), where employment is set unilaterally by the firm. Unions and firms are both risk neutral, and firms seek to maximize profits while unions seek to maximize their wage bill. The solution concept considered at this stage of the game is the two-person generalized Nash bargaining solution in which the bargaining power of firm i is measured by $\alpha_i \in [0, 1]$ and $1 - \alpha_i$ measures the bargaining power of union i. The bargaining power of each firm is exogenously given and it is public information before taking all decisions. We consider, as it seems realistic, that this power could differ between firms.

The timing of the game is as follows. In the first stage, the two firms simultaneously choose their locations. In stage two, it is simultaneously decided whether to negotiate over wages in period 1 or in period 2. This decision could be taken in each case by the firm, by the union or as a result of negotiations between a firm and its union. If wage negotiations take place in the same period, wage bargaining is simultaneous. Otherwise wage negotiations are sequential. In stage three, firms and unions bargain over wages in the period chosen in the

[4] Firms are indifferent as to whether they are leaders or followers since the leader and the follower obtain the same profits.

preceding stage. Finally, in stage four firms take price and employment decisions simultaneously. We solve the game by backward induction from the last stage of the game to obtain a subgame perfect Nash equilibrium.

3 Results

Let p_i denote the price set by firm i ($i = 1, 2$). We can determine the consumer who is indifferent between the two firms and who is located at a point x such that:

$$p_1 + t(x - a)^2 = p_2 + t(1 - x - b)^2. \tag{1}$$

From (1) we obtain:

$$x = \frac{p_2 - p_1}{2t(1 - a - b)} + \frac{1 + a - b}{2}. \tag{2}$$

Thus, the respective demands of firms 1 and 2, when both firms do not locate at the same point ($1 - a - b \neq 0$) are given by q_1 and q_2:

$$q_1 = \begin{cases} x & \text{if } 0 \leq x \leq 1 \\ 1 & \text{if } x > 1 \\ 0 & \text{if } x < 0 \end{cases}, \quad q_2 = \begin{cases} 1 - x & \text{if } 0 \leq 1 - x \leq 1 \\ 1 & \text{if } 1 - x > 1 \\ 0 & \text{if } 1 - x < 0 \end{cases} \tag{3}$$

We solve first the fourth stage of the game, which is common to the simultaneous or sequential previous negotiation over wages.

3.1 Prices

In this stage the firms simultaneously choose their prices and employment. Given the relationship between prices and output (employment), once the firms decide their prices their output and employment levels are determined by expression (2): $L_1 = q_1 = x$, $L_2 = q_2 = 1 - x$. The objective function of firm i is:

$$\pi_i(p_1, p_2) = (p_i - w_i)q_i, i = 1, 2. \tag{4}$$

From the first order condition for each firm we get the equilibrium prices when both firms sell the good:[5]

$$p_1 = \frac{1}{3}((3 + a - b)(1 - a - b)t + 2w_1 + w_2), \tag{5}$$

$$p_2 = \frac{1}{3}((3 - a + b)(1 - a - b)t + w_1 + 2w_2). \tag{6}$$

Therefore, the market price of firm i increases both with its own wage and with the wage paid by the rival. Thus, the demands of firms 1 and 2 and therefore their employment levels are:

[5] The second order conditions in the problems we analyze are always satisfied.

$$q_1 = L_1 = \frac{(3+a-b)(1-a-b)t - w_1 + w_2}{6(1-a-b)t}, \tag{7}$$

$$q_2 = L_2 = \frac{(3-a+b)(1-a-b)t - w_2 + w_1}{6(1-a-b)t}. \tag{8}$$

As usual, the output and employment levels of each firm decrease with its wage and increase with the wage paid by its rival. We now solve the third stage of the game, in which negotiation over wages takes place.

3.2 Wage negotiations

We compute the solution of the negotiation process in this stage as proposed by the generalized Nash bargain in which the bargaining power of firm i is measured by $\alpha_i \in [0,1]$; $1-\alpha_i$ measures the bargaining power of the union of firm i (union i). Thus, in the third stage of the game the result of the bargaining process is to choose w_i such that it maximizes $(\pi_i)^{\alpha_i}(U_i)^{1-\alpha_i}$, $i = 1, 2$. Let us first analyze the simultaneous case, then the sequential case.

3.2.1 Simultaneous bargaining over wages

Let w_i^C ($i = 1, 2$) denote the equilibrium wages in the case of simultaneous bargaining over wages (in the following the superscript C stands for the results in the case of simultaneous bargaining over wages). From the first order condition for each firm it is straightforward to show that equilibrium wages in the third stage of the game are:[6]

$$w_1^C = \frac{(1-a-b)t(1-\alpha_1)(9+a-b-(3-a+b)\alpha_2)}{3+\alpha_1+\alpha_2-\alpha_1\alpha_2}, \tag{9}$$

$$w_2^C = \frac{(1-a-b)t(1-\alpha_2)(9-a+b-(3+a-b)\alpha_1)}{3+\alpha_1+\alpha_2-\alpha_1\alpha_2}. \tag{10}$$

Under symmetric locations (i.e., when a=b), $w_1^C > w_2^C$ if and only if $\alpha_1 < \alpha_2$, which means that the firm with the greater bargaining power pays the lower wage.

Substituting (9) and (10) in (5) and (6) we obtain the equilibrium prices of the last stage of the game (p_1^C, p_2^C) as a function of firms' locations:

$$p_1^C = \frac{2(1-a-b)t(2-\alpha_1)(9+a-b-(3-a+b)\alpha_2)}{3(3+\alpha_1+\alpha_2-\alpha_1\alpha_2)}, \tag{11}$$

$$p_2^C = \frac{2(1-a-b)t(2-\alpha_2)(9-a+b-(3+a-b)\alpha_1)}{3(3+\alpha_1+\alpha_2-\alpha_1\alpha_2)}. \tag{12}$$

From (9) to (12) we get the following ratio:

[6]It can be shown that, as usual, wages are strategic complements. Thus, the greater the wage of the rival the greater the own wage is.

$$\frac{p_i^C}{w_i^C} = \frac{2(2-\alpha_i)}{3(1-\alpha_i)}, i = 1, 2. \tag{13}$$

When firms decide their locations, they take into account how those locations affect future wages and prices but in this model prices and wages are proportional and thus do not depend on firms' locations. Therefore, the ratio $\frac{p_i^C}{w_i^C}$ does not depend on the locations of the firms, but only on each firm´s own bargaining power.[7]

3.2.2 Sequential bargaining over wages

We solve sequential bargaining over wages considering that firm 1 bargains wages first. Thus, the wage that solves the bargaining process for firm 2 is such that: $w_2^F = argmax(\pi_2)^{\alpha_2}(U_2)^{1-\alpha_2}$ (the superscript F stands for the follower and L for the leader).[8] From the first order condition we get:

$$w_2 = \frac{(1-\alpha_2)((1-a-b)t(3-a+b)+w_1)}{2}. \tag{14}$$

Then, from firm 1's point of view the bargaining result consists of choosing the value of w_1^L that maximizes $(\pi_1)^{\alpha_1}(U_1)^{1-\alpha_1}$ subject to (14). It is straightforward to get the solution and, substituting the equilibrium values (w_1^L, w_2^F) in the preceding equation we get:

$$w_1^L = \frac{(1-a-b)t(1-\alpha_1)(9+a-b-(3-a+b)\alpha_2)}{2(1+\alpha_2)}, \tag{15}$$

$$w_2^F = \frac{(1-a-b)t(1-\alpha_2)((b-a)(1+\alpha_1)(1+\alpha_2)+3(5-\alpha_1(3-\alpha_2)+\alpha_2))}{4(1+\alpha_2)}. \tag{16}$$

Substituting (15) and (16) in (5) and (6) we obtain the equilibrium prices of the last stage of the game (p_1^L, p_2^F) as a function of firms' locations:

$$p_1^L = \frac{(1-a-b)t(7-\alpha_1(5-\alpha_2)+\alpha_2)(9+a-b-(3-a+b)\alpha_2)}{12(1+\alpha_2)}, \tag{17}$$

$$p_2^F = \frac{(1-a-b)t(2-\alpha_2)((b-a)(1+\alpha_1)(1+\alpha_2)+3(5-\alpha_1(3-\alpha_2)+\alpha_2))}{6(1+\alpha_2)}. \tag{18}$$

From (15) to (18) we get the following ratios:

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[7] In this case, the Lerner index is: $LI_i = \frac{p_i^C - w_i^C}{p_i^C} = \frac{1+\alpha_i}{2(2-\alpha_i)}$, which reflects that firms' locations do not have any impact on market power. The Lerner index measures the degree of market power: it is the ratio of price minus marginal cost to price (see Lerner, 1934).

[8] The case in which wages are bargained first in firm 2 is symmetric and, thus, we omit it.

$$\frac{p_1^L}{w_1^L} = \frac{7-\alpha_1(5-\alpha_2)+\alpha_2}{6(1-\alpha_1)}, \frac{p_2^F}{w_2^F} = \frac{2(2-\alpha_2)}{3(1-\alpha_2)}. \tag{19}$$

As in the simultaneous case we get that prices and wages are proportional and, thus, the ratios $\frac{p_1^L}{w_1^L}$ and $\frac{p_2^F}{w_2^F}$ do not depend on the locations of the firms, but only on their bargaining powers.[9]

3.3 Choice of negotiation timing

In the second stage of the game the timing of the bargaining process has to be determined. The point here is to choose who decides when the negotiation process is carried out. There are different possibilities to be considered. First, we might consider that this decision is taken by the agent (the firm or the union) with the higher bargaining power. As a result, both firms or both unions could take this decision or maybe one firm and one union. Second, we can study the case in which all four players (both firms and both unions) decide on this question. In this second case, wage negotiation takes place in the first period if and only if both the firm and its union agree. Otherwise bargaining is postponed to the next period given that both agents prefer to bargain rather than refusing negotiation. Let us first analyze firm' and unions' incentives to bargain over wages simultaneous or sequentially.

Lemma 1 *For any pair of locations a and b:*

i.- Both unions prefer to negotiate over wages sequentially rather than simultaneously.

ii.- Both firms prefer to be the follower in the negotiation stage rather than to negotiate over wages simultaneously, but simultaneous negotiation is better than to be the leader.

Proof. See the appendix. ■

Given that wages are strategic complements, the workers of both the leader and the follower firms obtain higher wages under sequential bargaining than when negotiations are simultaneous.[10] Although the leader firm hires less employees in the sequential case, the higher wage implies that the utility of the leader union is greater under sequential negotiations. The follower union obtains higher wages and more employment, and thus greater utility, in the sequential case. This implies that both unions obtain greater utility under sequential than under simultaneous bargaining. From the point of view of the firms, in the sequential case the leader firm obtains a lower price-cost margin and produces a lower output, which means that $\pi_1^C > \pi_1^L$. On the other hand, in the sequential

[9] The Lerner Indexes are: $LI_1 = \frac{p_1^L - w_1^L}{p_1^L} = \frac{(1+\alpha_1)(1+\alpha_2)}{7-\alpha_1(5-\alpha_2)+\alpha_2}, LI_2 = \frac{p_2^F - w_2^F}{p_2^F} = \frac{1+\alpha_2}{2(2-\alpha_2)}$. This reflects that under sequential negotiations firms' locations do not have any impact on market power.

[10] This result is standard in the literature on wage bargaining (see, for example, Bárcena-Ruiz and Campo, 2000)

case the follower firm obtains a higher price-cost margin and produces more output which means that $\pi_2^F > \pi_2^C$.

Solving the second stage of the game, we obtain the following result.

Proposition 1 *Bargaining over wages is simultaneous if and only if both firms decide on the period of time in which bargaining takes place. Otherwise negotiation takes place sequentially.*

Proof. Now we consider the different negotiation games that could take place. First, we consider that both unions decide the timing of the negotiation process. Given that both unions prefer to play sequentially, since the utility obtained by both unions is greater in that case, there are two equilibria. In these equilibria one union is the leader (bargains in the first period) and the other is the follower (bargains in the second period).

Second, consider that the two firms decide the timing of the negotiation process. In this case as shown above, the follower (leader) firm obtains higher (lower) profits than in the simultaneous case. As a result, there is a dominant strategy for each firm, which is to bargain in the second period. Then we have a simultaneous game in the bargaining stage.

Third, consider that one firm and the union of the rival firm decide the timing of bargaining in the second stage. In this case the firm has a dominant strategy, which is to bargain in the second period, and the union thus chooses to negotiate in the first period. The only equilibrium is that in which the union is the leader and the rival firm acts as a follower. The same result can be obtained if the game is played, on the one hand, by one firm and its union and, on the other hand, by a union.

Fourth, imagine that the game is played by all four possible players: both firms and both unions. Take into account that if one union or its firm decides to play in the second period the bargaining is in that period (i.e. they are able to delay wage negotiations). Firms always have a dominant strategy, which is to play in the second period to avoid becoming the leader. Thus, the only equilibrium is to negotiate in that period and this is an equilibrium of the game because neither union can push its firm to behave as a leader. The same result can be obtained if the game is played on the one hand by one firm and its union and on the other hand by one firm.

As a result we have that bargaining over wages is simultaneous if and only if the two firms have a say in the timing of the bargaining game: if one of them has no say in this decision then its union will behave as the leader in the bargaining process. ■

This proposition shows that the bargaining process is simultaneous if and only if both firms decide the timing of the negotiation process. It must be noted that in this stage of the game the agents decide the timing of the bargaining process for any pair of locations. It does not matter if they decide this alone or in a game with their unions.[11] If one firm has no say in this timing the game

[11] It also fits for the case in which one firm decides on this question with its union and the other takes the decision alone.

will be played sequentially.

3.4 Locations

In the first stage of the game the two firms simultaneously decide their locations. The following proposition allows us to determine some interesting properties of the equilibrium before solving the whole game.

Proposition 2 *Under simultaneous or sequential negotiations over wages both firms equally share the demand, hire the same number of employees and get the same price-cost margins and profits independently of the bargaining power of the firms or their leader-follower status.*

Proof. See the appendix. ■

This proposition shows that equilibrium locations are such that neither the bargaining power of the firms nor the sequential choice of wages influence firms' market share. Therefore, we obtain a symmetric result although the model is asymmetric when firms have different bargaining powers or when wages are bargained sequentially. Although the bargaining powers of the firms and the sequential negotiation affect their wages and prices, as firms' locations are chosen in the first stage, the firms adjust their prices and wages to their locations in such a way that each firm has half of the market.[12] Thus half of the workers are hired by each firm: $q_i = L_i = \frac{1}{2}$ $(i = 1, 2)$. Moreover, equilibrium locations are such that the relationship between price-cost margins and market share is equal for both firms (see proof of proposition 2 in the appendix), so if both firms have the same market share both get the same price-cost margins and profits.

Given that the profit of firm i can be written as $\pi_i = (p_i - w_i)q_i = (1 - \frac{w_i}{p_i})p_i q_i = (\frac{p_i}{w_i} - 1)w_i q_i$ and that $\frac{p_i}{w_i}$ does not depend on firms' locations, as seen above choosing the location that maximizes profits is equivalent to choosing the location that maximizes the value of sales or the wage bill. Thus, we can write the following corollary.

Corollary 1 *Firms' locations are the same whether this decision is taken by the owners of the firms or by the unions. Moreover, the locations of the firms are the same independently of whether the objective function of the owners is profits or sales revenues.*

In order to obtain firms' locations when wages are negotiated simultaneously, from the first order conditions we obtain the reaction functions of firms 1, $a(b)$, and 2, $b(a)$, for the first stage of the game:

$$a(b) = -\frac{7 - 5\alpha_2}{3(1 + \alpha_2)} - \frac{b}{3}, \quad b(a) = -\frac{7 - 5\alpha_1}{3(1 + \alpha_1)} - \frac{a}{3}. \tag{20}$$

[12] Under sequential and simultaneous wage bargaining firms' locations do not have any impact on market power (see footnotes 7 and 9).

Solving (20) we get that equilibrium locations in the simultaneous case are a^C and $1-b^C$ such that:

$$a^C = -\frac{7+13\alpha_1-11\alpha_2-5\alpha_1\alpha_2}{4(1+\alpha_1)(1+\alpha_2)}, b^C = -\frac{7+13\alpha_2-11\alpha_1-5\alpha_1\alpha_2}{4(1+\alpha_1)(1+\alpha_2)}.$$

Substituting the values of a^C and b^C we have the following equilibrium values $(i,j=1,2; i\neq j)$:

$$p_i^C = \frac{3t(2-\alpha_i)(3+\alpha_i+\alpha_j-\alpha_i\alpha_j)}{(1+\alpha_i)^2(1+\alpha_j)}, w_i^C = \frac{9t(1-\alpha_i)(3+\alpha_i+\alpha_j-\alpha_i\alpha_j)}{2(1+\alpha_i)^2(1+\alpha_j)},$$

$$\pi_i^C = \frac{3t(3+\alpha_i+\alpha_j-\alpha_i\alpha_j)}{4(1+\alpha_i)(1+\alpha_j)}, U_i^C = \frac{9t(1-\alpha_i)(3+\alpha_i+\alpha_j-\alpha_i\alpha_j)}{4(1+\alpha_i)^2(1+\alpha_j)}.$$

Comparing the equilibrium values obtained by the two firms, we first show the following result, due to Brekke and Straume (2004).[13]

Proposition 3 *Under simultaneous negotiations, in equilibrium:* $a^C>b^C$, $w_1^C>w_2^C$, $p_1^C>p_2^C$ *and* $U_1^C>U_2^C$ *iff* $\alpha_1<\alpha_2$.

This proposition shows that the firm with the lower bargaining power pays the higher wage and is located closer to the center of the market than its rival, which allows this firm to charge higher prices. As a firm locates closer to the center of the market its wage is lower but the rival also pays lower wages. Thus, being closer to the market is of interest if the reduction in the costs of the rival is not very high compared with that obtained by the firm. This is the case when the rival firm has a greater bargaining power because the wages that it is paying are lower. As a result, the firm with the lower bargaining power is closer to the market in order to get a strong reduction in its costs and the rival reacts locating further. However, as seen in proposition 2, the two firms obtain the same market share and profits. The union of the firm with the lower bargaining power obtains a greater utility than the workers of the other firm.

Let us now focus on the sequential case. We can maximize the value of sales revenue to get the solution from first order conditions. Reaction functions of firms 1 (the leader) and 2 (the follower), for the first stage of the game when wages are bargained sequentially are:

$$a(b) = -\frac{7-5\alpha_2}{3(1+\alpha_2)} - \frac{b}{3}, \; b(a) = -\frac{1}{3} - \frac{a}{3} - \frac{4(1-\alpha_1)}{(1+\alpha_1)(1+\alpha_2)}. \tag{21}$$

Comparing equations (20) and (21) we have that only the reaction function of firm 2 differs from the simultaneous case to the sequential one. Solving (21) we obtain that equilibrium locations are:

[13] In order to compare their results with ours, note that they consider that α_i measures the bargaining power of union or supplier i, not that of firm i as we consider.

$$a^L = -\frac{1+4\alpha_1-2\alpha_2-2\alpha_1\alpha_2}{(1+\alpha_1)(1+\alpha_2)}, b^F = -\frac{4-5\alpha_1+\alpha_2+\alpha_1\alpha_2}{(1+\alpha_1)(1+\alpha_2)}.$$

Substituting the values of a^L and b^F we have the following equilibrium values:

$$p_1^L = \frac{6t(7-\alpha_1(5-\alpha_2)+\alpha_2)}{(1+\alpha_1)^2(1+\alpha_2)^2}, p_2^F = \frac{12t(2-\alpha_2)}{(1+\alpha_1)(1+\alpha_2)^2},$$

$$w_1^L = \frac{36t(1-\alpha_1)}{(1+\alpha_1)^2(1+\alpha_2)^2}, w_2^F = \frac{18t(1-\alpha_2)}{(1+\alpha_1)(1+\alpha_2)^2},$$

$$U_1^L = \frac{18t(1-\alpha_1)}{(1+\alpha_1)^2(1+\alpha_2)^2}, U_2^F = \frac{9t(1-\alpha_2)}{(1+\alpha_1)(1+\alpha_2)^2},$$

$$\pi_1^L = \pi_2^F = \frac{3t}{(1+\alpha_1)(1+\alpha_2)}.$$

Comparing the equilibrium values obtained by the two firms, we obtain the following result.

Proposition 4 *Under sequential negotiations, in equilibrium:* $a^L > b^F$, $w_1^L > w_2^F$, $p_1^L > p_2^F$ *and* $U_1^L > U_2^F$ *iff* $\alpha_1 < \frac{1+\alpha_2}{3-\alpha_2}$.

This proposition shows that the firm that bargains wages first is closer to the market than the other firm ($a^L > b^F$) if its bargaining power is low enough, i.e. if $\alpha_1 < \frac{1+\alpha_2}{3-\alpha_2}$, where $\frac{1+\alpha_2}{3-\alpha_2} \geqslant \alpha_2$ being equal for α_2=1. To understand why, consider first that the bargaining powers of both firms are the same. In this case the leader firm is closer to the market given that, as wages are strategic complements, the leader in the negotiation stage pays higher wages than the follower. The follower knows that by being closer to the leader both wages are lower since market competition is stronger, but the leader reduces its wage more than the follower. Thus, the follower tries to be further from the market because by this means the costs of the leader firm increase more. As a result, if bargaining powers are equal, the leader is closer to the market than the follower. However, as we have seen in proposition 3, there is an additional effect that could outweigh the one mentioned above: if the bargaining power of one firm is higher than its rival´s that firm is further from the market. Then, the range of values of α_1 for which the leader is closer to the market is higher than in the simultaneous case but if the leader has a high bargaining power compared to the follower the result is reversed.

By comparing equilibrium locations obtained in the sequential and simultaneous cases, we obtain the following result:

Proposition 5 *In equilibrium:* $a^L > a^C$, $b^C > b^F$ *and* $1 - a^L - b^F > 1 - a^C - b^C$.

This proposition shows that, independently of the bargaining power of the firms, when wages are bargained sequentially the leader locates closer to the market than in the simultaneous case while the follower locates further away. This is due to the fact that given two locations a and $1-b$ the leader (firm 1) pays higher wages than in the simultaneous game (also relative to firm 2 wages) and has more incentives to be closer to the market to increase the competition between the two firms and avoid paying very high wages. The follower tries to locate further away (compared to the simultaneous case) to soften price competition. Thus, the leader tends to set a higher wage than the follower. Moreover, the degree of product differentiation (measured as the distance between the two firms) is greater under sequential negotiations.

In order to explain this result note that equation (20) shows that firms' locations are strategic substitutes. The optimal location of each firm only depends on the location and the bargaining power of the rival, and not on the firms' own bargaining power, which changes proportionally profits, sales revenues and union incomes, whenever firms locate. Figure 1 shows the reaction function of firm 1 and the reaction function of firm 2 for two different values of parameter α_1 in the first stage of the game. If, for example, α_1 is lower the reaction function of firm 2 moves downward from $b(a)$ to $b'(a)$ while the reaction function of firm 1 does not change (see Figure 1). As a result firm 1 locates closer to the center of the market and firm 2 locates further away because although both firms pay higher wages the increase in the wages paid by firm 1 is greater. This effect is described by Brekke and Straume (2004).[14]

[Insert figure 1 around here]

In general, from (20) we get that the lower the bargaining power of the owner of the rival firm is the higher the distance of one firm to the market is. Figure 1 also shows the comparison between the simultaneous and sequential cases. Thus, $b(a)$ is the reaction function in the simultaneous case and $b'(a)$ in the sequential case. We have that when wage negotiations are sequential the leader firm has a greater increase in its wage, so the effects are of a similar nature to those obtained in the simultaneous case when the bargaining power of firm 1 is lower. Thus the firm locates closer to the market to try to reduce wages through higher competition between unions.

As seen in Proposition 1, if both firms decide the timing of negotiation, in equilibrium both decide to play simultaneously because for given locations this is a dominant strategy. But equilibrium locations differ from simultaneous to sequential negotiation over wages. Thus an interesting question arises: which of the two alternative settings is preferred by the firms and by the unions. The following proposition shows the main result: sequential bargaining over wages is the preferred structure.

Proposition 6 *Comparing the simultaneous and sequential choices both the owners of the firms and the unions are better off if wages are negotiated sequentially.*

[14] See page 282 last paragraph.

By comparing firms' profits we get that $\pi_i^L = \pi_i^F > \pi_i^C$ $(i = 1, 2)$, which means that when firms bargain wages sequentially both the leader and the follower obtain greater profits than when negotiations are simultaneous. This is due to the fact that under both sequential and simultaneous negotiations the firms share the market equally ($q_i^L = q_i^F = q_i^C = \frac{1}{2}$) and the price-cost margin is greater in the sequential case ($p_i^L - w_i^L = p_i^F - w_i^F > p_i^C - w_i^C$) as the distance between the two firms is greater. Therefore, both firms prefer to negotiate over wages sequentially but are indifferent between being leaders or followers since in both cases they have the same profits. However, as seen in Proposition 1, when firms decide when to bargain for any given locations, in equilibrium wages are negotiated simultaneously.

If we compare the results obtained by the unions, we get that $U_i^L > U_i^F > U_i^C$. Therefore, both unions prefer to bargain wages sequentially. This is standard from the unions' point of view.

4 Conclusions

The timing of negotiations between firms and unions (or suppliers in general) differs from one industry to other and from country to country. One explanation is that bargaining strength differs and firms or unions are in some cases strong enough to impose their will when bargaining takes place. This is a very important decision because profits and unions' rents crucially depend on the timing of wage negotiations.

If we compare the equilibrium results in the two scenarios, simultaneous or sequential negotiation, we have that profits and union rents are higher when negotiation is sequential. Although unions are better off under sequential negotiation given any pair of locations, once the location has been chosen firms prefer to avoid a leader role in the negotiation stage. For this reason, if both firms have a say in the decision they will postpone negotiations to the last period and will play a simultaneous game at the bargaining stage, and the results obtained are those of Brekke and Straume (2004). But if one firm does not have the power to decide over this question and must accept the timing of negotiation imposed by its union or supplier, then bargaining over wages is sequential because the union imposes negotiation in the first period to behave as a leader. The leader at the bargaining stage locates closer to the market in an attempt to minimize consumer loss due to its high cost and price, while the follower locates further from the market to try to maintain high price-cost margins. The wages of the workers will be higher and given that demand is equally shared, firms' profits and union rents are higher because price-cost margins also increase.

If we consider that the distance between the two firms is a measure of the degree of product differentiation then that differentiation is increased by sequential negotiation. From a social welfare viewpoint we have that the increase in distance under sequential negotiation does not mean that social welfare is lower because the locations chosen are asymmetric and although the market is always equally shared the lower transportation costs of the consumers who buy from the leader firm could outweigh the higher costs of consumers who buy from the follower.

Although further extensions of the model would seem to be of interest, the results obtained are quite robust if we allow some changes of the objective function. For example, the utility function of the union should put different weights on wages and employment. Thus, the objective function at the bargaining stage is different, but the main results of the paper remain unchanged.

The timing of the game, particularly the fact that location is chosen before bargaining over wages, is important. Altering the timing of the first two stages prevents firms from choosing their location to alter future wages and prices and so the results are changed: the firm with the higher bargaining power pays a lower wage, locates closer to the center of the market and gets a higher market share than its rival. As a result it has higher profits but although more employees are hired by this firm than by its rival its union is worse off than its rival's.

5 Appendix

Proof of Lemma 1.

Using equations (7) to (12) and (15) and (18) we get the utility of each union and the profits of both firms in the simultaneous game ($U_i^C, \pi_i^C; i = 1, 2$, respectively) and in the sequential game in which for the sake of simplicity union 1 (or firm 1) is the leader ($U_1^L, U_2^F, \pi_1^L, \pi_2^F$). These expressions are straightforward to get:

$$U_1^C = \frac{(1-a-b)t(1+\alpha_1)(1-\alpha_1)(9+a-b-(3-a+b)\alpha_2)^2}{6(3+\alpha_1+\alpha_2-\alpha_1\alpha_2)^2},$$

$$U_2^C = \frac{(1-a-b)t(1+\alpha_2)(1-\alpha_2)(9-a+b-(3+a-b)\alpha_1)^2}{6(3+\alpha_1+\alpha_2-\alpha_1\alpha_2)^2},$$

$$U_1^L = \frac{(1-a-b)t(1+\alpha_1)(1-\alpha_1)(9+a-b-(3-a+b)\alpha_2)^2}{48(1+\alpha_2)},$$

$$U_2^F = \frac{(1-a-b)t(1-\alpha_2)((b-a)(1+\alpha_1)(1+\alpha_2)+3(5-\alpha_1(3-\alpha_2)+\alpha_2))^2}{96(1+\alpha_2)},$$

$$\pi_1^C = \frac{(1-a-b)t(1+\alpha_1)^2(9+a-b-(3-a+b)\alpha_2)^2}{18(3+\alpha_1+\alpha_2-\alpha_1\alpha_2)^2},$$

$$\pi_2^C = \frac{(1-a-b)t(1+\alpha_2)^2(9-a+b-(3+a-b)\alpha_1)^2}{18(3+\alpha_1+\alpha_2-\alpha_1\alpha_2)^2},$$

$$\pi_1^L = \frac{(1-a-b)t(1+\alpha_1)^2(9+a-b-(3-a+b)\alpha_2)^2}{288},$$

$$\pi_2^F = \frac{(1-a-b)t((b-a)(1+\alpha_1)(1+\alpha_2)+3(5-\alpha_1(3-\alpha_2)+\alpha_2))^2}{288}.$$

Let us analyze first the situation of the union of firm 1. Simple algebra shows that the sign of the difference between U_1^C and U_1^L depends on the sign of $-1+\alpha_1^2(\alpha_2-1)+\alpha_2-2\alpha_1(3+\alpha_2)$, which is negative. Thus, the union prefers to be the leader in bargaining over wages rather than to play simultaneously ($U_1^L > U_1^C$). The other union, which is playing the role of a follower, is in the same situation: it prefers to be the follower rather than to play simultaneously ($U_2^F > U_2^C$). This can be understood as follows: given that the wage of firm i is positive (i=1, 2) it is straightforward to see that the sign of $U_2^C - U_2^F$ is negative if $(a-b)(1+\alpha_1)(1+\alpha_2)(-7-\alpha_1-\alpha_2+\alpha_1\alpha_2)-3(-27+8\alpha_1+3\alpha_1^2-20\alpha_2+8\alpha_1\alpha_2-4\alpha_1^2\alpha_2-\alpha_2^2+\alpha_1^2\alpha_2^2)$ is positive. The second term is positive and so the whole expression is positive if $a \leq b$. If $a > b$ the whole expression is positive. To prove this it must be noted that as the wage paid by firm 2 is not negative we have: $a-b \leq (9-3\alpha_1)/(1+\alpha_1)$. The negative part of the expression increases with $a-b$, but if we consider its upper limit $a-b=(9-3\alpha_1)/(1+\alpha_1)$ the sign of the expression is the sign of $6(1-\alpha_1)(1-\alpha_2)(3+\alpha_1+\alpha_2-\alpha_1\alpha_2)$, which is positive. Thus, the union prefers to be the follower rather than to play simultaneously. Therefore, both the leader and the follower obtain greater utility than under simultaneous negotiations.

Comparing π_1^C and π_1^L it is straightforward to get that $\pi_1^C > \pi_1^L$. Thus a firm prefers to play simultaneously rather than to be a leader in bargaining over wages. Finally, the sign of the difference between π_2^C and π_2^F is the same as the sign of the difference between U_2^C and U_2^F. As a result a firm prefers to play as a follower in bargaining over wages rather than to choose wages simultaneously ($\pi_2^F > \pi_2^C$).

Proof of Proposition 2.

For the simultaneous game, using equations (7) to (12) it is straightforward to get that: $q_1^C = \frac{(1+\alpha_1)(9+a-b-(3-a+b)\alpha_2)}{6(3+\alpha_1+\alpha_2-\alpha_1\alpha_2)}$, $q_2^C = \frac{(1+\alpha_2)(9-a+b-(3+a-b)\alpha_1)}{6(3+\alpha_1+\alpha_2-\alpha_1\alpha_2)}$ and $\frac{p_1^C-w_1^C}{q_1^C} = \frac{p_2^C-w_2^C}{q_2^C} = 2(1-a-b)t$. We also have that: $\frac{\partial q_1^C}{\partial a} = \frac{\partial q_2^C}{\partial b}$.

In the first stage of the game both firms choose the locations that maximize their profits: $a = argmax\{(p_1^C-w_1^C)q_1^C\} = argmax\{2t(1-a-b)(q_1^C)^2\}$ and $b = argmax\{(p_2^C-w_2^C)q_2^C\} = argmax\{2t(1-a-b)(q_2^C)^2\}$. From the FOCs we have: $-(q_1^C)^2+2(1-a-b)\frac{\partial q_1^C}{\partial a} = 0$ and $-(q_2^C)^2+2(1-a-b)\frac{\partial q_2^C}{\partial b} = 0$. Given that $\frac{\partial q_1^C}{\partial a} = \frac{\partial q_2^C}{\partial b}$ we get $q_1^C = q_2^C$, so both firms have the same market share and employment. As a result, both firms have the same price-cost margins and profits: $p_1^C - w_1^C = 2(1-a-b)tq_1^C = p_2^C - w_2^C = 2(1-a-b)tq_2^C$ and $\pi_1^C = \pi_2^C$.

Focusing on the sequential game, from equations (7), (8), and (15) to (18) it is straightforward to get that: $\frac{p_1^L-w_1^L}{q_1^L} = \frac{p_2^F-w_2^F}{q_2^F} = 2(1-a-b)t$, $q_1^L = \frac{(1+\alpha_1)(9+a-b-(3-a+b)\alpha_2)}{24}$ and $q_2^F = \frac{15-a+b-\alpha_1(9+a-b)+(3-a+b)(1+\alpha_1)\alpha_2}{24}$. We also have that: $\frac{\partial q_1^L}{\partial a} = \frac{\partial q_2^F}{\partial b}$. In the first stage of the game both firms choose the locations that maximize their profits so the rest of the proof is straightforward following the same path as in the simultaneous bargaining case.

6 References

Addison J, Siebert WS (1993) The U. K.: Labour market institutions, law and performance. In: Hartog J, Theeuwes J (eds) *Labour markets contracts and institutions*. North Holland, Amsterdam

Bárcena-Ruiz JC, Campo ML (2000) Short-term or long-term labor contracts. *Labour Economics* 7: 249-260

Brekke KR, Straume OR (2004) Bilateral monopolies and location choice. *Regional Science and Urban Economics* 34: 275-288

Corneo G (1995) National wage bargaining in an internationally integrated product market. *European Journal of Political Economy* 11: 503-20

d'Aspremont C, Gabszewicz JJ, Thisse J-F (1979) On Hotelling's stability in competition. *Econometrica* 47: 1145-1150

De Fraja G (1993) Staggered vs. synchronized wage setting in oligopoly. *European Economic Review* 37: 1507-1522

Farber H (1986) The analysis of union behavior. In: Ashenfelter O, Layard R (eds) *Handbook of Labor Economics*, Vol. 2, North Holland, Amsterdam

Flanagan R (1993) The United States: decentralized heterogeneity. In: Hartog J, Theeuwes J (eds) *Labour markets contracts and institutions*. North Holland, Amsterdam

Freedman A, Fulmer W (1982) Last rites for pattern bargaining. *Harvard Business Review* 60: 30-48

Lambertini L (1994) Equilibrium locations in the unconstrained Hotelling game. *Economic Notes* 24: 438-446

Lambertini L (1997) Unicity of the equilibrium in the unconstrained Hotelling model. *Regional Science and Urban Economics* 27: 785-798

Layard R, Nickell S, Jackman R (1991) *Unemployment. Macroeconomic performance and the labour market*. Oxford University Press, Oxford

Lerner AP (1934) The concept of monopoly and the measurement of monopoly power. *Review of Economic Studies* 1: 157-75

McDonald I, Solow R (1981) Wage bargaining and employment. *American Economic Review* 71: 896-908

Malcomson J (1987) Trade union labor contracts: an introduction. *European Economic Review* 31: 139-148

Neven DJ, Röller L, Zhang Z (2002) Endonenous costs and price-costs margins. DIW Berlin Discussion Paper 294. German Institute for Economic Research, Berlin

Nickell S, Andrews M (1983) Union real wages and employment in Britain 1951-1979. *Oxford Economic Papers* 35: 183-206

Oswald AJ (1985) The economic theory of trade unions: an introductory survey. *Scandinavian Journal of Economics* 87: 160-183

Sasajima Y (1993) The Japanese labour market: its institutions and performance. In: Hartog J, Theeuwes J (eds) *Labour markets contracts and institutions*. North Holland, Amsterdam

Tabuchi T, Thisse J-F (1995) Asymmetric equilibria in spatial competition. *International Journal of Industrial Organization* 13: 213-227

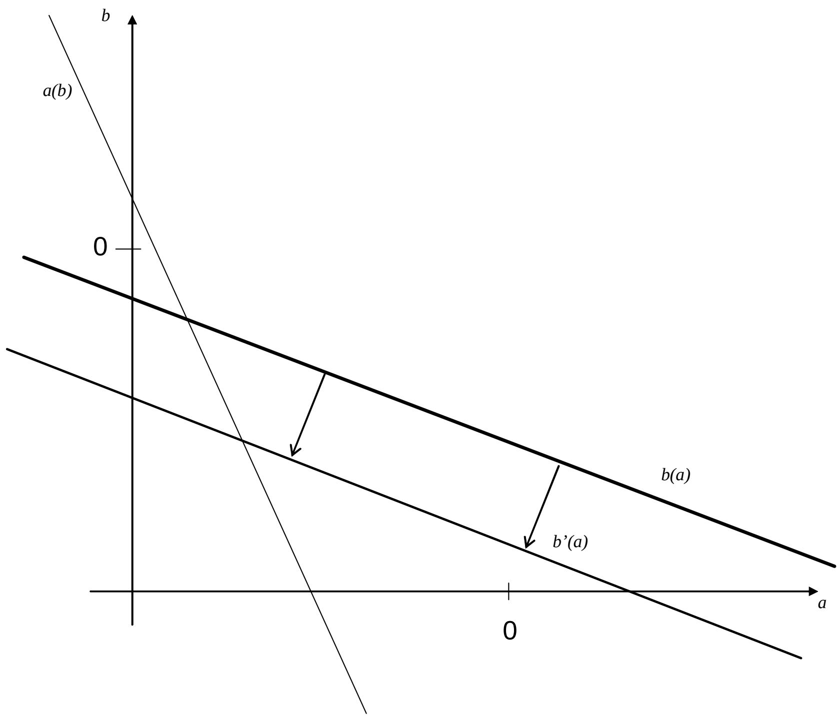

Figure 1: Firms' reaction functions in the first stage of the game.