Alternating Offers Union-Firm Bargaining: Order of Play and Efficiency

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Abstract

This paper shows that the Rubinstein alternating offers model can be modified to provide a Pareto superior outcome in the context of the right-to-manage union-firm bargaining. Two examples of bargaining protocols that yield a superior outcome are provided. In the first example, the union and the firm engage in a game in which the order of play is determined as part of the bargaining. We show that the game has a unique subgame perfect equilibrium in which the firm always moves first in the wage bargaining game and the equilibrium wage is, therefore, unique.

In the second example we examine a two-part-tariff alternating offers bargaining protocol, where the firm and the union bargain over the wage and transfer payments. We show that this bargaining protocol has a Pareto efficient, unique subgame perfect equilibrium. Thus, although the parties do not bargain over the level of employment, the outcome under this protocol is, nevertheless, "socially" optimal.

KEYWORDS: Union Wage premium, Efficient Bargaining, Right to Manage
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1 Introduction

Union-Firm bargaining has been studied within two alternative approaches: the axiomatic approach and the game theoretic approach.[1] The standard framework of the game theoretic approach is the Rubinstein (1982) alternating offers model (referred to, in the following, as the RAO model). Several features make the RAO model particularly attractive for studying union-firm bargaining. First, under reasonable conditions, it gives rise to a unique subgame perfect equilibrium. Second, it provides an explanation for bargaining power. Third, under certain conditions, it provides the same solution as the generalized Nash bargaining solution.

By its nature, however, the RAO model cannot explain the order of the play. For example, in a two-party bargaining game, it provides two possible outcomes: when Party 1 moves first and when Party 2 moves first. Which of these outcomes actually occurs is beyond the scope of the standard RAO model. The RAO model's inability to determine the order of play is not a major issue if the size of the "pie" is fixed[2] since, under this condition, the order of play affects only the distribution of the pie, but not its size.[3]

In many bargaining situations, however, the size of the pie is not fixed because the parties may be able to make additional post-bargaining decisions that depend on the outcome of the bargaining game.[4] In such cases, since the order of play affects these additional decisions, it will also affect the size of the pie. This is clearly the case in the context the right-to-manage (hereafter RTM) model, which is a standard framework for studying union-firm bargaining.[5] Within RTM model, the firm makes its employment decision after wage bargaining is completed, thus affecting the size of the pie. Since the choice of employment (and hence output) depends on the wage, and the wage in turn depends on order of play, it is clear that, in this case, the order of play affects the size of the pie. This suggests that, even if we remain within the framework of the RTM model, an improved bargaining protocol that takes into account potential gains from a welfare improving order of play is possible (and hence may emerge in equilibrium).

The objective of this paper is to show that the standard RAO bargaining model can be modified to provide a Pareto superior outcome, while still remaining within the RTM framework. To do this, we first show that, within the RTM framework, the standard RAO model implies that inefficiency is always greater when the union moves first in the wage bargaining game. We then provide two examples of bargaining protocols that yield superior outcomes.

In the first example, potential gains from an inefficiency reducing, and hence Pareto improving, order of

[1] For a good discussion of these two union-firm bargaining models see Booth (1995). See also Bean (1984).

[2] Which is, indeed, the case for most bargaining models discussed in the literature; see for example Muthoo (1999).

[3] An example of a paper in which the size of the pie is affected by the players' actions is Frankel (1998) where "creative ideas" can affect the size of the pie (but not its distribution).

[4] Or alternatively, because the parties may be able to make strategic pre-bargaining commitments whose implications depend (credibly) on the outcome of the bargaining game.

[5] The right to manage model is the most commonly used in the literature. Another model is the 'efficient bargaining model', where the union and the firm bargain over both the wage and level of employment. For a discussion of these two models see Booth (1995). Empirical evidence suggests, however, that it is rare for the union and firm to bargain over both wages and employment (see, for example Oswald (1982), Oswald (1993) and Oswald and Turnbull (1985)). For a discussion of an endogenous choice of the bargaining agenda, within a noncooperative game, see Koenigstein, et a. (2002) and Villeval and Konigstein (2005). They show that a single issue may actually emerge as the preferred agenda.

play are captured by a protocol that allows the order of play itself to be part of the bargaining. Specifically, we consider the following three stage bargaining game. In stage 1, the union and the firm use transfer payments to negotiate a mutually agreeable order of play that determine who will make the first offer in the forthcoming wage bargaining game. In stage 2, the wage is determined in an alternating offers bargaining game, given the agreed upon order of play. Finally, in stage 3 (in line with the RTM model), the firm makes its employment decision. We show that, in equilibrium, the firm will always move first in the bargaining game.[6] Since inefficiency is smaller when the firm moves first in the wage bargaining game, the equilibrium order of play implies that the outcome is Pareto superior. Moreover, since in equilibrium the firm always moves first, it also follows that, unlike in the standard RAO model, here there is only one equilibrium wage.

While in the first example the bargaining game leads to greater efficiency than the standard RAO game, it still does not yield a Pareto efficient outcome, because the level of employment is usually not "socially optimal". This is the result of the fact that we are within the RTM framework (using the wage as the single bargaining instrument) and not because we are using the RAO model. If we are willing to consider an additional bargaining instrument, the above protocol can be improved even further. Thus, in the second example, we consider an "even better" protocol (which is also modelled as a Rubinstein alternating offers game) under which the parties bargain over two instruments: the wage and a lump sum transfer which partitions the surplus. That is, bargaining is over a "two-part-tariff",[7] which can be interpreted as a package consisting of a wage and fringe benefits. There is, in fact, evidence to suggest that fringe benefits (for example, pension plans, life, accident and health insurance, vacation pay, etc.) may indeed be important in union contracts (see Freeman (1981), Freeman and Medoff (1984), Lewis (1986), Kornfeld (1993) and Akyeampong (2002), for estimates of the magnitude and importance of fringe benefits in union contracts in the US, Australia and Canada).[8]

We show that this two-part-tariff bargaining game has a Pareto efficient, unique subgame perfect equilibrium. Thus, although the parties do not bargain over the level of employment, the outcome is nevertheless socially optimal in that it maximizes the total surplus. Efficiency is achieved here since the subgame perfect equilibrium wage is, in fact, the socially optimal one, which in turn implies that the choice of the optimal level of employment is incentive compatible.[9] This result is reminiscent of Booth (1995) where efficiency is achieved in Nash bargaining over wages and severance pay.[10]

[6] In Appelbaum (2008), extremism is used as a strategic *pre-bargaining commitment* in a political conflict. As is the case here, since the size of the pie is not fixed, the order of play is determined endogenously as part of the bargaining.

[7] See Tirole (1988) for a discussion of two-part tariff schemes.

[8] For example, using Australian data, Kornfeld (1993) finds that "union members were about 15% more likely to have access to a pension plan than were nonunion workers". Similarly, using Canadian data, Akyeampong (2002) finds that coverage rates in insurance plans for unionized employees were approximately double those for non-unionized (about 80% versus 40%) and that the "union advantage in pension plan coverage was much larger (80% versus 27%)".

[9] In a related paper Appelbaum (2008) uses a Nash bargaining model (so that the order of play is, of course, irrelevant), with uncertainty and risk averse workers, to show that the optimal two-part tariff contract in the RTM bargaining model provides full income and employment insurance and is efficient.

[10] It is also related to Pal (2005), where a piece-rate contract may achieve an improved outcome compared to the standard RTM model.

2 The Standard Alternating Offers Bargaining Model

Consider the relationship between a firm and its workers. Workers are represented by a union whose objective is to maximize the (expected) utility of the membership. The workers' union consists of $\overline{n}$ members. An employed worker receives a wage rate of w, whereas an unemployed worker receives the opportunity cost wage, w^0. We assume that the firm employs only union workers. Thus, if we denote the number of employed workers by n, then this is also the number of employed *union* members.[11] Following the literature, we take the union's utility function to be given by:[12]

$$\widetilde{U}(n, w; \overline{n}, u^0) \equiv n\ \widetilde{u}(w) + (\overline{n} - n)\ \widetilde{u}(w^0) \tag{1}$$

where $\widetilde{u}$ is an increasing function. In order to avoid the need to examine insurance considerations (due to risk aversion), we assume that $\widetilde{u}$ is linear, so that we have $\widetilde{u}(w) = w,\ \widetilde{u}(w^0) = w^0$. In the following, we normalize both the union membership and the opportunity cost wage to 1 ($\overline{n} = 1,\ w^0 = 1$). The union's utility function is, therefore, given by:

$$U(n, w) \equiv n\ w + (1 - n) \tag{2}$$

The firm uses labour and capital services, n and K, respectively, to produce its output, y, according to the production function $y = f(K, n)$, where f is increasing and concave in K, n. Since we are not interested in explaining K, we normalize it to 1 and write the production function as:

$$y = f(1, n) \equiv F(n) \tag{3}$$

We assume that the contract between the firm and its union is reached by bargaining. Specifically, we use the standard Rubinstein alternating offers model, within the context of the RTM framework. That is, the union and the firm bargain over the wage, but the firm alone chooses the level of employment (after the wage has been determined). As was indicated in the introduction, this model seems to be supported by empirical evidence and is, indeed, commonly used in the literature.

The game between the two parties has the following time line: (i) in stage one, the union and the firm engage in an alternating offers bargaining game, in which the wage is determined, (ii) in stage two, given the outcome of the wage bargaining game, the firm chooses the level of employment.

3 The Solution of the Standard Alternating Offers Game

3.1 Stage Two: The Level of Employment

In stage two, the firm chooses the level of employment given the previously determined wage. Assuming that the firm is also risk neutral, and normalizing the price of output to 1, for any wage, w, its problem is given

[11] This assumption can be relaxed to allow for both union and non-union workers. See Besancenot and Vranceanu (1999).

[12] See Booth (1995), for a discussion of union objectives. For specific examples, see Oswald (1982) and Farber (1986).

by:

$$\underset{n}{\text{Max}}\{F(n) - wn\} \equiv \pi(w) \tag{4}$$

where $\pi(w)$ is the profit function. As usual, the profit function is decreasing and convex in w. Furthermore, from Hotelling's lemma, the optimal level of employment, n^*, is given by:

$$n^* = -\frac{\partial \pi(w)}{\partial w} \equiv n^*(w) \tag{5}$$

3.2 First Stage: The Wage Bargaining Game

In the first stage, the union and the firm engage in an infinite horizon alternating offers bargaining game that determines the wage rate. In this infinite horizon alternating offers bargaining problem, a game that has not ended, appears the same at all even and at all odd time periods. The solution is, therefore, stationary in the sense that both parties' offers and payoffs are the same in all even and all odd time periods. Thus, if we define w_f as the firm's offered wage when it makes an offer and w_u as the union's offered wage when it makes an offer, then the firm always offers w_f and the union always offers w_u. In addition to the stationarity, the solution to this bargaining game will have the common "no delay" property, namely, the equilibrium offers are, indeed, accepted.

Since the union has an outside option, ($w^0 = 1$), it can respond to any offer from the firm by: (i) accepting the offer, (ii) rejecting it and making a counter offer in the next round and (iii) opting out and getting the outside option wage. We assume that if the union opts out it can (immediately) receive its opportunity cost utility: $\overline{n}w^0 = 1$.[13]

In order to focus on the general case, we assume that the discount factors of the union and the firm, δ_u and δ_f, respectively, satisfy:

$$0 < \delta_u < 1,\ 0 < \ \delta_f < 1 \tag{6}$$

1. The Union Makes the Offer

First note that for any given wage, w, and the firm's choice of employment, $n^*(w)$, the union's utility is given by:

$$u(w) \equiv U[n^*(w),\ w] = n^*(w)\ w + (1 - n^*(w)) \tag{7}$$

When labour demand is globally inelastic then $u(w)$ is increasing everywhere. However, if demand eventually becomes (or always is) elastic, $u(w)$ will still be initially increasing (for low w), but eventually it will be decreasing. In fact, it is easy to show that, in such a case, there exists a finite wage, say $\widetilde{w}$, such that:

$$\widetilde{w} = \arg\max_{w}\{u(w) : w > 0\} \tag{8}$$

[13] Alternatively, it is possible to consider the case where the outside option can only be exercised in the next period. Since this is just an example of a bargaining procedure, we do not focus on the precise timing and nature of the outside option.

The union offers a wage that would make the firm indifferent between accepting the offer and rejecting it and waiting for its turn to make an offer, in the next period. But, of course, the union will never offer a wage that is smaller than 1.

For example, when labour demand is elastic, the union will never offer a wage that is larger than $\widetilde{w}$, since for all wages which are larger than $\widetilde{w}$, utility is decreasing. The union's offer in this case, w_u, is therefore given by:[14]

$$\pi(w_u) = \begin{cases} \widetilde{w} & \text{if } w_f \geq \widetilde{w}_f \\ \delta_f\ \pi(w_f), & \text{if } w_f^{''} \leq w_f \leq \widetilde{w}_f \\ 1 & \text{if } \ w_f \leq w_f^{''} \end{cases} \tag{9}$$

where $\widetilde{w}_f$ and and w_f'' are defined by:

$$\pi(\widetilde{w}) = \delta_f\ \pi(\widetilde{w}_f) \tag{10}$$

$$\pi(1) = \delta_f\ \pi(w_f'') \tag{11}$$

Condition (9) can be written as:

$$H^u(w_f, w_u; \delta_f) = 0 \tag{12}$$

In the following, it will be referred to as the HU curve. Since $\delta_f < 1$ and the profit function is decreasing, it follows that the HU curve is an increasing function that lies below the 45° line (in (w_u, w_f) space). Thus,

$$\text{for all } (w_u, w_f) \text{ such that}: \ H^u(w_f, w_u; \delta_f) = 0, \text{ we have } w_u > w_f \tag{13}$$

The HU curve is shown in Figure 1 (assuming that the production function is given by[15] $y = n^{1/2}$ and taking $\delta_f = .7$).

2. The Firm Makes the Offer

The firm offers the union a wage that would make the union indifferent between accepting the offer and rejecting it in favour of the better of its two alternative options. These two alternatives are: (i) rejects this offer and make a counter offer in the next round, (ii) rejects the offer and opt out for the opportunity cost payment (now), $u(w^0) = 1$. In other words, the firm sets its offer so that:

$$u(w_f) = \max\{\delta_u u(w_u), 1\} \tag{14}$$

This condition can be written as:

$$H^f(w_f, w_u; \delta_u) \equiv u(w_f) - \max\{\delta_u u(w_u), 1\} = 0 \tag{15}$$

In the following, this will be referred to as the HF curve. The HF curve is also shown in Figure 1 (with $\delta_u = .96$). It can be verified that the HF curve is monotonically increasing if demand is inelastic. If demand

[14] In the case of inelastic demand, the unionm's offer satisfies: $\pi(w_u) = \delta_f\ \pi(w_f)$, if $w_f \geq w_f^{''}$ and $\pi(w_u) = 1$, if $w_f \leq w_f^{''}$.

[15] Demand elasticity in this case is, therefore, constant and greater than 1.

is elastic, on the other hand, it is first (for lower wages) increasing and then decreasing. Moreover, it can also be shown that the HU curve is steeper than the HF curve.[16]

Since the purpose of this paper is to present *alternatives* to the standard alternating offers model, rather than to analyze it, we do not examine the properties of the equilibrium in detail. Thus, let us simply define the unique subgame perfect equilibrium of the above alternating offers game to be given by: $\{w_f(\delta_f, \delta_u)$, $w_u(\delta_f, \delta_u)\}$.[17] The unique subgame perfect equilibrium of the game is such that: (i) the firm always offers $w_f(\delta_f, \delta_u)$ and accepts an offer if and only if $w_u \leq w_u(\delta_f, \delta_u)$, (ii) the union always offers $w_u(\delta_f, \delta_u)$ and accepts an offer if and only if $w_f \geq w_f(\delta_f, \delta_u)$ and (iii) the union opts out, given an offer w_f, when $w_f < w_f(\delta_f, \delta_u)$ and $\delta_u u(w_u(\delta_f, \delta_u)) \leq 1$, where $w_f(\delta_f, \delta_u)$ and $w_u(\delta_f, \delta_u)$ are given by the solution to equations (12) and (15). An example of a unique equilibrium is shown in Figure 1.

Although we do not examine the properties of the above equilibrium in detail, it is important for our purposes to be able to rank two equilibrium wages, $w_f(\delta_f, \delta_u)$ and $w_u(\delta_f, \delta_u)$. It is easy to see that since $w_f(\delta_f, \delta_u)$ and $w_u(\delta_f, \delta_u)$ must lie on the HU curve, it follows immediately that:

$$w_u(\delta_f, \delta_u) > w_f(\delta_f, \delta_u), \text{ for all } \delta_f, \delta_u \tag{16}$$

In other worlds, in equilibrium, the union always offers a higher wage than the firm. But, since the standard Rubinstein alternating offers bargaining model does not explain the order of play, it means that we do not know which of the possible wages ($w_f(\delta_f, \delta_u)$ and $w_u(\delta_f, \delta_u)$) actually occurs.

4 Alternative Bargaining Protocols

4.1 The Effects of the Order of Play

In the above discussion, the protocol of the game does not determine the order of the play. Consequently, the equilibrium can only determine what happens for a given order of play, but it cannot tell us who will actually move first. This is not unreasonable in the context of a standard alternating offers model in which the size of the pie is fixed and there is a first mover advantage. Under these conditions, there is no possible Pareto improvement from amending the protocol and choosing the order of play. In our model, however, the size of the pie depends on the order of play since the firm makes an *additional* decision after the bargaining process is over: it chooses the level of employment and hence also output. Since the equilibrium wage is affected by the order of play, so are the firm's production decisions, and consequently, also the size of the pie. The fact that the size of the pie is affected by the order of play suggests that there may be further gains from choosing

[16] Proof is available upon request.

[17] The proof of existence and uniqueness is available upon request. Note, however, that for the existence of a unique subgame perfect equilibrium we first have to show that there exists a unique solution to equations (12) and (15). For example, with the production function $y = n^{1/2}$, when $w_f(\delta_f, \delta_u) > 1$, equations (12) and (15) can be solve explicitly to obtain: $w_u(\delta_f, \delta_u) = \frac{\sqrt{(17-\delta_f\delta_u(2-17\delta_f\delta_u-16\delta_f)-16\delta_u} \; -(1-\delta_f\delta_u)}{8(1-\delta_u)\delta_f}$ and $w_f(\delta_f, \delta_u) = \delta_u \; w_u(\delta_f, \delta_u)$. The uniqueness of the solution to equations (12) and (15) implies that there is a unique subgame perfect equilibrium. Alternatively, it can be shown that both the HU and HF curves are continuous and HU curve is always steeper than the HF, hence: (i) there must be an intersection between the HF and HU curves, (ii) there cannot be more than one intersection.

a Pareto improving bargaining protocol. In this section we provide two examples of bargaining protocols that yield superior outcomes.

First, note that given the equilibrium values $w_f(\delta_f, \delta_u)$ and $w_u(\delta_f, \delta_u)$, the payoffs of the union and the firm, when the union makes an offer are given by:

$$u[w_u(\delta_f, \delta_u)] \equiv u_u^*(\delta_f, \delta_u), \quad \pi[w_u(\delta_f, \delta_u)] \equiv \pi_u^*(\delta_f, \delta_u) \tag{17}$$

respectively. Similarly, the two payoffs, when the firm makes an offer, are given by:

$$u[w_f(\delta_f, \delta_u)] \equiv u_f^*(\delta_f, \delta_u), \quad \pi[w_f(\delta_f, \delta_u)] \equiv \pi_f^*(\delta_f, \delta_u) \tag{18}$$

respectively.

Second, from equations (12) and (15) it follows immediately that:

$$u_u^*(\delta_f, \delta_u) > u_f^*(\delta_f, \delta_u),\ \pi_f^*(\delta_f, \delta_u) > \pi_u^*(\delta_f, \delta_u),\ \text{for all } 0 < \delta_f < 1,\ 0 < \delta_u < 1 \tag{19}$$

In other words, both the union and the firm get a higher payoff when they move first (this is the usual first mover advantage).

Consider now the *total* payoffs in the two possible cases. If the firm moves first, total payoffs are given by:[18]

$$S_f(\delta_f, \delta_u) \equiv u_f^*(\delta_f, \delta_u) + \pi_f^*(\delta_f, \delta_u) = F[n^*(w_f(\delta_f, \delta_u))] - w^0 n^*(w_f(\delta_f, \delta_u)) + \overline{n} w^0 \tag{20}$$

but, when the union moves first total payoffs are given by:

$$S_u(\delta_f, \delta_u) \equiv u_u^*(\delta_f, \delta_u) + \pi_u^*(\delta_f, \delta_u) = F[n^*(w_u(\delta_f, \delta_u))] - w^0 n^*(w_u(\delta_f, \delta_u)) + \overline{n} w^0 \tag{21}$$

Note that in both cases, total payoffs are simply the total net value of the joint unit, which consists of the firm and the (total) union membership. This net value includes the total income: $F[n^*(w_f(\delta_f, \delta_u))] + \overline{n} w^0$, minus the "true cost" of labour: $n^*(w_u(\delta_f, \delta_u))\ w^0$.

Since the equilibrium wage depends on the order of the play and since the level of employment, and hence output, are affected by the wage, it follows that the size of the pie, here, is also affected by the order of play. This suggests that a Pareto improving protocol may be possible. Looking at the difference in payoffs, we get:

$$S_f(\delta_f, \delta_u) - S_u(\delta_f, \delta_u) = F[n^*(w_f(\cdot))] - F[n^*(w_u(\cdot))] + [n^*(w_u(\cdot)) - n^*(w_f(\cdot))] \tag{22}$$

Since $w_u(\cdot) > w_f(\cdot)$, we have $F[n^*(w_f(\cdot))] - F[n^*(w_u(\cdot))] > 0$. But $[n^*(w_u(\cdot)) - n^*(w_f(\cdot))] < 0$, so that from a first glance at equation (22) it is not clear if $S_f(\delta_f, \delta_u)$ is greater or smaller than $S_u(\delta_f, \delta_u)$. It is, however, possible to rank them, by considering the "social welfare" problem, given by the maximization of total net value:

$$\max_w S(w) = \max_w \{u(w) + \pi(w)\} =$$

[18]Since $\pi_f^*(\delta_f, \delta_u) = F[n^*(w_f(\delta_f, \delta_u))] - w_f(\delta_f, \delta_u)\ n^*(w_f(\delta_f, \delta_u))$, and $u_f^*(\delta_f, \delta_u) = w_f(\delta_f, \delta_u)\ n^*(w_f(\delta_f, \delta_u)) + (1 - n^*(w_f(\delta_f, \delta_u)))$.

$$\max_w\{F[n^*(w)] - w^0 n^*(w) + \overline{n}w^0\} = \max_w\{F[n^*(w)] - n^*(w) + 1\} \equiv S^* \tag{23}$$

It is easy to show that $S(w)$ reaches it maximum at $w^* = w^0$.[19] This results in a level of employment, $n^*(w^0)$, which is the same as the level of employment chosen by a private profit maximizing firm, when facing the wage $w^* = w^0$.[20] Hence the following must be true:

Proposition 1 $S_f(\delta_f, \delta_u) > S_u(\delta_f, \delta_u)$

Proof. This follows immediately from the fact that $w^* = 1$ and $w_u(\delta_f, \delta_u))] > w_f(\delta_f, \delta_u) \geq 1 = w^* = arg\max_w\{F[n^*(w)] - n^*(w) + 1\}$. ■

In other words, total payoffs are closer to the social maximum level when the firm moves first, because, in that case, the equilibrium wage is closer to the socially optimal one (of $w^* = w^0 = 1$).

It is interesting to note, however, that there is a trade-off between the existence of a union wage premium and the existence of an inefficiency. An inefficiency exists as long as $w_f(\delta_f, \delta_u) > 1$, and it decreases with $w_f(\delta_f, \delta_u)$.

4.2 Bargaining Over the Order of Play

Proposition 1 suggests that there exist potential gains from the adoption a different protocol; one which allows the two parties to take advantage of the fact that $S_f(\delta_f, \delta_u) > S_u(\delta_f, \delta_u)$. For example, they may engage in pre-bargaining negotiations, using transfer payments to determine the order of play.

Thus, consider the following three stage bargaining game. In stage 1, the union and the firm engage in negotiations that determine who will make the first offer in the forthcoming wage bargaining game in stage 2 (described below). We refer to this as the order of play bargaining (OPB) game. The OPB game is modelled as an infinite horizon, alternating offers game, in which the two parties use transfer payments to arrive at a mutually agreeable order of play. We define the transfers *to the union* when the union and the firm make an offer, as t_u and t_f, respectively. We assume that both parties can opt out of the OPB game in favour of the forthcoming wage bargaining (hereafter WB) game (to be played without an agreed order of play).

To be able to fix the values of opting out, suppose that when the firm and the union play the WB game without agreeing on the order of play, there is a probability q that the firm will move first. The outside options are, therefore, given by,

$$\overline{\pi}^*(\delta_f, \delta_u) = q\pi_f^*(\delta_f, \delta_u) + (1-q)\pi_u^*(\delta_f, \delta_u) \tag{24}$$

$$\overline{u}^*(\delta_f, \delta_u) = qu_f^*(\delta_f, \delta_u) + (1-q)u_u^*(\delta_f, \delta_u) \tag{25}$$

[19] The first order condition is given by: $\partial S(w)/\partial w = \partial\pi(w)/\partial w + \partial u(w)/\partial w = -n^*(w) + \partial n^*(w)/\partial w[w^0 - w] + n^*(w) = \partial n^*(w)/\partial w[w^0 - w] = 0$. Hence, $w^* = w^0$. Moreover, the second order condition is satisfied since: $\partial^2 S(w^*)/\partial w^2 = \partial^2 n^*(w^*)/\partial w^2[w^0 - w^*] + \partial n^*(w^*)/\partial w = \partial n^*(w^*)/\partial w < 0$.

[20] Note that the first order conditions for the two problems are identical.

where the values of the outside options satisfy:

$$\begin{aligned}\overline{\pi}^*(\delta_f,\delta_u) &< S_f(\delta_f,\delta_u),\ \overline{u}^*(\delta_f,\delta_u) < S_f(\delta_f,\delta_u) \\ \overline{\pi}^*(\delta_f,\delta_u)+\overline{u}^*(\delta_f,\delta_u) &= qS_f(\delta_f,\delta_u)+(1-q)S_u(\delta_f,\delta_u) \equiv \overline{S}(\delta_f,\delta_u) < S_f(\delta_f,\delta_u)\end{aligned} \tag{26}$$

In response to an offer in the OPB game, a party can either accept it, reject it and make a counter offer, or opt out. The OPB game, therefore, ends either when a transfer offer is accepted, or when one of the parties opts out. If the OPB game ends because an offer was accepted, the WB game begins immediately, according to the agreed upon order of play. On the other hand, if the OPB game ends because one of the parties opts out, the WB game also begins immediately, but without an agreed upon order of play.[21] As in the standard Rubinstein game, the order of play in the OPB game is not determined.

In stage two, the wage is determined in an infinite time, alternating offers bargaining game, in line with the agreed upon order of play. We refer to this as the wage bargaining (WB) game. The WB game is the same as the standard alternating offers game that was discussed above in Section 3. Finally, in stage three, given the outcomes in stages 1 and 2, the firm makes its employment decision. Again, this stage is the same as was described in Section 3.

4.2.1 The Solution of the Game

Since stages 2 and 3 were already discussion in Section 3 above, we now consider the OPB game in stage 1. First, from Proposition 1, it follows that:

Proposition 2 *In equilibrium, the firm will always move first in the WB game.*

Proof. This follows immediately from the fact that total payoffs are larger when the firm moves first (see Osborne and Rubinstein (1990) for a discussion of the equilibrium of coalitional games). ■

The unique subgame perfect equilibrium of the OPB game is characterized as follows:

Proposition 3 *The order of play bargaining game with outside options has a unique subgame perfect equilibrium, with transfers t_u^* and t_f^*, in which:*

1. It is always agreed that the firm moves first in the WB game.

2. (a) The union always offers a transfer of $t_u^* > 0$ and accepts a transfer t, if and only if $t \geq t_f^*$.

   (b) The union always opts out when it gets an offer $t < t_f^*$, if and only if $\delta_u[u_f^*(\delta_f,\delta_u)+t_u^*] \leq \overline{u}^*$.

3. (a) The firm offers a transfer of $t_f^* > 0$ and accepts a transfer t, if and only if $t \leq t_u^*$.

   (b) The firm always opts out when it gets an offer $t > t_u^*$, if and only if $\delta_f[\pi_f^*(\delta_f,\delta_u)-t_f^*] \leq \overline{\pi}^*(\delta_f,\delta_u)$.

[21] The assumption that the parties move immediately to the WB game is just an example and does not play an important role. Alternatively, we can consider different types of delays between the two games; depending on whether there was an acceptance, opting out, rejection (see, for example, Muthoo (1999)). We demonstrate one such alternative in the next section, were we assume that in case of acceptance or opting out, the game continues in the following period.

4. The equilibrium values of the transfers, t_1^* and t_2^*, are given explicitly in Appendix 6.1.

Proof. The game is a standard alternating offers bargaining game with outside options. The proof that in equilibrium it is always agreed that the firm moves first in the WB game follows from Proposition 2. The rest of the proof is the same as the one provided in Muthoo (1999) for games with outside options. The proof follows from the requirement that in a subgame perfect equilibrium the offers are such that a player is always indifferent between accepting, or rejecting the other player's offer. Since in equilibrium the firm always moves first in the WB game, this implies that we need to solve the two conditions (corresponding to the cases when the firm and the union make offers, respectively):[22]

$$u_f^*(\delta_f, \delta_u) + t_f^* = \max\{\delta_u(u_f^*(\delta_f, \delta_u) + t_u^*), \overline{u}^*\} \quad (27)$$

$$\pi_f^*(\delta_f, \delta_u) - t_u^* = \max\{\delta_f(\pi_f^*(\delta_f, \delta_u) - t_f^*), \overline{\pi}^*(\delta_f, \delta_u)\} \quad (28)$$

The equilibrium values t_u^* and t_f^* are the unique solution to these two equations. ■

Several points should be noted about the equilibrium of this three stage bargaining game. First, since the firm always moves first in the WB game, it follows that the equilibrium wage is always $w_f(\delta_f, \delta_u)$, for all δ_f, δ_u. That is, unlike in the RAO model where the wage is either $w_f(\delta_f, \delta_u)$, or $w_u(\delta_f, \delta_u)$, here we have a unique wage. Second, since the equilibrium wage is always $w_f(\delta_f, \delta_u)$, total payoffs are always $S_f(\delta_f, \delta_u)$ (which are higher than $S_u(\delta_f, \delta_u)$). Third, from equation (26) it follows that total payoffs in this game are also higher than average total payoffs in the standard RAO bargaining game: $S_f(\delta_f, \delta_u) > \overline{S}(\delta_f, \delta_u)$. Fourth, the equilibrium in the OPB game retains the usual feature of the RAO model, namely, the model does not tell us who actually moves first in the OPB game. But, since the size of the pie is the same ($S_f(\delta_f, \delta_u)$), regardless of who moves first (in the OPB game), the order of play in the OPB game is not "that important".

4.3 The Division of the "Optimal Size Pie"

While it is true that $S_f(\delta_f, \delta_u) > S_f(\delta_f, \delta_u)$, there is obviously an even better option. From equation (23) it follows that $S^* > S_f(\delta_f, \delta_u)$. Hence, if the union and the firm recognize the advantage of bargaining over S_f, they might as well "go all the way" and recognize that it is even better to bargain over the largest possible pie; S^*.

This can also be modelled as a Rubinstein alternating offers game with outside options, in which the union and the firm bargain over the wage and a lump sum transfer which partitions the *remainder* of the surplus. In other words, for any given wage, w, the union receives $u(w)$ and, in addition, the remainder of the total surplus (i.e., $S(w) - u(w)) = \pi(w)$) is then divided. We can think of this as bargaining over a two-part-tariff, for example, a package consisting of a wage and fringe benefits.

The bargaining game has the following protocol. The firm and the union make alternating offers of a wage and a partition of $\pi(w) : \{w_i, z_i\}, \ i = u, f$, respectively, where z_i, is the *share* of $\pi(w_i)$ that party i receives.

[22] Note that since in equilibrium the firm always moves first in the WB game, on the right side of equation (27) we have u_f^*, rather than u_u^* and on the left hand side of equation (28) we have π_f^*, rather than π_u^*.

Both can opt out of this game. If one of them opts out, the game is over and the WB game (as discussed in section 3.2 above) begins in the following period. Again, we assume that the opting out values are given by $\overline{\pi}^*(\delta_f, \delta_u)$ and $\overline{u}^*(\delta_f, \delta_u)$, as defined in equations (24) and (25).[23]

It is convenient to define the profit that corresponds to $w^* = w^0 = 1$ as $\pi^1 \equiv \pi(1) = \pi(w^0)$. Note that, since $u(w^*) = u(w^0) = 1$, this means that we have $S(w^0) = \pi^1 + u(w^0) = \pi^1 + 1$.

The unique subgame perfect equilibrium is characterized as follows:

Proposition 4 *The above bargaining game with outside options has a unique subgame perfect equilibrium, with wage and shares* $\{w^*,\ z_f^*(\delta_f, \delta_u)\}$, $\{w^*,\ z_u^*(\delta_f, \delta_u)\}$, *in which:*

1. (a) The firm always offers $w^* = w^0 = 1$ and a share $z_f^*(\delta_f, \delta_u)$ and accepts an offer $\{w, z_u\}$, if and only if $\pi(w) - z_u \geq \pi^1 - z_u^*(\delta_f, \delta_u)$.

   (b) The firm always opts out (in favour of the original bargaining game) when it gets an offer $\pi(w) - z_u < \pi^1 - z_u^*(\delta_f, \delta_u)$, if and only if $z_f^*(\delta_f, \delta_u) \leq \overline{\pi}^*(\delta_f, \delta_u)$.

2. (a) The union always offers $w^* = w^0 = 1$ and a share $z_u^*(\delta_f, \delta_u)$ and accepts an offer $\{w, z_f\}$ if and only if $u(w) + \pi(w) - z_f \geq u(w^*) + \pi^1 - z_f^*(\delta_f, \delta_u)$.

   (b) The union always opts out (in favour of the original bargaining game) when it gets an offer $u(w) + \pi(w) - z_f < u(w^*) + \pi^1 - z_f^*(\delta_f, \delta_u)$, if and only if $u(w^*) + z_u^*(\delta_f, \delta_u) \leq \overline{u}^*(\delta_f, \delta_u)$.

3. The equilibrium values of the shares, $\{z_f^*(\delta_f, \delta_u),\ z_u^*(\delta_f, \delta_u)\}$, are given explicitly in Appendix 6.2.

Proof. Except for the determination of the equilibrium wage, the game is a standard alternating offers bargaining game with outside options. The proof that in equilibrium the parties always offer w^* is given in Appendix 6.3. It follows immediately from the fact that $w^* = arg\max_w\{S(w)\}$, so that deviations are not profitable. The rest follows from the requirement that in a subgame perfect equilibrium the offers are such that a player is always indifferent between accepting, or rejecting the other player's offer. This implies that we need to solve the two conditions:[24]

$$\pi^1 - z_u = \delta_f \max\{z_f, \overline{\pi}^*\} \tag{29}$$

$$1 + (\pi^1 - z_f) = \delta_u \max\{1 + z_u, \overline{u}^*\} \tag{30}$$

The equilibrium values z_u^* and z_f^* are the unique solution to these two equations. The rest of the proof is similar to the one provided in Muthoo (1999).[25] ■

[23] Alternatively, we can simply take the outside option as in section 3.2, where the union's outside wage is $w^0 = 1$, whereas the firm's outside profits are zero. The equilibrium will be the same as the one described below, except that we need to take $\overline{u}^*(\delta_f, \delta_u) = 1$, $\overline{\pi}^*(\delta_f, \delta_u) = 0$.

[24] Note that in equation (30) we use the fact that $u(w^*) = 1$.

[25] Note that the only difference between this case and the example in Muthoo (1999), is that in his case the outside options can be exercised immediately (as in our OPB game in Section 4.2), whereas here they occurs only after the new game starts.

Several points should be noted about the equilibrium of this bargaining game. First, the equilibrium offered wage is always w^*, regardless of who makes the offers. Second, since the equilibrium wage is w^*, it follows that the bargaining equilibrium is Pareto efficient; namely, it maximizes total payoffs. This is an important result because it suggests that even within the RTM framework, and in spite of the fact that the parties do not bargain over the level of employment, the outcome is still socially optimal. Efficiency is achieved by offering the correct/optimal wage, which in turn leads the firm to choose the socially optimal level of employment. Third, in this equilibrium we have the usual feature of the Rubinstein model, namely, the model does not tell us who actually moves first. The selection of the optimal wage guarantees that the size of the pie is optimal, but it does not tell us who will move first. However, since the size of the pie is always optimal, regardless of who moves first, again the order of play is no longer "that important". Fourth, in equilibrium we always have a union wage premium, regardless of the parties' relative powers. Specifically, the equilibrium "full wage", $\overline{w}_i^*,\ i = u, f$, is given by $\overline{w}_u^* = 1 + z_u^*(\delta_f, \delta_u) > 1$, when the union moves first and $\overline{w}_f^* = 1 + \pi^1 - z_f^*(\delta_f, \delta_u) > 1$, when the firm move first. Hence, in this model, efficiency and a wage premium coexist.

From equations (29) and (30) we can see that there are four types of unique equilibria $E1 - E4$, corresponding the four lines in equations (35) and (36), respectively, in Appendix 6.2 (depending on the values of δ_f, δ_u and the other parameters).[26] An example of these equilibria is shown in Figure 2 for the production function: $y = n^{.5}$. Between the R and M curves we have equilibrium $E1$. Everywhere above the R curve we have equilibrium $E2$. Between the M curve and the area labelled as BC we have equilibrium $E3$. Within the BC area we also have equilibrium $E3$ (but since in this area, in the original game there is an interior solution with $w_u(\delta_f, \delta_u) > w_f(\delta_f, \delta_u) > 1,$ the outside options within this region are different than in the area outside BC).[27]

Finally, the effects of power (δ_f, δ_u) on the equilibrium *full* wages are as follows. For all $\{\delta_f, \delta_u\} \in E1$, or $\{\delta_f, \delta_u\} \in E3(BC)$, we have:[28]

$$\frac{d\overline{w}_u^*(\cdot)}{d\delta_u} > 0, \quad \frac{d\overline{w}_u^*(\cdot)}{d\delta_f} < 0, \quad \frac{d\overline{w}_f^*(\cdot)}{d\delta_u} > 0, \quad \frac{d\overline{w}_f^*(\cdot)}{d\delta_f} < 0 \tag{31}$$

For all $\{\delta_f, \delta_u\} \in E2$, the results are the same as above, except that the effect of δ_f on $\overline{w}_f^*$, is now:

$$\begin{array}{l} \frac{d\overline{w}_f^*(\cdot)}{d\delta_f} > 0, \text{ if } \delta_f < 1/2 \\ \frac{d\overline{w}_f^*(\cdot)}{d\delta_f} < 0, \text{ if } \delta_f > 1/2 \end{array}$$

For all $\{\delta_f, \delta_u\} \in E3$, the results are the same as in equation (31), except that the effect of δ_u on $\overline{w}_u^*$, is now:

$$\frac{d\overline{w}_u^*(\cdot)}{d\delta_u} = 0 \tag{32}$$

[26] The four types of equilibria correspond to the following cases respectively: (1) $\max\{z_f, \overline{\pi}^*\} = z_f$ and $\max\{1+z_u, \overline{u}^*\} = 1+z_u$, (2) $\max\{z_f, \overline{\pi}^*\} = z_f$, but $\max\{1+z_u, \overline{u}^*\} = \overline{u}^*$, (3) $\max\{z_f, \overline{\pi}^*\} = \overline{\pi}^*$ and $\max\{1+z_u, \overline{u}^*\} = 1+z_u$, (4) $\max\{z_f, \overline{\pi}^*\} = \overline{\pi}^*$ and $\max\{1+z_u, \overline{u}^*\} = \overline{u}^*$.

[27] For this example, the values of π^1, $\overline{u}^*$ and $\overline{\pi}^*$ are such that the case where $\max\{z_f, \overline{\pi}^*\} = \overline{\pi}^*$ and $\max\{1+z_u, \overline{u}^*\} = \overline{u}^*$ cannor occur. Hence, only equilibria $E1$, $E2$ and $E3$ are possible.

[28] This follows immediately from the optimal solutions for $z_u^*(\delta_f, \delta_u)$ and $z_f^*(\delta_f, \delta_u)$ in equations (29) and (30) and from the definitions of $\overline{u}^*$ and $\overline{\pi}^*$ in equations (24) and (25).

Since it seems reasonable that the firm's power should satisfy, $\delta_f > 1/2$, we conclude that the comparative statics results are as expected.

5 Conclusion

This paper shows that, within the context of the right to manage union-firm bargaining, the standard Rubinstein alternating offers model implies that inefficiency is always greater when the union moves first in the wage bargaining game; thus, the order of play in the wage bargaining affects the size of the pie. The paper then shows that the standard Rubinstein alternating offers model can be modified to provide a Pareto superior outcome. We provide two examples of bargaining protocols that yield superior outcomes. In the first example, the parties engage in a three stage bargaining game, in which the order of play is determined as part of the bargaining. We show that the game has a unique subgame perfect equilibrium, in which the firm always moves first in the wage bargaining game. Moreover, since in equilibrium the firm always moves first, it also follows that, unlike in the standard Rubinstein alternating offers model, there is only one equilibrium wage.

In the second example, we propose a two-part tariff alternating offers bargaining game, where the firm and the union bargain over the wage and transfer payments. We show that this bargaining protocol has a Pareto efficient unique subgame perfect equilibrium. Thus, although the parties do not bargain over the level of employment, under this protocol, the outcome is nevertheless socially optimal.

6 Appendix

6.1 The Equilibrium Values of the Transfers t_1^* and t_2^* :

$$t_f^*(\delta_1, \delta_2) = \begin{cases} \frac{(1-\delta_f)\delta_u \pi_f^* - (1-\delta_u) u_f^*}{(1-\delta_f \delta_u)} & \text{if} \quad \frac{\delta_f(1-\delta_u)(u_f^*+\pi_f^*)}{(1-\delta_f\delta_u)} \geq \overline{\pi}^* \text{ and } \frac{\delta_u(1-\delta_f)(u_f^*+\pi_f^*)}{(1-\delta_f\delta_u)} \geq \overline{u}^* \\ \overline{u}^* - u_f^* & \text{if} \quad \delta_f(u_f^* + \pi_f^* - \overline{u}^*) \geq \overline{\pi}^* \text{ and } \frac{\delta_u(1-\delta_f)(u_f^*+\pi_f^*)}{(1-\delta_f\delta_u)} \leq \overline{u}^* \\ \pi_f^* - \overline{\pi}^* & \text{if} \quad \frac{\delta_f(1-\delta_u)(u_f^*+\pi_f^*)}{(1-\delta_f\delta_u)} \leq \overline{\pi}^* \text{ and } \delta_f(u_f^* + \pi_f^* - \overline{\pi}^*) \geq \overline{u}^* \\ \overline{u}^* - u_f^* & \text{if} \quad \delta_f(u_f^* + \pi_f^* - \overline{u}^*) \leq \overline{\pi}^* \text{ and } \delta_u(u_f^* + \pi_f^* - \overline{\pi}^*) \leq \overline{u}^* \end{cases} \tag{33}$$

$$t_u^*(\delta_1, \delta_2) = \begin{cases} \frac{(1-\delta_f)\pi_f^* - (1-\delta_u)\delta_f \; u_f^*}{(1-\delta_f \delta_u)} & \text{if} \quad \frac{\delta_f(1-\delta_u)(u_f^*+\pi_f^*)}{(1-\delta_f\delta_u)} \geq \overline{\pi}^* \text{ and } \frac{\delta_u(1-\delta_f)(u_f^*+\pi_f^*)}{(1-\delta_f\delta_u)} \geq \overline{u}^* \\ (1-\delta_f)\pi_f^* + \delta_f(\overline{u}^* - u_f^*) & \text{if} \quad \delta_f(u_f^* + \pi_f^* - \overline{u}^*) \geq \overline{\pi}^* \text{ and } \frac{\delta_u(1-\delta_f)(u_f^*+\pi_f^*)}{(1-\delta_f\delta_u)} \leq \overline{u}^* \\ \delta_u(\pi_f^* - \overline{\pi}^*) - (1-\delta_u)u_f^* & \text{if} \quad \frac{\delta_f(1-\delta_u)(u_f^*+\pi_f^*)}{(1-\delta_f\delta_u)} \leq \overline{\pi}^* \text{ and } \delta_f(u_f^* + \pi_f^* - \overline{\pi}^*) \geq \overline{u}^* \\ \pi_f^* - \overline{\pi}^* & \text{if if } \delta_f(u_f^* + \pi_f^* - \overline{u}^*) \leq \overline{\pi}^* \text{ and } \delta_u(u_f^* + \pi_f^* - \overline{\pi}^*) \leq \overline{u}^* \end{cases} \tag{34}$$

6.2 The Equilibrium Values of the Shares $z_f^*(\delta_f, \delta_u)$ and $z_u^*(\delta_f, \delta_u)$:

$$z_f^*(\delta_f, \delta_u) = \begin{cases} (1+\pi^1)(1-\delta_u)/(1-\delta_u\delta_f) \text{ if } (1+\pi^1)(1-\delta_u)/(1-\delta_u\delta_f) \geq \overline{\pi}^* \\ \qquad \text{and } 1 + (1-\delta_f)\pi^1 - (1-\delta_u)\delta_f/(1-\delta_u\delta_f) \geq \overline{u}^* \\ 1 + \pi^1 - \delta_u\overline{u}^* \text{ if } 1 + \pi^1 - \delta_u\overline{u}^* \geq \overline{\pi}^* \text{ and } 1 + (1-\delta_f)\pi^1 - \delta_f(1-\delta_u \; \overline{u}^*) \leq \overline{u}^* \\ 1 + (1-\delta_u)\pi^1 - \delta_u(1-\delta_f \; \overline{\pi}^*) \text{ if } 1 + (1-\delta_u)\pi^1 - \delta_u(1-\delta_f \; \overline{\pi}^*) \leq \overline{\pi}^* \text{ and } 1 + \pi^1 - \delta_f\overline{\pi}^* \geq \overline{u}^* \\ 1 + \pi^1 - \delta_u \; \overline{u}^* \text{ if } 1 + \pi^1 - \delta_u \; \overline{u}^* \leq \overline{\pi}^* \text{ and } 1 + \pi^1 - \delta_f \; \overline{\pi}^* \leq \overline{u}^* \end{cases} \tag{35}$$

$$z_u^*(\delta_f,\delta_u)=\begin{cases}(1-\delta_f)\pi^1-(1-\delta_u)\delta_f/(1-\delta_u\delta_f) \quad \text{if } \ (1+\pi^1)(1-\delta_u)/(1-\delta_u\delta_f)\geq \ \overline{\pi}^* \\ \qquad \text{and } 1+(1-\delta_f)\pi^1-(1-\delta_u)\delta_f/(1-\delta_u\delta_f) \ \geq \overline{u}^* \\ (1-\delta_f)\pi^1-\delta_f(1-\delta_u \ \overline{u}^*) \ \text{ if } 1+\pi^1-\delta_u\overline{u}^*\geq\overline{\pi}^* \text{ and } 1+(1-\delta_f)\pi^1-\delta_f(1-\delta_u \ \overline{u}^*)\leq \ \overline{u}^* \\ \pi^1-\delta_f\overline{\pi}^* \quad \text{if } \ 1+(1-\delta_u)\pi^1-\delta_u(1-\delta_f \ \ \overline{\pi}^*)\leq\overline{\pi}^* \text{ and } 1+\pi^1-\delta_f\overline{\pi}^*\geq\overline{u}^* \\ \pi^1-\delta_f \ \overline{\pi}^* \ \text{ if } 1+\pi^1-\delta_u \ \overline{u}^*\leq\overline{\pi}^* \text{ and } 1+\pi^1-\delta_f \ \overline{\pi}^*\leq\overline{u}^*\end{cases} \tag{36}$$

6.3 Proof of Proposition 4

At any point in the game, given that, say, the firm follows the above strategy, it is optimal for the union to follow its above strategy as well. The proof that deviations from $z_u^*(\delta_f,\delta_u)$ and $z_f^*(\delta_f,\delta_u)$ are not profitable is the same as the proof that no deviations are profitable from the equilibrium values, $w_f(\delta_f,\delta_u)$, $w_u(\delta_f,\delta_u)$, in the standard model in Section 3.2. (which, in turn, is similar to the proof given in Muthoo (1999)), so we will not pursue it here. Instead, we consider deviations from the equilibrium wage. Suppose it is the union's turn to make an offer. If it offers $\{w^*, z_u^*(\delta_f,\delta_u)\}$, the firm will accept and the union will receive $u(w^*)+z_u^*(\delta_f,\delta_u)$. Now, consider what happens if it deviates and offers, the same share, but a lower wage: $w<w^*$. Such an offer is acceptable to the firm since, $\pi(w)-z_u^*(\delta_f,\delta_u)>\pi(w^*)-z_u^*(\delta_f,\delta_u)$. But, since $u(w)+z_u^*(\delta_f,\delta_u)<u(w^*)+z_u^*(\delta_f,\delta_u)$ this offer is not profitable to the union. Next, consider what happens if the union deviates and offers, say $w>w^*$. Such an offer will be rejected by the firm because $\pi(w)-z_u^*(\delta_f,\delta_u)<\pi(w^*)-z_u^*(\delta_f,\delta_u)$. Hence, since the firm rejects such an offer and, in turn, either offers (in the next period) $u(w^*)+\pi(w^*)-z_f^*(\delta_f,\delta_u)$, or opts out (if $z_f^*(\delta_f,\delta_u)\leq\overline{\pi}^*$), the union cannot get more than $\max\{\delta_u[u(w^*)+\pi(w^*)-z_f^*(\delta_f,\delta_u)],\ \delta_u^2[u(w^*)+z_u^*(\delta_f,\delta_u)],\delta_u\overline{u}^*\}$. But, since $u(w^*)+\pi(w^*)-z_f^*(\delta_f,\delta_u)=\delta_u\max\{u(w^*)+z_u^*(\delta_f,\delta_u),\overline{u}^*\}$ it follows that the union cannot get more than $\max\{\delta_u\max\{u(w^*)+z_u^*(\delta_f,\delta_u),\overline{u}^*\},\ \delta_u^2[u(w^*)+z_u^*(\delta_f,\delta_u)],\delta_u\overline{u}^*\}$. But, clearly $u(w^*)+z_u^*(\delta_f,\delta_u)>\ \delta_u^2[u(w^*)+z_u^*(\delta_f,\delta_u)]$. Furthermore, if $\max\{u(w^*)+z_u^*(\delta_f,\delta_u),\overline{u}^*\}=u(w^*)+z_u^*(\delta_f,\delta_u)$, then again $u(w^*)+z_u^*(\delta_f,\delta_u)>\ \delta_u[u(w^*)+z_u^*(\delta_f,\delta_u)]$. If, on the other hand, $\max\{u(w^*)+z_u^*(\delta_f,\delta_u),\overline{u}^*\}=\overline{u}^*$, we have equilibrium $E1$ and it can be easily verified that again $u(w^*)+z_u^*(\delta_f,\delta_u)>\ \delta_u\ \overline{u}^*$. Hence we conclude that any deviation from w^* is not desirable. Similarly, we can go the other way around and show that deviations are not profitable for the firm either. Finally, uniqueness can be proven by defining the maximum and minimum payoffs for the union and the firm and showing that they are equal. We will not pursue this here.

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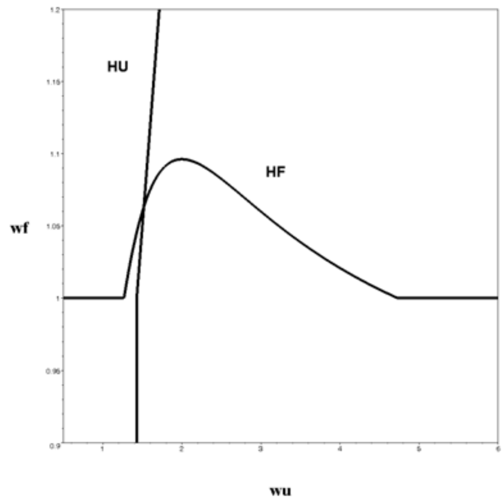

Figure 1: HU and HF Curves, with: $\delta_f = .7$, $\delta_u = .96$.

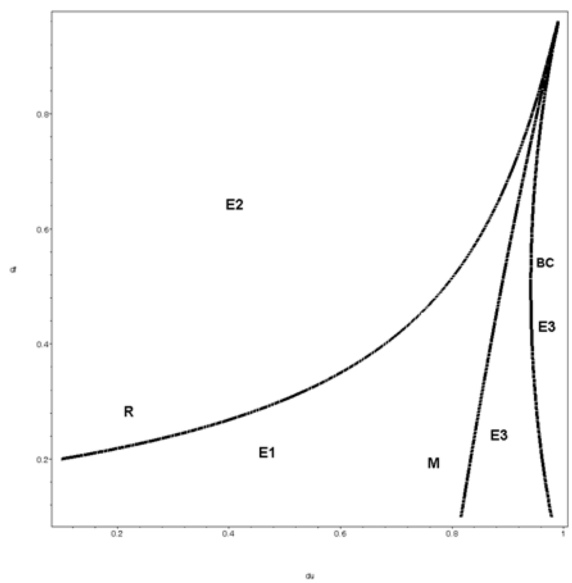

Figure 2: Possible Equilibria in the Efficient Alternating Offers Bargaining Game.