

WAGE BARGAINING UNDER THE NATIONAL LABOR RELATIONS ACT

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Abstract

Sections 8(a)(3) and 8(a)(5) of the National Labor Relations Act prohibit a firm from unilaterally increasing the wage it pays the union during the negotiation of a new wage contract. To understand this regulation, we study a counterfactual model where the firm can unilaterally increase wages during contract negotiations. Comparing this model to the case where the firm must pay the wage from the expired contract, we show that the firm may strategically increase the union's temporary wage to upset the union's incentive to strike and to decrease the union's bargaining power. Consequently, increasing temporary wages may shrink the set of equilibrium contracts in the firm's favor. Indeed, as the union becomes more patient, the set of equilibrium wages converges to the expired wage, the best equilibrium outcome to the firm. We further demonstrate that our counterfactual model is valid since our results maintain even if the union is allowed to block the firm's temporary wage increase.

JEL Classification: C72 Noncooperative Games, C73 Stochastic and Dynamic Games, C78 Bargaining Theory

Keywords: Collective Bargaining, National Labor Relations Act

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1 Introduction

Economists have devoted much attention to strikes and wage negotiations. Empirical studies have found that a strike is less likely to occur the higher the wage from the expired contract.¹ Expired wages play a key role in the contract negotiation model of Haller and Holden (1990) and Fernandez and Glazer (1991), where striking is used as a strategic weapon for the union to obtain higher wages. Other work has shown that the firm can hire replacement workers to diminish the harm of a strike.² In this paper, we study how a firm can circumvent a strike by increasing temporary wages so that the union finds striking too costly.

In the United States and many other countries, once a wage contract has expired, the firm is prohibited from lowering wages during negotiations. It is the opposite movement in wages that concerns us. Indeed, just such a case came before the Supreme Court (*Katz v. NLRB*, 1962). In this case, the firm (Willamsburg Steel Products Company) unilaterally increased wages before an agreement was reached. The Court deemed that the firm’s behavior violated the National Labor Relations Act (NLRA) Section 8(a)(5)’s requirement that the firm and union “bargain collectively,” which by Section 8(d) of the NLRA requires “the employer and the representative of the employees to meet at reasonable times and confer in good faith with respect to wages, hours, and other terms or conditions of employment.” The Court said that the unilateral wage increase “inhibits the actual process of discussion” and “reflects a cast of mind against reaching an agreement.” Citing this case, Leslie (2000) concludes that the NLRA prohibits both unilateral increases and decreases to wages during negotiations. Nevertheless, the Court did concede that the NLRA permits a firm to grant temporary wage increases during negotiations with the union’s approval. In this paper, we study both *unilateral* wage increases made by the firm during negotiations and wage increases that must be approved by the union. We show that in either case, the firm can upset the union’s incentive to strike.

¹See empirical works by Card (1990a, 1990b), Gundersen et al. (1986), and Vroman (1989). Ausubel et al. (2002) and Kennan and Wilson (1993) survey theoretical models on contract negotiation.

²See Cramton and Tracey (1998).

To study the firm's incentive to increase the temporary wage the union earns during negotiations, we start with the contract negotiation model of Haller and Holden (1990) and Fernandez and Glazer (1991).³ In contrast to the standard bilateral bargaining model of Rubinstein (1982), the contract negotiation model allows the players' payoffs during disagreement to be determined by a normal form game, called the disagreement game. Upon disagreement, the union may choose to either strike or work for the expired wages while bargaining over a new contract. The negotiation game generally admits multiple subgame perfect equilibrium outcomes, including inefficient outcomes with delayed agreements. The contract negotiation model fixes the wage during negotiation to be equal to the wage from the expired contract. In this paper, we generalize the contract negotiation model by allowing the firm to unilaterally increase wages before the union decides whether to strike.

We first show that our model cannot be analyzed under the framework of Busch and Wen (1995) where the disagreement game is given in normal form; the explicit timing in our disagreement game imposes additional equilibrium restrictions. With the temporary wage increases explicitly modeled, we find that the firm sometimes does have an incentive to increase wages during negotiations. By doing so, the firm is able to reduce the union's incentive to strike, thereby shrinking the set of equilibrium wage contracts in the firm's favor. And more startling, we find that as the union becomes more patient, the set of equilibrium wage contracts shrinks to the expired wage contract: this is indeed the union's worst equilibrium in the contract negotiation model. We also consider a model where the union must first approve the wage increase for it to be effective since the Supreme Court has interpreted the NLRA as prohibiting the firm from *unilateral* wage increase. We show that the union's approval is innocuous: all of our results bounding the equilibrium contracts remain unchanged.

In the next section we describe a non-cooperative bargaining model where the firm may unilaterally increase the union's compensation. In Section 3, we analyze the range of subgame

³See also Busch and Wen (1995), Houba (1997), Muthoo (1999), and Slantchev (2003) for general negotiation models.

perfect equilibrium contracts. We show how the range of equilibrium contracts can drastically change when the firm can upset the union's incentive to strike by temporarily increasing wages. We then modify this model in Section 4 to allow the union to block the firm's wage increases. Conclusions are in Section 5.

2 A Model with Unilateral Compensation

Consider a situation where a union and firm negotiate a new wage contract that specifies how to share the firm's future gross profit, normalized to one per period over an infinite horizon. The expired wage is denoted as $w^0 \in [0, 1]$. The union must be paid at least w^0 per period if the union works during the contract negotiation.

The negotiation proceeds with alternating offers as in Rubinstein's (1982) bargaining model. The union proposes in odd periods and the firm proposes in even periods. There are four stages in every bargaining period. In any odd period, including the first period, such that no agreement has been reached, the union proposes a wage demand $w' \in [0, 1]$ in the first stage, and then the firm decides whether to accept the union's demand in the second stage. If the firm accepts the union's demand, the negotiation ends with the permanent wage w' taking effect. Otherwise, if the firm rejects the union's demand, the negotiation proceeds to the third stage where the firm may increase the temporary wage to $c' \geq w^0$. Henceforward, we refer to a temporary wage as *compensation* to distinguish it from the permanent wage being negotiated over. In the fourth stage after observing c' , the union decides whether to work in the current period (in which case the union receives c' and the firm receives $1 - c'$), or to strike (in which case both the union and the firm receive 0). The negotiation then proceeds to the following even period.

Similarly, there are four stages in any even period. The firm offers an wage contract $w'' \in [0, 1]$ in the first stage and the union decides whether to accept the firm's offer in the second stage. The union's acceptance concludes the negotiation. Otherwise, upon rejection, the game proceeds to the third stage, where the firm compensates $c'' \geq w^0$ for the current

period. In the fourth stage, the union decides whether to work (in which case the union receives c'' and the firm receives $1 - c''$), or to strike (in which case both the union and the firm receive 0). Figure 1 illustrates this negotiation process.

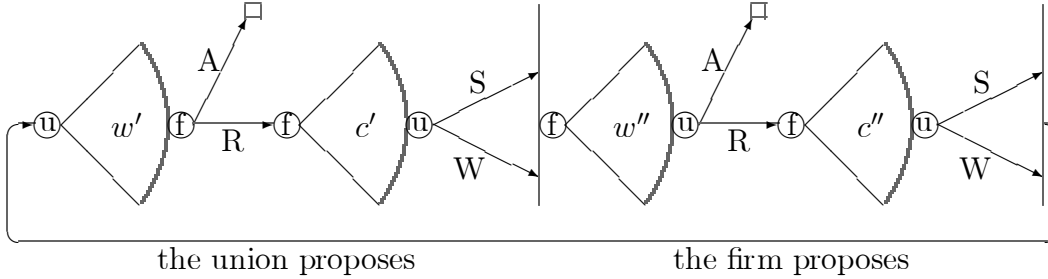


Figure 1. Contract negotiation with unilateral compensation.

This model has perfect information, so histories and strategies are defined in the usual fashion. For example, a history consists of all past contract proposals and rejections, all past compensations offered by the firm, and all past decisions by the union on whether to work or to strike. A strategy assigns a feasible action to the acting party after each possible finite history. Every strategy profile induces a unique probability distribution on the set of pure outcome paths. Denote a generic pure outcome path as $\pi = (d^1, d^2, \dots, d^{T-1}, a^T)$, where $d^t \in R^2$ is the interim disagreement payoff vector in period t such that for $0 \leq t < T$,

$$d^t = (d_u^t, d_f^t) = \begin{cases} (0, 0) & \text{if the union strikes in period } t, \\ (c, 1 - c) & \text{if the union works for } c \geq w^0 \text{ in period } t, \end{cases}$$

and $a^T \in \Delta^1$ (the unit simplex in R^2) represents the agreement reached in period $T \geq 1$. An outcome with perpetual disagreement is represented by an infinite sequence of interim disagreement payoff vectors. From such a generic outcome path π , average discounted payoffs to the union and the firm are

$$(1 - \delta_i) \sum_{t=1}^{T-1} \delta_i^{t-1} d_i^t + \delta_i^{T-1} a_i, \quad \text{for } i = u, f,$$

where $(\delta_u, \delta_f) \in (0, 1)^2$ are the union's and firm's discount factors per period. In this paper, we will adopt the concept of subgame perfect equilibrium, which induces a Nash equilibrium

in every subgame after any possible finite history. Hereafter, we simply refer to a subgame perfect equilibrium as an equilibrium.

Our model generalizes the contract negotiation model of Haller and Holden (1990) and Fernandez and Glazer (1991) by allowing the firm to increase compensation to the union. In other words, if the firm is restricted to offer $c = w^0$ in every stage 3, then the model described here is equivalent to the contract negotiation model. Now we review some of the key results from the contract negotiation model. The following Proposition 1 asserts a lower bound and an upper bound for equilibrium contracts:⁴

Proposition 1 *In the contract negotiation model (i.e., where $c = w^0$),*

(i) the lowest equilibrium contract in any period is w^0 for all $(\delta_u, \delta_f) \in (0, 1)^2$;

(ii) equilibrium contracts are bounded from above by M_u in any odd period and $1 - m_f$ in any even period,⁵ given by

$$M_u = \begin{cases} w^0 & \text{if } (\delta_u, \delta_f) \notin A, \\ \frac{(1-\delta_f)+\delta_f(1-\delta_u)w^0}{1-\delta_u\delta_f} & \text{if } (\delta_u, \delta_f) \in A, \end{cases} \quad (1)$$

$$1 - m_f = (1 - \delta_u)w^0 + \delta_u M_u, \quad (2)$$

where

$$A = \left\{ (\delta_u, \delta_f) \in (0, 1)^2 : \delta_f \leq \delta_f^A(\delta_u, w^0) = \frac{\delta_u^2 - (1 - \delta_u + \delta_u^2)w^0}{\delta_u^2 - \delta_u w^0} \right\}. \quad (3)$$

Proof: See Lemmas 2 and 4 of Fernandez and Glazer (1991). **Q.E.D.**

This contract negotiation model has multiple equilibrium outcomes, including inefficient ones,⁶ if and only if $(\delta_u, \delta_f) \in A$ for any $w^0 \in [0, 1]$. Note that $(\delta_u, \delta_f) \in A$ if and only if

$$w^0 \leq \delta_u(1 - m_f) = \frac{\delta_u^2(1 - \delta_f) + \delta_u(1 - \delta_u)w^0}{1 - \delta_u\delta_f}. \quad (4)$$

⁴While the lower bound w^0 can always be supported by an equilibrium, Bolt (1995) shows that when $\delta_u > \delta_f$, M_u and $1 - m_f$ cannot be supported with the strategy profile offered by Fernandez and Glazer (1991). This means that this upper bound may not be the least upper bound of equilibrium contracts.

⁵Here, M_u denotes an upper bound of the union's equilibrium payoffs in an odd period and m_f denotes a lower bound of the firm's equilibrium payoffs in an even period.

⁶See Bolt (1995) for the construction of multiple equilibria for the case of $\delta_u > \delta_f$. When there are multiple equilibria, they can be used to support equilibria with delayed agreement; see for example, pages 50-51 of Osborne and Rubinstein (1990).

Fernandez and Glazer (1991) construct the values of M_u and m_f of (1) and (2) by considering the union's alternating striking strategy, whereby it strikes whenever its demand is rejected and works whenever it rejects the firm's offer. Condition (4) is necessary for the union to credibly strike in an odd period after its demand is rejected. The left side of (4) is the lowest payoff the union can get if it works in the current (odd) disagreement period: the union gets w^0 in the current period, followed by its worst continuation payoff w^0 . In order for the union to strike in an odd period, its payoff must exceed w^0 . The right side of (4) is an upper bound of the payoffs the union can get if it strikes. In other words, if condition (4) fails, the union will definitely work during an odd period in any equilibrium. Given the union's alternating striking strategy, the firm's interim disagreement payoff is 0 when the firm responds to the union's demand, and the union's interim disagreement payoff is w^0 when the union responds to the firm's offer.

When the union and the firm have a common discount factor $\delta \in (0, 1)$, Proposition 1 simplifies to:⁷

Corollary 1.1 *In the contract negotiation model (i.e., where $c = w^0$), if the union and firm have a common discount factor $\delta \in (0, 1)$, then*

(i) *the lowest equilibrium contract is w^0 in any period for all $\delta \in (0, 1)$;*

(ii) *the highest equilibrium contract is M_u in any odd and $1 - m_f$ in any even periods, where*

$$M_u = \begin{cases} w^0 & \text{if } 0 < \delta < \sqrt{w^0}, \\ \frac{1+\delta w^0}{1+\delta} & \text{if } \sqrt{w^0} \leq \delta < 1, \end{cases} \quad 1 - m_f = \begin{cases} w^0 & \text{if } 0 < \delta < \sqrt{w^0}, \\ \frac{\delta+w^0}{1+\delta} & \text{if } \sqrt{w^0} \leq \delta < 1. \end{cases}$$

In Appendix A, we demonstrate that our model (where $c \geq w^0$) cannot be analyzed by Busch and Wen (1995). The disagreement in Busch and Wen (1995) is modeled as a static game in normal form. The disagreement game in our model, however, has its dynamic structure, where the firm offers compensation first and then the union decides to work or strike. Appendix A shows that treating the normal form representation of this dynamic

⁷When the union and the firm have a common discount factor, M_u and $1 - m_f$ can be supported as the highest equilibrium wage contracts in odd and even periods. See Haller and Holden (1990) and Bolt (1995).

game does not change Proposition 1. In contrast, we will see that the range of equilibrium contracts does change when we treat the disagreement game in its extensive form.

3 Equilibrium Analysis

In this section, we derive a range of equilibrium wage contracts in our model where the firm may unilaterally increase compensation the union during the contract negotiation. We identify three sets of discount factors under which the firm behaves quite differently. On one extreme when the union's discount factor is small enough, the firm does not have to increase compensation the union since there is a unique equilibrium that leads to the lowest equilibrium contract. On the other extreme when the union's discount factor is large enough, the firm increases compensation in order to induce the union to work in every odd period. When the union's discount factor is in an intermediate range, the firm does not increase the compensation to the union because it is too costly to induce the union to work. Given the firm's discount factor, the upper bound of equilibrium wage contracts eventually falls with respect to the union's discount factor, a result that is quite counter-intuitive. As the union becomes sufficiently patient, any equilibrium wage contract will be arbitrarily close to the expired contract, which is also the lowest equilibrium wage contract for all discount factors.

3.1 A Lower Bound of Equilibrium Contracts

We first establish the existence of a simple equilibrium for all discount factors $(\delta_u, \delta_f) \in (0, 1)^2$ and all expired wages $w^0 \in [0, 1]$. As in the contract negotiation model, w^0 is the lowest equilibrium wage contract for all possible discount factors.

Proposition 2 *For all $(\delta_u, \delta_f) \in (0, 1)^2$ and $w^0 \in [0, 1]$, there is an efficient equilibrium where the union and the firm agree on w^0 in the first period.*

Proof: See Appendix B.

Q.E.D.

The equilibrium of Proposition 2 is supported by a very simple strategy profile, in which the union always demands w^0 and rejects any offer that is less than w^0 , the firm always offers

w^0 and rejects any demand that is more than w^0 , the firm never increases compensation, and the union always works. The proof of Proposition 2 shows that neither the union nor the firm has any incentive to deviate from this strategy profile. It is obvious that w^0 is also the lowest equilibrium wage contract since the union can choose to work and receive at least w^0 in every period. Now we state this result as

Proposition 3 *For all $(\delta_u, \delta_f) \in (0, 1)^2$ and $w^0 \in [0, 1]$, the union never receives less than w^0 in any equilibrium.*

3.2 An Upper Bound of Equilibrium Contracts: Conditions

With the existence of an equilibrium, we now turn our attention to derive an upper bound of equilibrium contracts. Let M_u^* be an upper bound the union's equilibrium payoffs in any odd period, and m_f^* be a lower bound of the firm's equilibrium payoffs in any even period. Note that $1 - m_f^*$ is an upper bound of the union's equilibrium payoffs in any even period. We use M_u^* and m_f^* here to distinguish them from those in Proposition 1 (for the model where the firm cannot increase compensation). From the setup of the model and existence result of Proposition 2, both M_u^* and m_f^* are well defined functions of (δ_u, δ_f) and $w^0 \in [0, 1]$. Proposition 3 implies that

$$M_u^* \geq w^0 \quad \text{and} \quad 1 - m_f^* \geq w^0.$$

Similar to the backward induction technique in Shaked and Sutton (1984), we now derive a set of necessary conditions for M_u^* and m_f^* , imposed by subgame perfection. First, consider an even period where the firm makes an offer. By subgame perfection, since the union's payoffs in next (odd) period cannot exceed M_u^* , and the union's payoff during the current even period cannot exceed c'' (if the firm compensates c'' and the union works), the union's payoff from rejecting a firm's offer cannot exceed $(1 - \delta_u)c'' + \delta M_u^*$. This implies that the union will accept any offer that exceeds $(1 - \delta_u)c'' + \delta M_u^*$. Therefore in any equilibrium, the

firm receives at least (recall that the firm chooses $c'' \geq w^0$)

$$m_f^* = \max_{c'' \geq w^0} [1 - (1 - \delta_u)c'' - \delta_u M_u^*] = 1 - [(1 - \delta_u)w^0 + \delta_u M_u^*], \quad (5)$$

in any even period by making an offer sufficiently high (such as $1 - m_f^*$) to induce the union to accept while not increasing compensation (i.e., $c'' = w^0$) if the union rejects.

Next consider an odd period where the union proposes a contract demand. Recall that there are four stages in an odd period. In the last stage after the union rejects the firm's offer and the firm offers $c' \geq w^0$, the union decides to strike or work during the current period. The firm is able to induce the union to work by offering a sufficiently high compensation c' such that

$$(1 - \delta_u)c' + \delta_u w^0 \geq \delta_u (1 - m_f^*). \quad (6)$$

The left side of (6) represents the union's lowest possible payoff if it works for compensation c' , while the right side of (6) is the union's highest possible payoff if it strikes. Condition (6) ensures that the union gets a higher payoff from working than from striking.

If the firm induces the union to work with c' that satisfies condition (6), the firm will receive at least

$$(1 - \delta_f)(1 - c') + \delta_f m_f^*.$$

Alternatively, the firm may choose not to increase compensation. As in the contract negotiation model, the union may strike during the current odd period. Therefore, if the firm does not increase compensation, Proposition 1 applies and the firm's equilibrium payoffs are at least $1 - M_u$. To summarize, the firm chooses between these two alternatives and so the union's equilibrium payoffs in any odd period are at most

$$\begin{aligned} M_u^* &= 1 - \max \left\{ 1 - M_u, \sup_{s.t.(6)} [(1 - \delta_f)(1 - c') + \delta_f m_f^*] \right\} \\ &= \min \left\{ M_u, 1 - \sup_{s.t.(6)} [(1 - \delta_f)(1 - c') + \delta_f m_f^*] \right\}. \end{aligned} \quad (7)$$

Now we state these arguments as

Proposition 4 *For all $(\delta_u, \delta_f) \in (0, 1)^2$ and $w^0 \in [0, 1]$, M_u^* and m_f^* satisfy (5) and (7).*

3.3 Incentive to Compensate

Instead of solving M_u^* and m_f^* directly from (5) and (7), we will use the results we have so far to pin down the values of M_u^* and m_f^* for all $(\delta_u, \delta_f) \in (0, 1)^2$ and $w_0 \in [0, 1]$.

Proposition 3 states that w^0 is the lowest equilibrium contract. When $(\delta_u, \delta_f) \notin A$, w^0 is also the unique equilibrium contract if the firm does not increase compensation. It is obvious then that when $(\delta_u, \delta_f) \notin A$, the firm should not increase compensation.

Lemma 1 *When $(\delta_u, \delta_f) \notin A$, we have that $M_u^* = 1 - m_f^* = w^0$.*

When $(\delta_u, \delta_f) \in A$, Proposition 1 asserts that

$$M_u = \frac{(1 - \delta_f) + \delta_f(1 - \delta_u)w^0}{1 - \delta_u\delta_f}. \quad (8)$$

To obtain the M_u^* and m_f^* , condition (5) states that the firm should not increase compensation to the union and the union should work in every even period.

Suppose that the firm chooses to induce the union to work in an odd period with $c' \geq w^0$ that satisfies condition (6), then the proposals that are consistent with the subgame perfection must satisfy the following equations:

$$1 - M'_u = (1 - \delta_f)(1 - c') + \delta_f m'_f, \quad (9)$$

$$1 - m'_f = (1 - \delta_u)w^0 + \delta_u M'_u. \quad (10)$$

Equation (9) states that the firm is indifferent between accepting contract M'_u and rejecting it (after which collecting $1 - c'$ in the current odd period and m'_f in the following even period). Equation (10) states the union is indifferent between accepting contract $1 - m'_f$ and rejecting it (after which collecting w^0 in the current even period and M'_u in the following odd period). Equations (9) and (10) yield

$$M'_u = \frac{(1 - \delta_f)c' + \delta_f(1 - \delta_u)w^0}{1 - \delta_u\delta_f}. \quad (11)$$

Note by (11) that M'_u is increasing with respect to c' and is equal to M_u at $c' = 1$. If the firm is able to induce the union to work in an odd period with $c' \geq w^0$, then any equilibrium

contract in an odd period will be at most M'_u given by (11). Comparing M'_u in (11) and M_u in (8) when $(\delta_u, \delta_f) \in A$, we have

Proposition 5 $M'_u \leq M_u$ if and only if $c' \leq 1$.

Proposition 5 is quite intuitive and important. Since it is always costly to the firm if the union strikes after firm's rejection, the firm benefits if the firm can successfully induce the union to work in an odd period without compensating the union more than its gross profit. Otherwise, it is too costly for the firm to induce the union to work, and the firm is better off not compensating the union more than w^0 in an odd period. Proposition 5 also asserts that $c' = 1$ is the threshold where the firm is just indifferent between increasing compensation and not increasing compensation.

From condition (6), the optimal (the lowest necessary) compensation needed to induce the union to work in an odd period is

$$c^* = \frac{\delta_u}{1 - \delta_u}(1 - m_f^* - w^0). \quad (12)$$

At the threshold of $c^* = 1$, the firm is indifferent between $c' = 1$ and $c' = w^0$. Setting $c^* = 1$, equation (12) yields

$$m_f^* = \frac{2\delta_u - 1}{\delta_u} - w^0. \quad (13)$$

which is a critical value of m_f^* . If the value of m_f^* is higher than the right side of (13), the optimal compensation c^* will be less than 1, and so the firm will offer c^* to the union. Otherwise, the firm will not increase compensation to the union. At such a threshold, it must be the case that $m_f^* = m_f$, which yields

$$\begin{aligned} 1 - m_f^* &= 1 - m_f = (1 - \delta_u)w^0 + \delta_u M_u, \\ \Rightarrow \frac{1 - \delta_u}{\delta_u} + w^0 &= (1 - \delta_u)w^0 + \delta_u \frac{(1 - \delta_f) + \delta_f(1 - \delta_u)w^0}{1 - \delta_u \delta_f}. \end{aligned} \quad (14)$$

Solving δ_f from (14) in terms of δ_u and w^0 , we obtain

$$\delta_f^B(\delta_u, w^0) = \frac{(1 - w^0)\delta_u^2 + \delta_u - 1}{(2 - w^0)\delta_u^2 - \delta_u}. \quad (15)$$

Define the set B as

$$B = \{(\delta_u, \delta_f) \in (0, 1)^2 : \delta_f \leq \delta_f^B(\delta_u, w^0)\}. \quad (16)$$

We will show that the firm will choose to induce the union to work in every odd period if and only if $(\delta_u, \delta_f) \in B$. The following lemma asserts that the fact of $B \subset A$ for all $w^0 \in [0, 1]$, as well as a few other properties of sets A and B :

Lemma 2 *Given $w^0 \in [0, 1]$, we have*

- (i) $\delta_f^A(\delta_u, w^0) \in (0, 1)$ for all $\delta_u \in \left(\frac{\sqrt{(4-3w^0)w^0}-w^0}{2-2w^0}, 1\right)$;
- (ii) $\delta_f^B(\delta_u, w^0) \in (0, 1)$ for all $\delta_u \in \left(\frac{\sqrt{5-4w^0}-1}{2-2w^0}, 1\right)$;
- (iii) $\delta_f^A(\delta_u, w^0) > \delta_f^B(\delta_u, w^0)$ for all $\delta_u \in \left(\frac{\sqrt{5-4w^0}-1}{2-2w^0}, 1\right)$;
- (iv) $\delta_f^A(1, w_0) = \delta_f^B(1, w_0) = 1$, and

$$\frac{\partial \delta_u^A(\delta_u, w^0)}{\partial \delta_u} = \frac{\partial \delta_u^B(\delta_u, w^0)}{\partial \delta_u} = 0 \quad \text{at } \delta_u = 1.$$

Part (iii) of Lemma 2 implies that $A \subset B$, as illustrated in the following Figure 2:

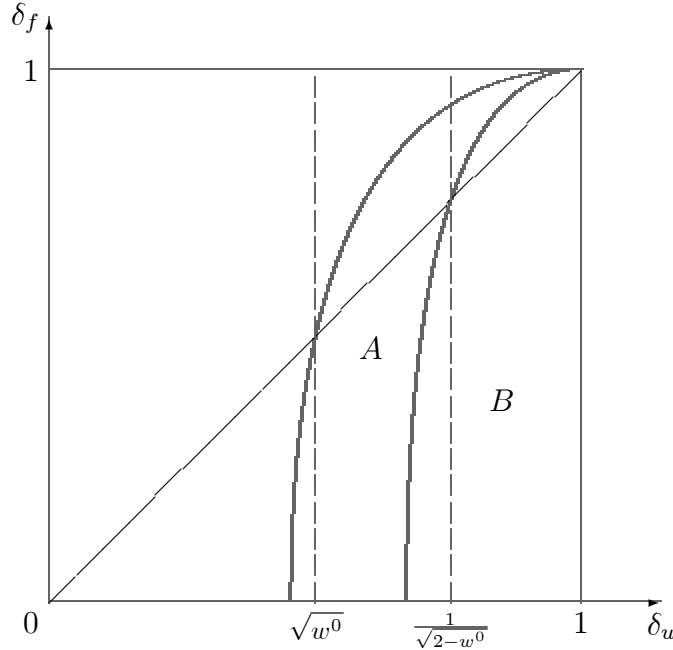


Figure 2. Sets A and B of (δ_u, δ_f) .

3.4 Values of M_u^* and m_f^*

To solve the value of M_u^* in terms of (δ_u, δ_f) and w^0 , we first compute the corresponding value \widetilde{M}_u^* when the firm offers the optimal compensation c^* in (6) and then compare \widetilde{M}_u^* with M_u to determine the value of M_u^* . If the firm offers c^* in every odd period then the union will work in every odd period.⁸ Substituting $\mathcal{C} = c^*$ of (12) into (9), we obtain

$$\widetilde{M}_u^* = \frac{\delta_u + \delta_f - 2\delta_u\delta_f}{1 - \delta_u}(1 - m_f^*) - \frac{\delta_u(1 - \delta_f)}{1 - \delta_u}w^0. \quad (17)$$

Equations (5) and (17) yield the corresponding value of \widetilde{M}_u^* when the firm offers c^* to the union and so the union works in every odd period, we have

$$\begin{aligned} \widetilde{M}_u^* &= \frac{\delta_u + \delta_f - 2\delta_u\delta_f}{1 - \delta_u}[(1 - \delta_u)w^0 + \delta_u\widetilde{M}_u^*] - \frac{\delta_u(1 - \delta_f)}{1 - \delta_u}w^0 \\ \Rightarrow \widetilde{M}_u^* &= \frac{\delta_f - \delta_u^2 - 2\delta_u\delta_f + 2\delta_u^2\delta_f}{1 - \delta_u - \delta_u^2 - \delta_u\delta_f + 2\delta_u^2\delta_f}w^0. \end{aligned} \quad (18)$$

From the construction, it is easy to see that on the boundary of set B where $\delta_f = \delta_f^B(\delta_u, w^0)$, the firm has the same interim disagreement payoff of zero from either compensating the union with its entire gross profit in every odd period or not increasing compensation. Recall that (18) gives an upper bound of equilibrium contracts when the firm provides just sufficient compensation to avoid the union's striking in every odd period. To summarize, we have

Proposition 6 *From conditions (5) and (7), we have*

$$M_u^* = \begin{cases} M_u & \text{if } (\delta_u, \delta_f) \notin B \\ \widetilde{M}_u^* & \text{if } (\delta_u, \delta_f) \in B \end{cases} = \begin{cases} w^0 & \text{if } (\delta_u, \delta_f) \notin A \\ \frac{(1-\delta_f)+\delta_f(1-\delta_u)w^0}{1-\delta_u\delta_f} & \text{if } (\delta_u, \delta_f) \in A \setminus B \\ \frac{\delta_f - \delta_u^2 - 2\delta_u\delta_f + 2\delta_u^2\delta_f}{1 - \delta_u - \delta_u^2 - \delta_u\delta_f + 2\delta_u^2\delta_f}w^0 & \text{if } (\delta_u, \delta_f) \in B \end{cases}$$

As a special case when the union and the firm have a common discount factor $\delta \in (0, 1)$,

Proposition 6 simplifies to

⁸For the sake of argument, the firm could offer slightly higher than c^* so that the union strictly prefers working over striking.

Corollary 6.1 *When $\delta_u = \delta_f = \delta \in (0, 1)$, we have*

$$M_u^* = \begin{cases} w^0 & \text{if } \delta \in (0, \sqrt{w^0}) \\ \frac{1+\delta w^0}{1+\delta} & \text{if } \delta \in \left[\sqrt{w^0}, \frac{1}{\sqrt{2-w^0}} \right] \\ \frac{2\delta^2-\delta}{2\delta^2-1} w^0 & \text{if } \delta \in \left(\frac{1}{\sqrt{2-w^0}}, 1 \right) \end{cases} \quad (19)$$

M_u^* can be supported by an equilibrium for all $(\delta_u, \delta_f) \notin B$ and $\delta_u \leq \delta_f$ in the same way as in the contract negotiation model. When $(\delta_u, \delta_f) \in B$, supporting M_u^* in an equilibrium uses inefficient continuation payoffs, such as payoff vector (w^0, m_f^*) in the subgame after the union works under the optimal compensation c^* in the previous odd period. If an inefficient proposal is feasible then M_u^* can be easily supported by equilibrium. Otherwise, Proposition 6 provides an upper bound of equilibrium contracts.

Compared with the contract negotiation model, our Proposition 6 implies that the firm benefits from its ability to compensate when the union's and the firm's discount factors lie in set B . The lowest equilibrium contract is unaffected by the firm's ability to compensate. This means that allowing the firm to compensate the union generally improves the efficiency of equilibrium outcomes, but in a somewhat lopsided way. The firm's ability to compensate the union may limit the upper bound of equilibrium contracts. This effect depends on the union's discount factor and firm's discount factor. Note that

$$\lim_{\delta_u \rightarrow 1} M_u^* = \lim_{\delta_u \rightarrow 1} \frac{\delta_f - \delta_u^2 - 2\delta_u \delta_f + 2\delta_u^2 \delta_f}{1 - \delta_u - \delta_u^2 - \delta_u \delta_f + 2\delta_u^2 \delta_f} w^0 = \frac{\delta_f - 1}{\delta_f - 1} w^0 = w^0.$$

Dramatically, as the union becomes more and more patient, any equilibrium contract will be sufficiently close to the expired contract w^0 , which is the lowest equilibrium contract to the union.

Proposition 7 *For any given $\delta_f \in (0, 1)$ and $w^0 \in [0, 1]$, we have $\lim_{\delta_u \rightarrow 1} M_u^* = w^0$.*

Figure 3 illustrates M_u and M_u^* for a given value of δ_f . Notice that $M_u^* = M_u$ for $\delta_u \leq \bar{\delta}_u$, where $(\delta_u, \delta_f) \in B$ for all $\delta_u \geq \bar{\delta}_u$. When $\delta_u \geq \bar{\delta}_u$, M_u is increasing (to one as δ_u goes to one), but M_u^* is decreasing (to w^0 as δ_u goes to one).

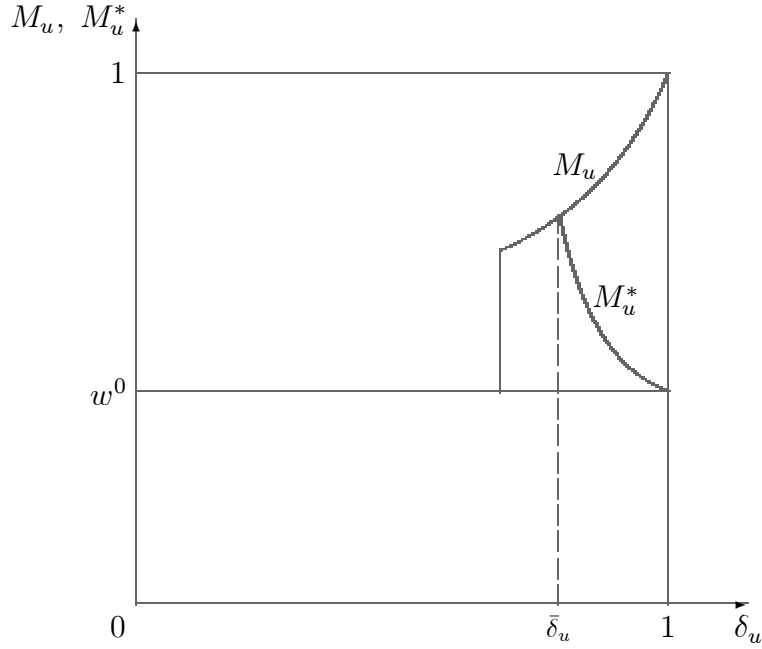


Figure 3. M_u and M_u^* for $\delta_f = 0.8$ and $w^0 = 0.4$.

Propositions 6 and 7 (also Figure 3) suggest that as the union becomes more patient, the union becomes worse off in general, in sharp contrast to the conventional result that patience is a virtue. The reason for this counter-intuitive finding comes from one of our earlier results. As the union becomes more patient, the union needs less compensation to work in every odd period, which hurts the union.

To conclude, we find that the firm may benefit from compensating the union in odd periods when the union is relatively more patient than the firm. However, the firm will not carry out the compensation since the union and the firm would agree on a new wage contract immediately. When the union is not more patient relative to the firm, the firm could not benefit from compensating the union. In this situation, the firm either does not have to compensate (when $(\delta_u, \delta_f) \notin A$), or does not want to compensate since the compensation needed to provide the union enough incentive to work is too high (when $(\delta_u, \delta_f) \in A \setminus B$).

4 Compensation with the Union's Consent

The NLRA prohibits the firm from unilaterally increasing compensation to the union during a contract negotiation. The Supreme Court considers that such unilateral actions would undermine the union's authority to represent the workers and interfere with collective bargaining. In the previous section, we showed that under certain conditions, the firm has an incentive to increase compensation to induce the union to work in every odd period, so the firm's unilateral ability to compensate can also hurt the workers economically. The NLRA does not completely prohibit the firm from compensating the workers, but rather gives power to the union to block the firm's action.

Now we examine whether it is credible for the union to block the firm's compensation. Our answer is negative. In order to analyze this issue more formally, we modify our model studied in the previous section so that the union decides whether to approve the firm's compensation before deciding whether to strike or to work in any period after disagreement.⁹

The negotiation proceeds in the fashion of alternating-offers as in the previous model. There is one more stage where the union decides whether to approve the firm's compensation offer. More specifically, in any odd period before reaching an agreement, the union proposes $w' \in [0, 1]$ in the first stage, the firm then decides whether to accept the union's demand in the second stage. Acceptance concludes the negotiation. At the third stage after the firm rejects the union's demand, the firm may offer compensation $c' \geq w^0$ to the union. Different from the previous model, the union now decides whether to approve the firm's compensation in stage four. In stage five, the union decides whether to work for $c' \geq w^0$ if the union has approved c' or for expired contract w^0 if the union has disapproved c' , or whether to strike during the current period. Then the negotiation proceeds to the following even period, which is similar to an odd period except that the firm proposes a wage contract and the union responds; stages 3, 4 and 5 in an even period are identical to those in an odd

⁹Whether the union decides simultaneously or sequentially to approve/disapprove the firm's compensation and to work/strike will not change our conclusions.

period.

As in the model where the firm may unilaterally offer additional compensation, this modified model has perfect information. Histories, strategies and payoffs are defined in the usual fashion according to the additional element in the model. The union's decision on whether to approve the firm's compensation introduces new subgames so subgame perfection requires the strategy profile induced in these new subgames to be Nash equilibria as well.

Despite the union's ability to block the firm's compensation, w^0 is still the lowest equilibrium contract. In the rest of this section, we show that the union cannot credibly block the firm's additional compensation when the firm offers it. When $(\delta_u, \delta_f) \notin B$, we know that the firm either does not have to or does not want to increase compensation. It will continue to be the case when the union can block the firm's additional compensation. Suppose that the union always approves the compensation offered by the firm. Then this modified model is virtually the same as our original model. On the other hand, if the firm does not increase compensation, then the union's approval decision becomes irrelevant.

We now shift our attention to the case of $(\delta_u, \delta_f) \in B$. We adopt the same notation as before: M_u^* is an upper bound of the union's equilibrium payoffs in any odd period and m_f^* is a lower bound of the firm's equilibrium payoffs in an even period.

First, for the same argument as from our original model where the firm may unilateral increase compensation, condition (5) continues to be valid. The firm will not increase compensation and the union will work in any even period.

Next, we consider an odd period. Recall that the union may now block the firm's compensation offer. In order for the firm's compensation c' to be ineffective, it must be the case that the union strikes in the current odd period whether the union approves c' or not. Note that if the union chooses to strike, then its continuation payoffs will not be higher than $\delta_u(1 - m_f^*)$. If the union chooses to work for the current period however, its continuation payoffs will not be less than w^0 (after the union refuses c') or $(1 - \delta_u)c' + \delta_u w^0$ (after the union approves c'). Figure 4 illustrates the situation that the union is most likely to strike

in an odd period after the firm offers $c' \geq w^0$, where the union is rewarded with the upper bound of equilibrium wages after it strikes and punished with the lowest equilibrium contract in the continuation after it works.

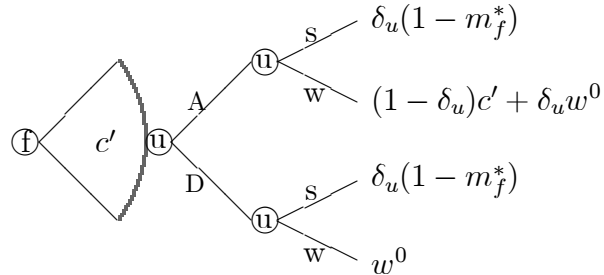


Figure 4. The union's four possible continuation payoffs.

Restricting $c' \geq w^0$ implies that the union never disapprove (D) the firm's compensation and then works for the current odd period, which is quite intuitive. Figure 4 shows that when condition (6) holds, it is not credible for the union to disapprove (D) compensation c' and then to strike (S). In addition, any equilibrium outcome in our original model can also be supported in the current model by duplicating the continuation equilibrium in the subgames after the union approves or disapproves the firm's compensation.

Proposition 8 *Allowing the union to block the firm's additional compensation will not change the set of equilibrium contracts.*

Proposition 8 implies that suppressing the union's ability to block the firm's compensation makes no difference, the results obtained in Sections 2 and 3 are still valid. In particular, we have found that the firm can still upset the union's incentive to strike when $(\delta_u, \delta_f) \in B$ even if the union can block the firm's action.

5 Concluding Remarks

Our paper is motivated by a spate of empirical evidence that shows a negative relationship between the expired wage and incidence of a strike. We take this evidence seriously and ask

whether the firm can upset the union's incentive to strike by offering higher temporary wages during a negotiation. Another motivation comes from Cramton and Tracey (1998), where the firm hires replacement workers to reduce the cost of a strike. Along the same lines, the firm may wish to circumvent a strike by offering its own workers temporarily higher wages. What actually pointed us to this issue is the Supreme Court's ruling that unilateral wage increases during negotiations violate the NLRA. Specifically, wage increases were considered to undermine the union's authority and the collective bargaining environment. However, even aside from these considerations, we recognize the strategic effect of higher temporary wages on the union's incentive to strike.

To examine this aspect of the NLRA, we incorporate the firm's choice to increase temporary wages into the contract negotiation model of Haller and Holden (1990) and Fernandez and Glazer (1991). We find that in contrast to these original models, the range of equilibrium contracts shrinks in the firm's favor. Indeed, as the union becomes more patient, the set of equilibrium wages converges to the expired contract, the best equilibrium outcome to the firm. Recent extensions of the original negotiation model demonstrate that simply allowing the firm more options in a normal form disagreement game will only enlarge the set of equilibrium outcomes. Our model, on the other hand, where the disagreement is given in extensive form, shows that the timing of moves matters. Or as Kennan and Wilson (1993) put it, "Exact specification of procedures is essential to obtain detailed predictions of the outcomes of bargaining."

6 Appendix A

In this appendix, we argue that treating the dynamic disagreement game in its normal form does not alter the set of equilibrium payoffs characterized by Proposition 1. Consider the normal form representation of the disagreement, where the firm's and union's strategy spaces and payoff functions are

$$\begin{aligned}
 A_f &= [w^0, \infty) \\
 A_u &= \{a_u(\cdot) : [w^0, \infty) \rightarrow \{\text{Strike}, \text{Work}\}\}, \\
 (d_u(a_u, a_f), d_f(a_u, a_f)) &= \begin{cases} (0, 0) & \text{if } a_f = c \text{ and } a_u(c) = \text{Strike}, \\ (c, 1-c) & \text{if } a_f = c \text{ and } a_u(c) = \text{Work}. \end{cases}
 \end{aligned}$$

Note that the union's decision to work or strike depends on the firm's compensation offer.

According to Busch and Wen (1995), in order to support the highest equilibrium contract, we need to find the firm's lowest disagreement payoff and the union's highest disagreement payoff supportable in an equilibrium. The firm's lowest supportable disagreement payoff is the firm's minimax value 0 in the disagreement game, achieved when the union strikes. The union's highest supportable disagreement payoff is the highest difference between the union's disagreement payoff and the firm's gain from deviating:

$$\max_{a_f, a_u} \left[d_u(a_u, a_f) - \left(\max_{a_f} d_f(a_u, a_f) - d_f(a_u, a_f) \right) \right] = [c - ((1 - w^0) - (1 - c))] = w^0,$$

achieved when the union works even if the firm does not increase compensation. This implies that Proposition 1 would continue to hold if one treated the normal form representation of the underlying game as the disagreement game. Therefore, allowing the firm to increase compensation would not change the results from the contract negotiation model of Haller and Holden (1990) and Fernandez and Glazer (1991).

7 Appendix B

Proof of Proposition 2: Consider the following strategy profile: In any odd period, the union demands w^0 and the firm accepts demands of no more than w^0 . In any even period, the firm offers w^0 and the union accepts offers of no less than w^0 . The firm does not increase compensation and the union chooses to work in any period. In what follows, we show that this strategy profile constitutes an equilibrium.

Since the continuation payoffs are independent of the history in any stage of any period, it is optimal for the union to work for any compensation. Given that, the firm should not increase compensation. In any odd period, the firm receives $1 - w^0$ after rejecting the union's demand so the firm will reject any wage demand higher than w^0 . In any even period, the union's payoff from rejecting the firm's offer is w^0 so it is optimal for the union to reject any wage offer that is less than w^0 . In summary, neither the union nor the firm has any incentive to deviate from the strategy profile described above. **Q.E.D.**

Proof of Lemma 2: The proof is divided into four parts.

(i) Recall $\delta_f^A(\delta_u, w^0)$ from (2), note that

$$\begin{aligned} (1 - w^0)\delta_u^2 + w^0\delta_u - w^0 > 0 & \text{ iff } \delta_u < -\frac{\sqrt{(4 - 3w^0)w^0} + w^0}{2 - 2w^0} \text{ or } \delta_u > \frac{\sqrt{(4 - 3w^0)w^0} - w^0}{2 - 2w^0}, \\ \delta_u^2 - w^0\delta_u > 0 & \text{ iff } \delta_u < 0 \text{ or } \delta_u > w^0. \\ \Rightarrow \delta_f^A(\delta_u, w^0) > 0 & \text{ iff either } 0 < \delta_u < w^0 \text{ or } \frac{\sqrt{(4 - 3w^0)w^0} - w^0}{2 - 2w^0} < \delta_u < 1. \end{aligned}$$

On the other hand, when $\delta_u^2 - w^0\delta_u < 0$, $\delta_f^A(\delta_u, w^0) < 1$ if and only if

$$(1 - w^0)\delta_u^2 + w^0\delta_u - w^0 > \delta_u^2 - w^0\delta_u \Leftrightarrow w^0(1 - \delta_u)^2 < 0,$$

which is impossible. When $\delta_u^2 - w^0\delta_u > 0$, $\delta_f^A(\delta_u, w^0) < 1$ if and only if $w^0(1 - \delta_u)^2 > 0$, which is trivial.

(ii) Recall $\delta_f^B(\delta_u, w^0)$ from (17), note that

$$(1 - w^0)\delta_u^2 + \delta_u - 1 > 0 \text{ iff } \delta_u < -\frac{1 + \sqrt{5 - 4w^0}}{2 - 2w^0} \text{ or } \delta_u > \frac{\sqrt{5 - 4w^0} - 1}{2 - 2w^0},$$

$$\begin{aligned}
(2 - w^0)\delta_u^2 - \delta_u > 0 & \quad \text{iff } \delta_u < 0 & \quad \text{or } \delta_u > \frac{1}{2 - w^0}. \\
\Rightarrow \delta_f^B(\delta_u, w^0) > 0 & \quad \text{iff } \text{either } 0 < \delta_u < \frac{1}{2 - w^0} \text{ or } \frac{\sqrt{5 - 4w^0} - 1}{2 - 2w^0} < \delta_u < 1.
\end{aligned}$$

On the other hand, when $(2 - w^0)\delta_u^2 - \delta_u < 0$, $\delta_f^B(\delta_u, w^0) < 1$ if and only if

$$(1 - w^0)\delta_u^2 + \delta_u - 1 > (2 - w^0)\delta_u^2 - \delta_u \Leftrightarrow (1 - \delta_u)^2 < 0,$$

which is impossible. When $(2 - w^0)\delta_u^2 - \delta_u > 0$, $\delta_f^B(\delta_u, w^0) < 1$ if and only if $(1 - \delta_u)^2 > 0$, which is trivial.

(iii) Note the following equivalency: If $\delta_u \in \left(\frac{\sqrt{5-4w^0}-1}{2-2w^0}, 1\right)$, $\delta_f^A(\delta_u, w^0) > \delta_f^B(\delta_u, w^0)$ if and only if

$$\begin{aligned}
\frac{(1 - w^0)\delta_u^2 + w^0\delta_u - w^0}{\delta_u(\delta_u - w^0)} & > \frac{(1 - w^0)\delta_u^2 + \delta_u - 1}{\delta_u[(2 - w^0)\delta_u - 1]} \\
\Leftrightarrow (1 - w^0)^2 \cdot (1 - \delta_u)^2 \cdot \delta_u & > 0,
\end{aligned}$$

which is trivial for all permissible values of δ_u and w^0 .

(iv) This part of the proof is straightforward. For example

$$\frac{\partial \delta_u^B(\delta_u, w^0)}{\partial \delta_u} = \frac{[2(1 - w^0)\delta_u + 1][(2 - w^0)\delta_u^2 - \delta_u] - [2(2 - w^0)\delta_u - 1][(1 - w^0)\delta_u^2 + \delta_u - 1]}{[(2 - w^0)\delta_u^2 - \delta_u]^2}.$$

At $\delta_u = 1$, this derivative equals 0.

Q.E.D.

Proof of Proposition 6: From condition (7), we have that $M_u^* = \min\{M_u, \widetilde{M}_u^*\}$. For (δ_u, δ_f) , M_u is increasing with respect to δ_u for any given δ_f . Now we show that \widetilde{M}_u^* is decreasing with respect to δ_u for any given δ_f wherever it is well defined. Differentiating \widetilde{M}_u^* with respect to δ_u , we have

$$\begin{aligned}
\frac{\partial \widetilde{M}_u^*}{\partial \delta_u} & = \frac{\partial}{\partial \delta_u} \left[\frac{\delta_f - 2\delta_f \cdot \delta_u + (2\delta_f - 1) \cdot \delta_u^2}{1 - (1 + \delta_f) \cdot \delta_u + (2\delta_f - 1) \cdot \delta_u^2} \right] \\
& = \frac{(\delta_f - 1)[\delta_f - 2(2\delta_f - 1) \cdot \delta_u + (2\delta_f - 1) \cdot \delta_u^2]}{[1 - (1 + \delta_f) \cdot \delta_u + (2\delta_f - 1) \cdot \delta_u^2]^2}.
\end{aligned} \tag{20}$$

Observe that the second term on the numerator of (20) is

$$\delta_f - 2(2\delta_f - 1) \cdot \delta_u + (2\delta_f - 1) \cdot \delta_u^2 = \begin{cases} \delta_f > 0 & \text{when } \delta_u = 0 \\ 1 - \delta_f > 0 & \text{when } \delta_f = 1, \end{cases}$$

$$\text{and } \frac{\partial}{\partial \delta_u} [\delta_f - 2(2\delta_f - 1) \cdot \delta_u + (2\delta_f - 1) \cdot \delta_u^2] = 2(2\delta_f - 1)(\delta_u - 1),$$

which is positive if and only if $\delta_f < 1/2$. We have shown that $\delta_f - 2(2\delta_f - 1) \cdot \delta_u + (2\delta_f - 1) \cdot \delta_u^2$ is monotonic with respect to δ_u for any given $\delta_f \in (0, 1)$, and it has positive values at $\delta_u = 0$ and 1. Therefore, it is always positive for all $(\delta_u, \delta_f) \in (0, 1)^2$.

Together with the fact the $(\delta_f - 1) < 0$ (the first term on the numerator of (20)), the right hand side of (20) is negative and so \widetilde{M}_u^* is decreasing with respect to δ_u for any given δ_f . As we argued, $\widetilde{M}_u^* = M_u$ on the boundary of set B and M_u is increasing with respect to δ_u for any given δ_f . This implies that if $(\delta_u, \delta_f) \in B$, we must have $M_u > \widetilde{M}_u^*$ and so $M_u^* = \widetilde{M}_u^*$ if and only if $(\delta_u, \delta_f) \in B$. **Q.E.D.**

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