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**Abstract**

*We examine whether the outcome of bargaining over wage and employment between an incumbent firm and a union remains efficient under entry threat. The workers\' reservation wage is not known to the entrant, and entry is profitable only against the high reservation wage. The entrant observes the pre-entry price, but not necessarily the wage agreements. When wage is not observed, contracts feature over-employment. Under separating equilibrium the low type is over-employed, and under pooling equilibrium the high type is over-employed. But when wage is observed, pooling equilibrium may not always exist, and separating equilibrium does not involve any inefficiency.*

**Keywords:**

Efficient Bargaining, Entry Threat, Signalling, Inefficiency

**JEL Code:**

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**Entry Threats, and Inefficiency in 'Efficient Bargaining'**

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# 1 Introduction

It is well known that when a firm and a labour union bargain over both wage and employment the resulting contract is Pareto efficient (McDonald and Solow, 1981). However, it is not well understood whether this efficiency property will be preserved if contracting takes place amidst entry threats. Several authors have demonstrated that entry threats can significantly affect the incumbent firm's employment contracts (see, for example, Dewatripont, 1987, 1988; Ohnishi, 2001; Pal and Saha, 2006, 2008). But they have assumed bargaining protocols which are inherently inefficient (such as the right-to-manage bargaining). In this paper we ask: Does the outcome of 'efficient bargaining' remain efficient under entry threat, and does the agenda of bargaining (i.e. wage and employment both) help to preserve efficiency?

We try to answer these questions in a simple model of entry, where the entrant does not know the true marginal cost (MC) of the incumbent, and entry is profitable only if the MC is high. The incumbent firm-union pair can signal its true MC either by price alone, or by both price and wage. The possibility of two alternative signalling mechanisms arises from the fact that wage agreements may not be necessarily disclosed to outsiders. In the first case, because of limited avenue for information transmission, contracts are distorted. The low cost type will be over-employed if it needs to separate itself through 'limit pricing'. The high cost type will also be over-employed, when it wants to mimic the low cost type. But in the second case (signalling through both price and wage) as information revelation becomes easier, separation of the types occurs even with first best employment. So efficiency of employment is unaffected by entry threats in a separating equilibrium. However, for a pooling equilibrium the verdict is mixed. If the union's bargaining power is below a critical level, pooling equilibrium will not exist, an outcome efficient indeed, reflecting the fact that information suppression is harder, when both price and wage are observable. But if the union is sufficiently powerful, the inefficiency returns in the form of over-employment of the high cost type.

The paper is organised as follows. In Section 2 we describe the setup, subsequently in Section 3 present the main analysis. Section 4 concludes.

# 2 The setup

There is an incumbent firm (labelled firm 1), which negotiates both wage ($w$) and employment ($l$) with its labour union. There is also a potential entrant (firm 2) with marginal cost $c$. The union supplies all workers to firm 1 and does not serve any other firm. Following the Nash bargaining approach, we assume that the bargaining power of the union is given by $\gamma$, $(0 \leq \gamma \leq 1)$ and conversely that of the firm by $(1-\gamma)$. The reservation payoffs of the two bargaining parties are zero. Crucially, outside the wage and employment contract no other payments, covert or overt, are made by the firm to the union or by the union to the firm.

The production technology of firm 1 is assumed to be, for simplicity, $x = l$. The market demand curve is linear: $p = A - x$. Thus, firm 1's profit is $\Pi = (p - w)l$. The union tries to maximise its net wage bill $U = (w - \theta)l$, where $\theta$ is the reservation wage. Crucially, $\theta$ is drawn by Mother Nature and it could be high ($\theta_2$) or low ($\theta_1$); $\theta_2 > \theta_1$. This information is known only to the incumbent firm and union, but not to the entrant until it enters. It believes that $\theta_2$ occurs with probability $\rho$ and $\theta_1$ occurs with probability $(1 - \rho)$. Once drawn $\theta$ remains the same over two periods which is our relevant time horizon.

The incumbent firm sells in both periods and each period's output is bargained over (along with the wage). The entrant observes the output (equivalently price) of the first period and may enter in the second period, based on its belief about the incumbent. Entry requires incurring a fixed cost $F$ and entry is profitable only against $\theta_2$. Note that the entrant does not interact with the incumbent's union.[1] All strategic firm interactions are Cournot. Both the incumbent firm and its union dislike entry.

Stages of the game involved are as follows.

Period 1

| | |
|---|---|
| Stage 1: | Mother Nature chooses the reservation wage of the workers ($\theta$). (The same reservation wage prevails in both periods) |
| Stage 2: | Firm 1 and its union bargain over the first period $w$ and $l$. |
| Stage 3: | Production takes place. Firm 2 observes only $p$, or both $p$ and $w$ and takes entry decision. |

Period 2

| | |
|---|---|
| Stage 1: | If firm 2 enters it instantly learns the true $\theta$. Firm 1 and union negotiate over $w$ and $l$. Cournot duopoly emerges. If firm 2 does not enter, firm 1 retains its monopoly, and output is chosen via bargaining. |

Let us first consider the symmetric information wage-employment contracts. Under monopoly the efficient contract solves the following problem:

$$\max_{w,l} Z = U^{\gamma}\Pi^{1-\gamma} = [(w-\theta)l]^{\gamma}[(A-l-w)l]^{1-\gamma}$$

and the solution is:

$$w_i^M = \gamma\frac{A-\theta_i}{2} + \theta_i, \quad l_i^M = \frac{A-\theta_i}{2} \tag{1}$$

The employment is given by a vertical contract curve (unaffected by the bargaining powers of the two parties), and the wage is a sum of the base wage $\theta_i$ and a fixed proportion of surplus.[2] The proportion depends on the bargaining power of the union. Since the wage

[1] That is plausible in many situations: international competition, large difference is skill requirements of the incumbent and the entrant, localised trade unions by law or by institutional set up, etc.

[2] The underlying first order conditions are

$$\begin{aligned} A-2l &= w - \tfrac{\gamma}{1-\gamma}(A-l-w) \\ w &= \gamma(A-l)+(1-\gamma)\theta. \end{aligned}$$

and employment belong to the contract curve, the outcome is efficient ( *à la* McDonald and Solow, 1981). In fact, this efficiency remains in tact, even if a profit-sharing arrangement is introduced into union-firm contracts (Anderson and Devereux, 1989). In contrast, under right-to-manage bargaining (Nickell and Andrews, 1983), the outcome is inefficient; employment is chosen from the labour demand curve instead of the contract curve.

Associated with the monopoly contract are the following payoffs: for union $U_i^M = \gamma\frac{(A-\theta_i)^2}{4}$ and for firm 1 $\Pi_i^M = (1-\gamma)\frac{(A-\theta_i)^2}{4}$.

Under (symmetric information) duopoly, for a given $\theta_i$ the contract curve is given by $l_i = \frac{A-2\theta_i+c}{3}$ and the equilibrium wage, employment, union's payoff and firm 1's profit are $w_i^D = \gamma\frac{A-2\theta_i+c}{3} + \theta_i$, $l_i^D = \frac{A-2\theta_i+c}{3}$, $U_i^D = \gamma\frac{(A-2\theta_i+c)^2}{9}$ and $\Pi_i^D = (1-\gamma)\frac{(A-2\theta_i+c)^2}{9}$, respectively. Clearly, here too the contract remains efficient. Firm 2's profit is $R_i = \frac{(A-2c+\theta_i)^2}{9} - F$, $i = 1, 2$. Since we have assumed entry to be profitable only against $\theta_2$, we must have $R_1 < 0 < R_2$, i.e. $\frac{(A-2c+\theta_1)^2}{9} < F < \frac{(A-2c+\theta_2)^2}{9}$.

# 3 Bargaining under entry threat: The case of unobservable wage

We first consider the scenario where the entrant does not observe the wage; it observes only the price and tries to infer the type of the union. Now, if the entrant's expected profit upon entry is positive ($ER = \rho R_1 + (1-\rho)R_2 > 0$) and the union is of low type, the incumbent firm-union pair will try to signal the true type of the union (through price) in order to deter entry. This is the case of separating equilibrium. Alternatively, if the entrant's expected profit upon entry is negative ($ER < 0$) and the union is of high type, the incumbent firm-union pair will try to hide true information. This is the case of pooling equilibrium. In either case, distortions in employment may occur.

If the entrant's priors are such that its expected profit is positive, the entrant can be discouraged only if it can be informed of the truly low type of the union, and this is achieved through a separating equilibrium.

**Separating equilibrium:** Under separating equilibrium the firm-union pair should set a sufficiently low price if $\theta = \theta_1$, and a high price if $\theta = \theta_2$. These two prices must satisfy the following incentive compatibility conditions:

$$\Pi_1(p_1; w_1) + \delta\Pi_1^M \geq \Pi_1^M + \delta\Pi_1^D, \tag{2}$$

$$U_1(p_1; w_1) + \delta U_1^M \geq U_1^M + \delta U_1^D \tag{3}$$

$$\Pi_2(p_1; w_2) + \delta\Pi_2^M \leq \Pi_2^M + \delta\Pi_2^D \tag{4}$$

$$U_2(p_1; w_2) + \delta U_2^M \leq U_2^M + \delta U_2^D. \tag{5}$$

Condition (2) states that, for $\theta = \theta_1$ by setting $p_1$ entry is deterred and firm 1's profit (discounted and summed over two periods) is greater than what it would have been had the monopoly price $p_1^M$ $(= \frac{A+\theta_1}{2})$ been set and entry occurred. Condition (4) states that for $\theta = \theta_2$ by setting $p_2 = p_2^M (= \frac{A+\theta_2}{2})$ entry is accommodated and thereby firm 1's profit becomes greater than what it would have been had $p_1$ been set and deterred entry. Conditions (3) and (5) state the same from the union's point of view for $\theta_1$ and $\theta_2$ respectively.

Now we note that since wage is not observed by the entrant, it retains its standard rent-sharing role under efficient bargaining. It implies that both profit and net wage bill will be proportional to the joint surplus $S_i = (A - p_i)(p_i - \theta_i)$. In particular when $p_1$ is set, we get $w_i = \gamma(A - l_1 - \theta_i) + \theta_i$ and $U(p_1, w_i) = (w_i - \theta_i)(A - p_1) = \gamma(p_1 - \theta_i)(A - p_1) = \gamma S_i(p_1)$, which in turn gives $\Pi_i(p_1, w_i) = (p_1 - w_i)(A - p_1) = (1-\gamma)(p_1 - \theta_i)(A - p_1) = (1-\gamma)S_i(p_1)$. Similarly, it can be shown that $U_i^M = \gamma S_i^M = \gamma\frac{(A-\theta_i)^2}{2}$ and $\Pi_i^M = (1-\gamma)\frac{(A-\theta_i)^2}{2}$. Similar relation holds for $U_i^D$ and $U_i^M$. Because both parties' payoffs are proportional to the joint surplus, we can compress four incentive compatibility conditions into two and restate these in terms of joint surplus. When explicitly written, these constraints become

$$(p_1 - \theta_1)(A - p_1) \geq \frac{(A - \theta_1)^2}{4} - \delta[\frac{(A - \theta_1)^2}{4} - \frac{(A - 2\theta_1 + c)^2}{9}], \tag{6}$$

$$(p_1 - \theta_2)(A - p_1) \leq \frac{(A - \theta_2)^2}{4} - \delta[\frac{(A - \theta_2)^2}{4} - \frac{(A - 2\theta_2 + c)^2}{9}]. \tag{7}$$

Nash bargaining over $w_i$ and $l_i$ must satisfy the constraints (6) and (7), if the resulting prices are to reveal true $\theta$. Formally one needs to maximize $Z = [(w_i - \theta_i)l_i]^\gamma[(A - w_i - l_i)]^{1-\gamma}$ subject to (6) and (7).

It can be checked that condition (6) is satisfied if $p_1 \in [\underline{p}_1 = \frac{A+\theta_1}{2} - \sqrt{\triangle_1}, \bar{p}_1 = \frac{A+\theta_1}{2} + \sqrt{\triangle_1}]$ and condition (7) is satisfied if $p_1 \notin [p_1^L = \frac{A+\theta_2}{2} - \sqrt{\triangle_2}, p_1^U = \frac{A+\theta_2}{2} + \sqrt{\triangle_2}]$, where $\triangle_i = \delta[\frac{(A-\theta_i)^2}{4} - \frac{(A-2\theta_i+c)^2}{9}]$, $i = 1, 2$. Clearly, $\underline{p}_1 < p_1^L < p_1^M$, assuming $\triangle_1 > \triangle_2 > \frac{(\theta_2-\theta_1)^2}{4}$.[3] Therefore, any $p_1 \in [\underline{p}_1, p_1^L]$ and $p_2 = p_2^M$ will satisfy both constraints. See Figure 1 for a diagrammatic representation. If the union is of low type, price will be distorted downward to a limit price such as $p_1^L$. This is in line with the well known result of limit pricing (Milgrom and Roberts, 1982). We may also specify suitable out-of-equilibrium beliefs that support the proposed (perfect Bayesian) equilibrium.

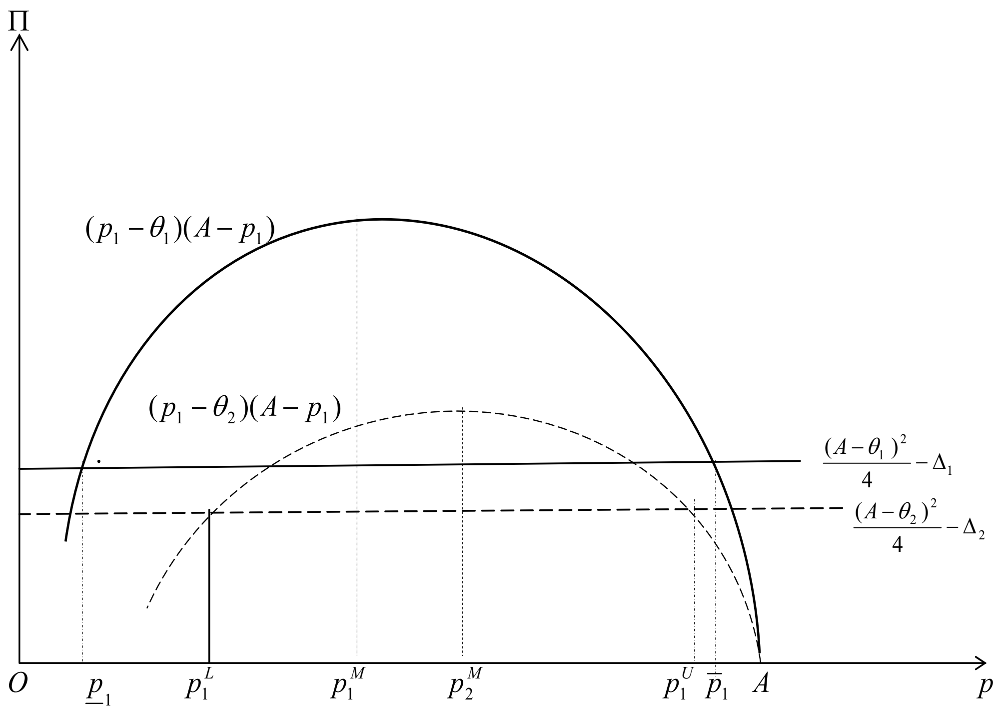


Figure 1: Limit pricing

**Pooling equilibrium:** Alternatively, if $ER < 0$ entry will not take place, unless the

[3]Which holds for a wide range of parametric configurations: $\triangle_1 > \triangle_2 \Rightarrow c < \frac{2A+7\theta_1+7\theta_2}{16}$ and $\triangle_2 > \frac{(\theta_2-\theta_1)^2}{4} \Rightarrow \delta > [\frac{(\theta_2-\theta_1)^2}{4}]/[\frac{(A-\theta_2)^2}{4} - \frac{(A-2\theta_2+c)^2}{9}]$.

entrant is able to update its priors and be sure that the incumbent is high cost type. Therefore, by not signalling the true $\theta$ the union-firm pair can prevent entry and be better off when the true $\theta$ is $\theta_2$. Formally, the equilibrium price must satisfy the incentive compatibility conditions of the low type, which is given by condition (6), and the following condition for the high type

$$(p_1 - \theta_2)(A - p_1) \geq \frac{(A-\theta_2)^2}{4} - \delta[\frac{(A-\theta_2)^2}{4} - \frac{(A-2\theta_2+c)^2}{9}]. \tag{8}$$

Note that this is just condition (7) with the inequality now reversed, so that the untruthful behaviour is preferred. Clearly, the symmetric information monopoly price corresponding to the low type union, $p_1^M$, falls in the overlapping range of prices that satisfy both conditions (6) and (8), by construction. Therefore, it is optimal for the firm-union pair to set $p_1^M$ regardless of $\theta = \theta_1$ or $\theta = \theta_2$.

**Proposition 1**: *When wage is not observed by the entrant, entry threat infuses inefficiency into the union-firm bargaining in the form of over-employment. Under separating equilibrium the low type is over-employed, and under pooling equilibrium the high type is over-employed. Along with price, wage is also distorted downwardly.*

The inefficiency results from the fact that without distorting price the low cost cannot distinguish itself from the high type, and nor can the high type pretend to be a low type. This is in line with the standard story of limit pricing; the entry implications are also standard. The fact that wage and employment are both bargained over helps to base the incentive constraints on the joint surplus, and this ensures the existence of separating equilibrium. Pal and Saha (2008) have shown that under right-to-manage bargaining entry threat can create frictions in rent-sharing and may render signalling impossible.[4] Under

[4] Regardless of the bargaining protocol, limit pricing requires the incumbent firm to commit to a high level of employment. However, under right-to-manage bargaining anticipation of such commitment enables the union to bargain for a very high wage and to shift the cost of signalling largely to the firm. This can disrupt the firm's incentive constraints and separating equilibrium may not exist. Under efficient bargaining such hard bargaining by the union is not possible, because wage and employment are determined

'efficient bargaining' that problem is averted, but still the firm-union pair has only one instrument of signalling in their disposal: price. This limits their ability to transmit information, or alternatively makes it easier to suppress information. Therefore, price distortions are still necessary to reveal information. Consequently inefficiency arises.

We should also note that along with price wage is also reduced. Under separating equilibrium employment and wages are: for $\theta_1$, $l_1^L = 1 - p_1^L > 1 - p_1^M = l_1^M = \frac{A-\theta_1}{2}$ and $w_1^L = \gamma(p_1^L - \theta_1) + \theta_1 < w_1^M$; and for $\theta_2$, $l_2 = l_2^M$, $w_2 = w_2^M$. For $(l, w)$ to be efficient, it must lie on the union-firm contract curve, $l_i = \frac{A-\theta_i}{2}$, $i = 1, 2$. Clearly, that is not the case for $\theta = \theta_1$. Under pooling equilibrium, the outcome is inefficient for $\theta = \theta_2$: $l_2 = l_1^M > l_2^M = \frac{A+\theta_2}{2}$ and $w_2 = w_1^M < w_2^M$.

### 3.1 Both wage and price are observable

We now turn to the scenario where both wage and price are observed by the entrant. Since there are two instruments available, one expects that information revelation will now be easier, and distortions may not necessarily occur on both dimensions. Alternatively stated, information suppression may now become difficult, and the scope for pooling equilibrium may diminish. This will surely benefit the entrant, but may or may not benefit the union-firm pair.[5]

**Separating equilibrium:** First consider the case of $ER > 0$. As before wage and employment must satisfy incentive constraints for both the firm and the union. But now as the wage is observable, it is no longer just a rent sharing mechanism. It may need to be distorted for the purpose of revealing information. Therefore, we cannot focus on the joint surplus in this case. Individual parties' incentive constraints are to be considered.

The pair $(l_1, w_1)$ will reveal $\theta = \theta_1$, if the following two conditions are met: (a) *Both* the firm and the $\theta_1$ union find it profitable to choose $(l_1, w_1)$ and deter entry, instead of

simultaneously.

[5]Side-payments between the union and the firm are ruled out following other works in the literature Pal and Saha (2008) and Ishiguro and Shirai (1998). Institutional mechanisms governing industrial relations and trade union agreements commonly bar such side payments in most countries.

choosing $(l_1^M, w_1^M)$ and induce entry. (b) *Either* the firm *or* the $\theta_2$ union, or *both* must be worse off by choosing $(l_1, w_1)$ instead of choosing $(l_2^M, w_2^M)$.

Note the difference in the second requirement. For separation of the low type, it is necessary that the high type does not mimic the low type. If the high type were to mimic the low type, the entrant must reason that it must be in the interest of *both* parties; otherwise one party would veto such a proposal. Suppose, the firm benefits from such mimicking, but the union does not; then the only way the firm can make the union agree to this is by making a side-payment. But by assumption side-payments are ruled out. Therefore, the firm will have no choice but stick to their status quo which is $(l_2^M, w_2^M)$ the symmetric information wage and employment.

In other words, we are invoking an 'intuitive rule' that the entrant will apply in its reasoning about the bargaining. Unless both parties stand to gain, no deviation from the symmetric information contract will be agreed upon. Taking the symmetric information contract as a status quo and enforcing in the case of a disagreement is to avoid any bargaining impasse. The following assumptions make it clear.

**Assumption 1:** If any wage and/or employment are distorted from their symmetric information level, it must be agreed upon both parties.

**Assumption 2:** When a proposed distortion does not benefit both parties, the symmetric information wage and employment will be agreed upon.

Formally, the incentive compatibility conditions of the firm and the union are given by (9) and (10) respectively, if the union is $\theta_1$ type; and by (11) and (12) respectively, if the union is $\theta_2$ type.

$$(A - l_1 - w_1)l_1 \geq (1-\gamma)[(1-\delta)\frac{(A-\theta_1)^2}{4} + \delta\frac{(A-2\theta_1+c)^2}{9}] \tag{9}$$

$$(w_1 - \theta_1)l_1 \geq \gamma[(1-\delta)\frac{(A-\theta_1)^2}{4} + \delta\frac{(A-2\theta_1+c)^2}{9}] \tag{10}$$

$$(A - l_1 - w_1)l_1 \leq (1-\gamma)[(1-\delta)\frac{(A-\theta_2)^2}{4} + \delta\frac{(A-2\theta_2+c)^2}{9}] \tag{11}$$

$$(w_1 - \theta_2)l_1 \leq \gamma[(1-\delta)\frac{(A-\theta_2)^2}{4} + \delta\frac{(A-2\theta_2+c)^2}{9}] \tag{12}$$

The separating equilibrium pair $(l_1, w_1)$ solves the following problem:

$$\max_{w_1,l_1} Z_1 = U_1^{\gamma}\Pi_1^{1-\gamma} = [(w_1-\theta_1)l_1]^{\gamma}[(A-l_1-w_1)l_1]^{1-\gamma}$$

subject to the constraints

(9) and (10) and [(11) or (12) or both].

Now, note that (9) and (11) cannot be satisfied simultaneously. Moreover, any $(w_1, l_1)$ that satisfies (9), also satisfies (11) if the inequality sign is reversed in the latter. That means, any wage employment pair that is incentive compatible for 'the firm facing a $\theta_1$ union' to signal the true state will also allow 'the firm facing a $\theta_2$ union' to mimic 'the firm facing a $\theta_1$ union'. But by Assumption 1 'the firm facing a $\theta_2$ union' will not be able to set $(w_1, l_1)$ unless the $\theta_2$ union also wants to mimic the $\theta_1$ union. Therefore, for separating equilibrium to work we need to ensure that the $\theta_2$ union does not find optimal to mimic the $\theta_1$ union; in other words, constraint (12) are to be satisfied along with (9) and (10).

Consider Figure 2 for a graphical illustration. Any $(l_1, w_1)$ pair that lies above the indifference curve $\bar{u}_1\bar{u}_1$ of the $\theta_1$ union and below the indifference curve $\bar{u}_2\bar{u}_2$ of the $\theta_2$ union satisfies both (10) and (12). Here $\bar{u}_1\bar{u}_1$ corresponds to a net wage bill (for $\theta_1$ union): $(w_1-\theta_1)l_1 = \gamma[(1-\delta)\frac{(A-\theta_1)^2}{4} + \delta\frac{(A-2\theta_1+c)^2}{9}] = \bar{u}_1$; and $\bar{u}_2\bar{u}_2$ corresponds to a net wage bill (of $\theta_2$ union): $(w_1-\theta_2)l_1 = \gamma[(1-\delta)\frac{(A-\theta_2)^2}{4} + \delta\frac{(A-2\theta_2+c)^2}{9}] = \bar{u}_2$. Since $\bar{u}_2\bar{u}_2$ is flatter than $\bar{u}_1\bar{u}_1$ on the $(l, w)$ plane, the set of $(w, l)$ satisfying (10) and (12) is non-empty. Moreover, the point of intersection $B$ of these two indifference curves corresponds to a lower level of employment than point $D$ which occurs at the intersection of $\bar{u}_1\bar{u}_1$ and the iso-profit curve of the 'firm facing a $\theta_1$ union' denoted as $\bar{\Pi}_1\bar{\Pi}_1$. This iso-profit curve maps all $(w, l)$ that ensures equality in condition (9) (see Appendix 1 for proof).

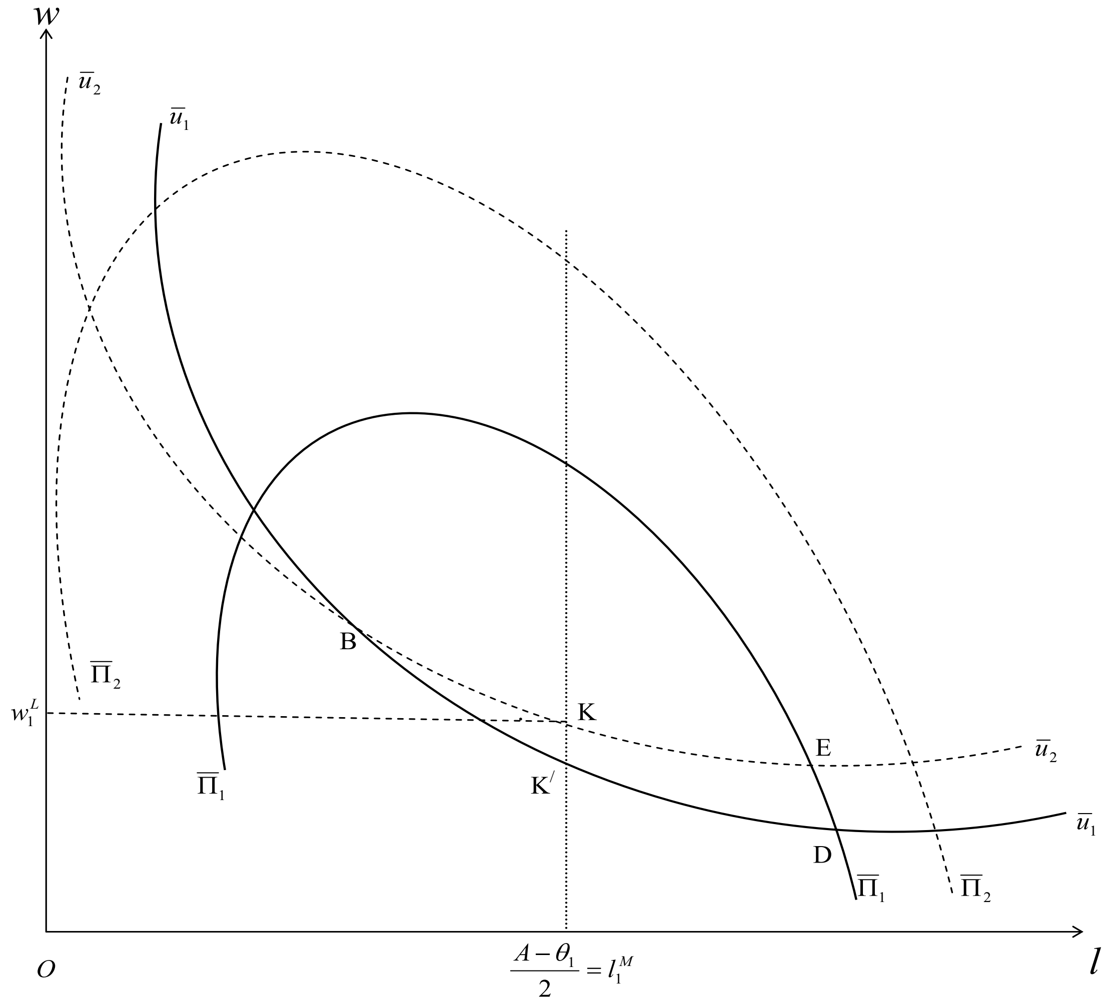


Figure 2: Observable wage

Hence in Figure 2 any $(l_1, w_1)$ belonging to the region $BKED$ can credibly signal that the union is $\theta_1$ type. Now it can be checked that the contract curve involving the firm and the $\theta_1$ union, which is $l = \frac{A-\theta_1}{2}$, runs through the region $BKED$ and point $B$ always lies to the left of it (see Appendix 2 for proof). Therefore, it immediately follows that symmetric information employment will truthfully reveal the union type. In other words, employment will remain efficient.

But what about the wage? Clearly, for the separating equilibrium to work, wage must lie between point $K'$ and $K$. Let us denote the wage at point $K$ by $w_1^L$. As long as $w_1^M < w_1^L$ the symmetric information wage is also not distorted. It can be shown that that is indeed the case as long as the union's bargaining power is below a critical level, say $\hat{\gamma}$ (see Appendix 3 for proof).[6] But if $\gamma > \hat{\gamma}$, $w_1$ needs to be restricted to $w_1^L$ for all

[6] $w_1^L = \theta_2 + \frac{2}{A-\theta_1}\gamma[(1-\delta)\frac{(A-\theta_2)^2}{4} + \delta\frac{(A-2\theta_2+c)^2}{9}]$,

$\gamma \geq \hat{\gamma}$. Thus the separating equilibrium employment-wage pairs are $(l_1^M, w_1^M)$ for $\gamma < \hat{\gamma}$, and $(l_1^M, w_1^L)$ for $\gamma \geq \hat{\gamma}$. For $\theta_2$ union the wage-employment choice is $(w_2^M, l_2^M)$. Since these points belong to the respective type's contract curve, we can argue that under separating equilibrium efficiency is preserved, though the low type union takes a wage cut if $\gamma > \hat{\gamma}$.

**Pooling equilibrium:** If the entrant's prior beliefs are such that its expected profit is negative ($ER < 0$), the possibility of pooling equilibrium emerges. Here, the $\theta_2$ type union would like to mimic a $\theta_1$ type union; but in order to do so the firm and the union both must agree. That is, *both* must find it profitable to set $(w_1^M, l_1^M)$ and deter entry, instead of sticking to the (status quo) $(l_2^M, w_2^M)$ and induce entry. Therefore, the incentive compatibility conditions (11) and (12) must both be reversed, as given by the following.

$$(A - l_1 - w_1)l_1 \geq (1-\gamma)[(1-\delta)\frac{(A-\theta_2)^2}{4} + \delta\frac{(A-2\theta_2+c)^2}{9}] \tag{11a}$$

$$(w_1 - \theta_2)l_1 \geq \gamma[(1-\delta)\frac{(A-\theta_2)^2}{4} + \delta\frac{(A-2\theta_2+c)^2}{9}] \tag{12a}$$

Other incentive compatibility conditions remain unchanged. For $\theta_2$ union the problem is to solve the following problem.

$$\max_{w_1,l_1} Z_2 = U_2^{\gamma}\Pi_2^{1-\gamma} = [(w_1-\theta_2)l_1]^{\gamma}[(A-l_1-w_1)l_1]^{1-\gamma}$$

subject to the constraints

(9), (10), (11a) and (12a).

By a similar argument made in the case of separating equilibrium it can be shown that $(l_1^M, w_1^M)$ always satisfies (9), (10) and (11a), but not (12a) if $\gamma \leq \hat{\gamma}$. This implies that a deviation from $(w_2^M, l_2^M)$ to $(w_1^M, l_1^M)$ will not be agreed upon by both the firm and the $\theta_2$ union, and therefore, by Assumption 2 the status quo $(w_2^M, l_2^M)$ remains. In other words there is no pooling equilibrium, if $\gamma \leq \hat{\gamma}$.

But if $\gamma > \hat{\gamma}$, $(l_1^M, w_1^M)$ satisfies all four constraints ((9), (10), (11a) and (12a)). That means both the the firm and the $\theta_2$ union will agree to setting $(l_1^M, w_1^M)$ instead of $(w_2^M, l_2^M)$. With this intuitive reasoning we can argue that a pooling equilibrium is possible only if

$\hat{\gamma} = \frac{(\theta_2-\theta_1)\frac{A-\theta_1}{2}}{[\frac{(A-\theta_1)^2}{4} - \frac{(A-\theta_2)^2}{4}] + \delta[\frac{(A-\theta_2)^2}{4} - \frac{(A-2\theta_2+c)^2}{9}]}$.

the union is sufficiently powerful. The strength of the union matters because a strong union has much more to gain from preventing entry (by suppressing information), while its bargaining partner, a weak firm, does not have much profit to protect; nevertheless it is also better off by preserving its market power. Hence, the pooling equilibrium emerges. Of course with it over-employment will occur for $\theta_2$ union. We can here also suitably specify the out-of-equilibrium beliefs of the entrant to support the proposed equilibrium.

**Proposition 2**: *When the entrant observes both price and wage, entry threat does not cause inefficiency to the bargaining outcome if the union's bargaining power is below a critical level ($\hat{\gamma}$), although the $\theta_1$ union may accept a reduction in wage. Pooling equilibrium does not exist and the separating equilibrium does not involve any limit pricing. But if the union's bargaining power exceeds $\hat{\gamma}$ and the entrant's priors are such that its expected profit is negative ($ER < 0$), then a pooling equilibrium emerges in which the $\theta_2$ union is over-employed.*

Comparing Proposition 1 and Proposition 2 we can say that the possibility of inefficient outcomes is much less when wage is also observable to the entrant. The intuition is that with an additional information carrier (namely the wage) information suppression is more difficult, or equivalently information revelation becomes easier. Consequently, pooling equilibrium may not exist at all. Above all, the separating equilibrium employment is not distorted from the symmetric information levels. Only when the union is powerful, information suppression becomes optimal for both parties, and some inefficiency emerges. In a nutshell, the availability of an additional signalling device makes information revelation much easier, and thus mitigates to a great extent the inefficiency problem caused by asymmetric information.

# 4 Concluding remarks

Our analysis suggests that for the purpose of improving efficiency it is not sufficient to induce the firms and unions to bargain over both wage and employment by some institutional mechanism, or to introduce an element of profit sharing in the payment system when bargaining takes place only over wage. When there are entry threats the firms may be required to disclose wage agreements (and similar agreements with other input suppliers). Though this will not directly give away the incumbent's private cost information, it will certainly improve the entrant's ability to process information, and yet at the same time will save the incumbents from taking costly signalling measures. The society will also be better off by encouraging right level of entry. To what extent this can be done in reality remains an open issue, as it has bearing on both industrial relations regulation and anti-trust policies.

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# Appendix

**Appendix 1: The point B always lies to the left of point D as shown in Figure 2**

Proof: We have, $\frac{\partial w}{\partial l}\mid_{\bar{u}_1\bar{u}_1} = -\frac{w_1-\theta_1}{l_1} < -\frac{w_1-\theta_2}{l_1} = \frac{\partial w}{\partial l}\mid_{\bar{u}_2\bar{u}_2}$. That is, the union's indifference curve $\bar{u}_1\bar{u}_1$ is steeper than $\bar{u}_2\bar{u}_2$ in the $l-w$ plane. Therefore, these two indifference curves intersect only once.

Now, it is sufficient to prove that the level of employment corresponding to point B ($l_1^B$) is less than the level of employment corresponding to point D ($l_1^D$): $l_1^B < l_1^D$.

Now solving the equations of $\bar{u}_1\bar{u}_1$ and $\bar{u}_2\bar{u}_2$, we get $l_1^B = \frac{\bar{u}_1-\bar{u}_2}{\theta_2-\theta_1}$, where $\bar{u}_1 = \gamma[(1-\delta)\frac{(A-\theta_1)^2}{4} + \delta\frac{(A-2\theta_1+c)^2}{9}]$ and $\bar{u}_2 = \gamma[(1-\delta)\frac{(A-\theta_2)^2}{4} + \delta\frac{(A-2\theta_2+c)^2}{9}]$.

Again solving the equations of $\bar{u}_1\bar{u}_1$ and $\bar{\Pi}_1\bar{\Pi}_1$, we get $l_1 = \frac{1}{2}[A-\theta_1 \pm \sqrt{(A-\theta_1)^2 - \frac{4}{\gamma}\bar{u}_1}]$. We discard the root $\frac{1}{2}[A-\theta_1 - \sqrt{(A-\theta_1)^2 - \frac{4}{\gamma}\bar{u}_1}]$, since it corresponds to the point of intersection of $\bar{u}_1\bar{u}_1$ and $\bar{\Pi}_1\bar{\Pi}_1$ that is closer to the $w$-axis. Hence, $l_1^D = \frac{1}{2}[A-\theta_1 + \sqrt{(A-\theta_1)^2 - \frac{4}{\gamma}\bar{u}_1}]$.

Now,

$$
\begin{aligned}
l_1^B < l_1^D &\Rightarrow \frac{\bar{u}_1-\bar{u}_2}{\theta_2-\theta_1} < \frac{1}{2}[A-\theta_1 + \sqrt{(A-\theta_1)^2 - \frac{4}{\gamma}\bar{u}_1}] \\
&\Rightarrow \gamma[(1-\delta)\frac{2A-\theta_1-\theta_2}{4} + \frac{4\delta}{9}(A-\theta_1-\theta_2+c) < \frac{1}{2}[A-\theta_1 + \sqrt{\delta(A-\theta_1)^2 - \frac{4\delta}{9}(A-2\theta_1+c)^2}],
\end{aligned}
$$

which is obvious for $\gamma = 0$. Since the LHS is increasing in $\gamma$ and the RHS doesnot depend on $\gamma$, it is sufficient to show that the above inequality is true for $\gamma = 1$. Now, if $\gamma = 1$, the above inequality implies that

$$\frac{2A-\theta_1-\theta_2}{4} - \frac{\delta}{36}(2A+7\theta_1+7\theta_2-16c) < \frac{A-\theta_1}{2} + \sqrt{\delta\{\frac{(A-\theta_1)^2}{4} - \frac{(A-2\theta_1+c)^2}{9}\}},$$

which is obvious, since $\frac{2A-\theta_1-\theta_2}{4} < \frac{A-\theta_1}{2} \Rightarrow \theta_1 < \theta_2$ and $c < \frac{2A+7\theta_1+7\theta_2}{16}$ (by construction). QED

**Appendix 2: The point B always lies to the left of the contract curve of the low state: $l = \frac{A-\theta_1}{2}$**

Proof: We need to prove that $l_1^B < \frac{A-\theta_1}{2}$.

$$\begin{aligned}
&l_1^B < \frac{A-\theta_1}{2}\\
\Rightarrow&\frac{\bar{u}_1-\bar{u}_2}{\theta_2-\theta_1} < \frac{A-\theta_1}{2}\\
\Rightarrow&\gamma[(1-\delta)\frac{2A-\theta_1-\theta_2}{4} + \frac{4\delta}{9}(A-\theta_1-\theta_2+c)] < \frac{A-\theta_1}{2},
\end{aligned}$$

which is obvious for $\gamma = 0$. If the above is true for $\gamma = 1$, then it is true $\forall\gamma$.

Now, if $\gamma = 1$,

$$\begin{aligned}
&l_1^B < \frac{A-\theta_1}{2}\\
\Rightarrow&-\frac{\theta_2-\theta_1}{4} < \frac{\delta}{36}[2A+7\theta_1+7\theta_2-16c],
\end{aligned}$$

which is true since $\theta_2 > \theta_1$ and $c < \frac{2A+7\theta_1+7\theta_2}{16}$ (by construction). QED

**Appendix 3: If $\gamma > \hat{\gamma}$, $w_1^M > w_1^L$**

Proof: $w_1^L$ is given by the solution of $(w_1-\theta_2)l_1 = \bar{u}_2$ and $l_1 = \frac{A-\theta_1}{2}$, where $\bar{u}_2 = \gamma[(1-\delta)\frac{(A-\theta_2)^2}{4} + \delta\frac{(A-2\theta_2+c)^2}{9}]$. Solving these two equations, we get $w_1 = \theta_2 + \frac{2}{A-\theta_1}\gamma[(1-\delta)\frac{(A-\theta_2)^2}{4} + \delta\frac{(A-2\theta_2+c)^2}{9}] = w_1^L$, say. Now,

$$\begin{aligned}
&w_1^L < w_1^M\\
\Rightarrow&\theta_2 + \frac{2\gamma}{A-\theta_1}[(1-\delta)\frac{(A-\theta_2)^2}{4} + \delta\frac{(A-2\theta_2+c)^2}{9}] < \theta_1 + \gamma\frac{A-\theta_1}{2}\\
\Rightarrow&\gamma > \frac{(\theta_2-\theta_1)\frac{A-\theta_1}{2}}{[\frac{(A-\theta_1)^2}{4} - \frac{(A-\theta_2)^2}{4}] + \delta[\frac{(A-\theta_2)^2}{4} - \frac{(A-2\theta_2+c)^2}{9}]} = \hat{\gamma},
\end{aligned}$$

say. Therefore, if $\gamma > \hat{\gamma}$, $w_1^M > w_1^L$. QED