Profit-Sharing : Does it Reduce Bargaining Inefficiencies ?

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Abstract

Within an incomplete information framework, we develop a model of wage determination in a unionized Cournot oligopoly. The assumption of incomplete information allows the possibility of strikes, which waste industry potential ressources, at equilibrium. Facing such deadweight loss, the government or the social planner may decide to adopt a policy, like a profit-sharing scheme. Under two different bargaining structures (firm-level vs industry-level), we investigate the effects of adopting profit-sharing on the wage outcome and the bargaining inefficiencies, like strikes. Our main results are as follows. If the base wage bargaining takes place at the industry-level, then the introduction of a profit-sharing scheme increases the bargaining inefficiencies. But if the base wage bargaining takes place at the firm-level and the number of firms in the industry is greater than two, then the introduction of a profit-sharing scheme reduces the bargaining inefficiencies.

Keywords: wage bargaining, profit-sharing, incomplete information, strikes.
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1 Introduction

Wage bargaining is unquestionably the mean feature of collective bargaining contracts, but contracts also deal with issues related to the employment level or other forms of pay like workers' participation schemes. Theoretically, Weitzman (1985) has stressed the impact of profit-sharing schemes on the unemployment level, in the framework of macroeconomic models of an imperfectly competitive economy. He has shown that a profit-sharing system can increase the employment level if it lowers the base wage. But Weitzman's argumentation has been challenged on two points: (i) the problematic of the implementation of profit-sharing schemes at the firm-level [see Wadhwani (1988)], (ii) there is little empirical evidence that by introducing profit-sharing schemes firms are able to reduce the base wage and to increase the employment level [see Bhargava and Jenkinson (1992), Cahuc and Dormont (1992,1993)].

However, Weitzman's argumentation as well as the problematic of its implementation have been analyzed assuming monopolistic competition on the product market. But other market structures, like oligopolistic industries, also derserve some interest. Once we take into account the interdependence of firms in a unionized Cournot oligopoly, a profit-sharing scheme may be a strategic commitment, which permits a firm to increase its market share, its profits, and its workers' pay [see Bensaïd *et al.* (1990), Bensaïd and Gary-Bobo (1991), Fung (1989), Stewart (1989)].

During the eighties profit-sharing schemes have become a major alternative form of compensation in the U.K. and even more in France, with the government promoting profit-sharing through tax incentives. In U.K., there were 145 profit-sharing agreements in 1987 and 2049 in 1991. During the same period the number of workers involved in profit-sharing agreements increased from 26,411 to 581,000 [see Bhargava and Jenkinson (1992)]. In France, profit-sharing schemes have been multiplying quite substantially [see Table 1]. In 1986, there were 2,160 profit-sharing agreements and 10,700 in 1990. In 1986, 590,000 workers were involved in profit-sharing schemes, and there were 2,000,000 in 1990.

	1986	1987	1988	1989	1990
Agreements in force	2160	2630	4600	7000	10700
Workers involved (thousands)	590	730	980	1390	2000
Percentage of workers involved	4	5	7	10	14

Table 1: Profit-Sharing in France. Excluding agriculture and public administration. Source: L.Bloch (1992).

However, empirical studies, based on British or French data[1], suggest that the base wage does not decrease or even rises after the introduction of profit-sharing [see Bhargava and Jenkinson (1992) for the U.K., Cahuc and Dormont (1992,1993) for France]. In France, it is forbidden to substitute the profit-share for the base wage. Also, empirical investigations made by Cahuc and Dormont (1992,1993) seem to confirm that this prohibition is respected. But this *add-on* nature of profit-sharing is inconsistent with Weitzman's line of argument. Therefore, other motives for the introduction of profit-sharing and its growth have to be advanced.

A first motive is that the introduction of profit-sharing may increase worker productivity and firm profitability. For the French manufacturing industry, Cahuc and Dormont (1992) have observed a postive correlation between profit-sharing systems and firms' economic results in terms of productivity and growth. This is not too surprising since one main objective of the French legislation was to stimulate the productivity and competitivity of the manufacturing industry. Thereafter, Cahuc and Dormont (1993) have studied the causality between profit-sharing and productivity: the huge increase in profit-sharing agreements seems to improve the productivity of the French manufacturing industry. Bhargava and Jenkinson (1992) have observed similar results for the U.K. (manufacturing, construction, and retailing sectors) during the eighties.

All these previous studies, empirical or theoretical, have considered complete information frameworks. But once we consider incomplete information bargaining models, a second motive why profit-sharing is introduced may be put forward: profit-sharing may reduce bargaining inefficiencies, like the strike activity. Bargaining is interpreted as a process of exchange of offers and counteroffers necessitated by opposite preferences and by initial differences in information known to the negotiators separately. The assumption of incomplete information allows the possibility of strikes (or delay in reaching a base wage agreement), which waste industry ressources, at equilibrium. Facing such deadweight loss of wasting ressources, the government or the social planner may decide to adopt a policy. Is profit-sharing an accurate policy for reducing bargaining inefficiencies?

In France, wage negotiations are mainly conducted at the firm-level. Since the mid-eighties, we have observed a huge increase of profit-sharing agreements in the French manufacturing industry, associated with a sharp decrease in the number of strikes and workdays not worked. In 1986, there were 1,041,400 workdays not worked and 693,700 in 1990 [see Tables 1 and 2]. Similar facts have been observed for the U.K. (In 1987, there were

[1] Cahuc and Dormont (1992,1993) empirical studies are based on a French panel data consisting of manufacturing firms observed over the period 1986-1989, while Bhargava and Jenkinson (1992) study is based on a comprehensive data set of U.K. companies that introduced profit-sharing schemes during the period 1978-1989.

3,546,000 workdays not worked and 761,000 in 1991). All these stylized facts supports the study of the impact of profit-sharing on the relationship between the bargaining structure, the wage outcome and the strike activity. So, we slightly modify our question as follows. Is profit-sharing an accurate policy for reducing bargaining inefficiencies whatever the bargaining structure?

France	Localized Strikes			Generalized Strikes			Total of Strikes	
Year	NLS	WLS	DS	NGS	WGS	DS	NTS	DS
1986	1391	21,8	567,6	78	194,4	473,8	1469	1041,4
1987	1391	18,6	511,5	66	135,3	457,5	1457	969,0
1988	1852	27,2	1094,0	46	76,8	147,6	1898	1241,6
1989	1743	20,3	800,2	38	54,9	104,1	1781	904,1
1990	1529	18,5	528,0	29	55,8	165,7	1558	693,7
1991	1318	18,8	497,3	12	183,0	168,2	1330	665,5
1992	1330	16,3	359,1	15	123,1	131,3	1345	490,4

Table 2: Strikes and Lockouts in France. NLS: the number of localized strikes (the call to strike concerns only one establishment); one strike represents one establishment on strike. WLS: monthly average of workers involved in strikes in progress each month (thousands). DS: wordays not worked (thousands). NGS: the number of generalized strikes (the call to strike extends to several enterprises); one strike represents several enterprises. WGS: workers involved in strikes (thousands). NS=NLS+NGS. Agriculture and public administration are excluded. Source: ILO Yearbook 1995.

This paper is a first attempt to give a theoretical answer to this question. Within an incomplete information framework, we develop a model of wage determination with profit-sharing in a unionized Cournot oligopoly. We impose the following game structure. Firstly, given a profit-sharing parameter fixed statutorily by the government, unions and firms negotiate over the base wage level according to institutional features (industry-level vs firm-level bargaining). Secondly, firms compete à la Cournot on the product market. We adopt Rubinstein (1982) alternating-offer bargaining model with two-sided incomplete information about the negotiators' impatience, for describing the base wage bargaining process. In Vannetelbosch (1997), we have studied the same model but without profit-sharing. We have shown that firm-level wage outcome is not necessarily lower than industry-level wage outcome, while potential inefficiency is larger when bargaining takes place at the industry-level.

In this paper, we go beyond the analysis offered in Vannetelbosch (1997) by investigating, for different bargaining structures, how profit-sharing as well as private information affects the base wage, the level of employment and the strike activity. The main results of the paper are as follows. Firstly, if the base wage bargaining takes place at the industry-level, then the introduction of a profit-sharing scheme increases the potential bargaining inefficiencies. But if the base wage bargaining takes place at the firm-level and the number of firms in the industry is greater than two, then the introduction of a profit-sharing scheme reduces the potential bargaining inefficiencies. French experience seems to corroborate the model developed in the paper as well as an incomplete information framework for investigating wage negotiations with profit-sharing [see Tables 1 and 2]. Secondly, the firm-level base wage outcome is not necessarily lower than the industry-level base wage outcome. This result is due to the assumption of two-sided incomplete information. When the game becomes one of complete information then the industry-level base wage outcome is always higher. Thirdly, potential inefficiency or strike activity is larger when bargaining takes place at the industry-level. These last two results are also valid in the case without profit-sharing [see Vannetelbosch (1997)].

The paper is organized as follows. In Section 2, the model is presented. The Cournot game in the oligopolistic market is solved assuming that the base wages have already been determined. Section 3 describes the base wage bargaining game and solves this game for the industry-level bargaining system. It also analyses the relationship between the industry-level bargaining structure, the profit-sharing system, and the strike activity. Section 4 is devoted to the base wage bargaining game for the firm-level bargaining system and analyses the relationship between the firm-level bargaining structure, the profit-sharing system, and the strike activity. Finally, Section 5 concludes.

2 Description of the Oligopolistic Market

We consider a market for a homogeneous commodity produced by $N \geq 2$ identical profit-maximizing firms, denoted $n = 1, ..., N$. Let q_n denotes the quantities of the commodity produced by firm n. Let $P(Q) = a - b\,Q$ be the market-clearing price when aggregate quantity on the market is $Q \equiv \sum_{n=1}^{N} q_n$. More precisely,

$$P\left(Q\right) = \begin{cases} a - b\,Q & \text{if} \quad Q < \frac{a}{b} \\ 0 & \text{if} \quad Q \geq \frac{a}{b} \end{cases} \tag{1}$$

with $a, b > 0$. We assume that the firms are producing under constant returns to scale with labour as the sole input, i.e. $q_n = l_n$, where l_n is labour input. The total cost to firm n of producing quantity q_n is $q_n w_n$. The general price level is normalized to unity so that w_n is the real base wage in firm n.

Associated with each firm there is a continuum of identical workers who supply each one unit of labour with no disutility. We denote by $\overline{w}$ the expected real income of a worker who loses his job. It may be interpreted as the unemployment benefit. The total real profit, π_n, in firm n is

$$\pi_n\left(w_n, l_n, (q_1, ..., q_N)\right) = \begin{cases} \left(a - b\sum_{n=1}^{N} q_n\right) q_n - l_n w_n & \text{if } \sum_{n=1}^{N} q_n < \frac{a}{b} \\ 0 & \text{if } \sum_{n=1}^{N} q_n \geq \frac{a}{b} \end{cases} \tag{2}$$

In a profit-sharing scheme, firms promise to pay each worker a base wage and a share of real profits per capita, λ. We consider the following profit-sharing system: the government or social planner fixes at some predetermined value the profit-sharing parameter λ, letting firms and unions negotiate over the base wage. Profit-sharing is assumed to be enforceable by law. The owners of the firms are assumed to be risk-neutral. Therefore, the utility level of firm n is given by

$$\Lambda_n\left(w_n, l_n, (q_1, ..., q_N)\right) = (1 - \lambda) \cdot \pi_n\left(w_n, l_n, (q_1, ..., q_N)\right); \tag{3}$$

where λ is the share of the profit going to the workers.

In each firm the risk-neutral workers are represented in the base wage bargaining process by a utilitarian union. The continuum of workers who supply labour to each firm is normalized to unity. Hence, local union n's utility is given by

$$u_n\left(w_n, \overline{w}, l_n, (q_1, ..., q_N)\right) = l_n\, w_n + (1 - l_n)\, \overline{w} + \lambda \cdot \pi_n\left(w_n, l_n, (q_1, ..., q_N)\right). \tag{4}$$

Interactions between the product market, the profit-sharing system and the bargaining level are analysed according to the following game structure. In stage one, wages are bargained at the firm-level (local wage bargaining) or at the industry-level (central wage bargaining). In stage two, Cournot competition occurs: firms simultaneously choose their quantities to produce, which determines their levels of employment, the industry output and the market clearing price. The model is solved backwards.

In the last stage of the game, the wage levels have already been determined (through collective bargaining) and the N firms compete by choosing simultaneously their outputs (and hence, employment) to maximize profits with price adjusting to clear the market. Assuming an interior solution to the Cournot competition game, the unique Nash equilibrium of this stage game yields:

$$Q^*\left(w_1, ..., w_N\right) = \frac{N\, a - W}{b\,(N+1)}; \tag{5}$$

$$q_n^*\left(w_1, ..., w_N\right) = \frac{a - N\, w_n + W_{-n}}{b\,(N+1)} \qquad n = 1, .., N; \tag{6}$$

where $W = \sum_{n=1}^{N} w_n$ and $W_{-n} = W - w_n$. The Nash equilibrium output of a firm (and hence, equilibrium level of employment) is decreasing with its own wage and the number of firms in the industry, while it is increasing with other firms' wages and total industry demand.

In the first stage of the game, firms and unions negotiate the base wage level foreseeing perfectly the effect of wages on firms' decisions concerning employment. To investigate the effects of adopting profit-sharing on the wage outcome and the bargaining inefficiencies in oligopolistic industries, we consider two bargaining structures: central and local wage settlements.

3 Central Wage Bargaining

At the industry-level, workers are represented by a single unions representative, which we call the central union (CU). The CU's objective function is to maximize the sum of local unions' utilities. The CU negotiates the industry base wage level with the employers representative, which we call the central firm (CF). The CF's objective function is to maximize the sum of local firms' profits. A uniform base wage is set by industrial associations for all firms when the negotiation is centralized. These industrial associations (CU and CF) correctly anticipate the effect of wages on subsequent Cournot competition game.

3.1 The Bargaining Problem

There are two bargainers - also called players - (CU and CF) who must agree on a base wage w from the set X. X is the set of feasible agreements: $X \equiv \{w \in \mathbb{R} \,|\, 0 \leq w \leq a\}$. The players either reach an agreement in the set X, or fail to reach agreement, in which case the disagreement event E occurs. The two bargainers have well defined preferences over $X \cup \{E\}$. The vN-M utility of a local firm n for a base wage agreement w is[2]

$$\Lambda\left(w, l^*\left(w\right)\right) = \left(1-\lambda\right)\left[l^*\left(w\right)\cdot\left(a - w - b\,N\;l^*\left(w\right)\right)\right], \tag{7}$$

while that of a local union n is the total amount of money received by its members

$$u\left(w, \overline{w}, l^*\left(w\right)\right) = l^*\left(w\right)\cdot w + \left(1 - l^*\left(w\right)\right)\cdot\overline{w} + \lambda\cdot\left[l^*\left(w\right)\cdot\left(a - w - b\,N\;l^*\left(w\right)\right)\right]. \tag{8}$$

If the two parties (CU and CF) fail to agree, then a local firm obtains a profit of zero and a local union receives $\overline{w}$, so that CF's and CU's disagreement points are, respectively, zero and $N\overline{w}$. The utility function of a local union is unique only up to a positive affine transformation. For the sake of presentation, we rewrite local union's utility function:

$$u\left(w, \overline{w}, l^*\left(w\right)\right) = l^*\left(w\right)\cdot\left[w - \overline{w}\right] + \lambda\cdot\left[l^*\left(w\right)\cdot\left(a - w - b\,N\;l^*\left(w\right)\right)\right], \tag{9}$$

such that the CU's disagreement point shifts from $N\overline{w}$ to zero. Therefore, the vN-M utility of the local union for the agreement w is

$$u(w, \overline{w}) = \frac{a-w}{b\left(N+1\right)}\left(w - \overline{w}\right) + \lambda\frac{1}{b}\left(\frac{a-w}{N+1}\right)^2, \tag{10}$$

[2] For sake of presentation, we omit the subscript "n" for the central wage bargaining case.

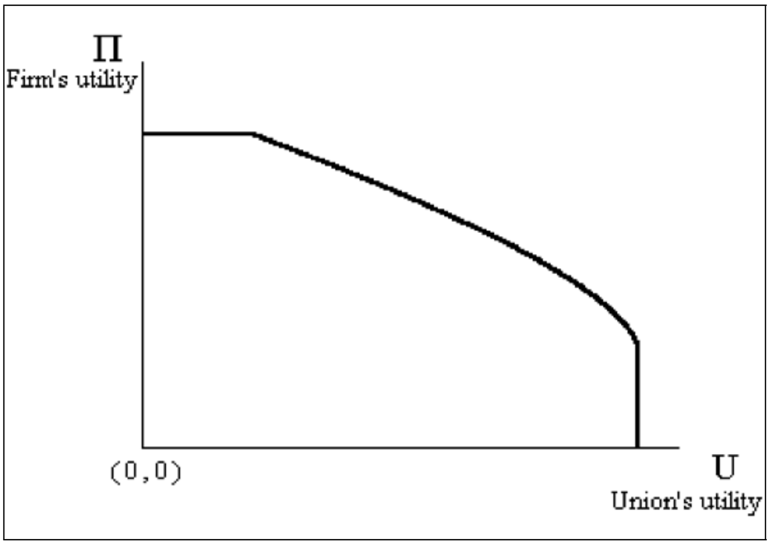

Figure 1: The Bargaining Set

while that of a local firm is

$$\Lambda(w) = (1-\lambda)\frac{1}{b}\left(\frac{a-w}{N+1}\right)^2. \tag{11}$$

We assume that there is free disposal, so that the set of possible utility pairs CU-CF that can result from agreement is

$$Y \equiv \left\{ \left(\left[0, \frac{N}{b}\frac{a-w}{(N+1)}\left((w-\overline{w}) + \lambda\left(\frac{a-w}{N+1}\right)\right)\right], \left[0, \frac{N(1-\lambda)}{b}\left(\frac{a-w}{N+1}\right)^2\right] \right) \middle| w \in X \right\}.$$

This bargaining set Y is depicted in Figure 1. It can be easily verified that it is a compact convex set, which contains the disagreement point $d = (0,0)$ in its interior. Thus $\langle Y, d\rangle$ is a bargaining problem.

3.2 How Do the Agents Reach an Agreement

The negotiation is modelled as a noncooperative bargaining game. The bargaining process is described by Rubinstein (1982) alternating-offer bargaining model. The bargaining procedure is as follows. The bargainers can take actions only at periods in the infinite set $T \equiv \{1, 2, ...\}$. These bargainers make alternatively base wage offers, with CU making offers in odd-numbered periods and CF making offers in even-numbered periods. The bargaining game starts in period 1 with CU proposing an agreement (an element of X). At period 2, CF either accepts the offer or proposes a counteroffer. The game ends when one of the bargainers accepts the opponent's previous offer. No limit is placed on the time that may be expended in bargaining: perpetual disagreement is a possible outcome of the game. An outcome in which agreement on w is reached at period t is denoted by (w, t).

It is assumed that CU is on strike in every period until an agreement is reached. Both players are assumed to be impatient. They have time preferences with constant discount factors. The subscripts "u" and "f" identify CU and CF, respectively. Payoffs in the wage bargaining are given by the vN-M utility functions U (for CU) and Π (for CF) defined[3] by $U(w,t) \equiv N \cdot \delta_{\mathrm{u}}^{t-2} \cdot u(w, \overline{w}, l^*(w))$ and $\Pi(w,t) \equiv N \cdot \delta_{\mathrm{f}}^{t-2} \cdot \Lambda(w, l^*(w))$ for every $(w,t) \in X \times T$, where $\delta_i \in (0,1)$ is player i's discount factor, for $i =$u,f. Perpetual disagreement payoffs are equal to zero for both players. Given the homogeneity of the players (N identical firms and N identical unions), we assume that all local unions have the same discount factor δ_{u} and all firms have also the same discount factor δ_{f}.

Let Δ be the length of the bargaining period. We focus on the case where the interval between offers and counteroffers is short, i.e. as the period length Δ shrinks to zero. We express the bargainers' discount factors in terms of discount rates, r_{u} and r_{f}, by the formula $\delta_i = \exp(-r_i \Delta)$, for $i =$u,f. Greater patience implies a lower discount rate and a higher discount factor: $r_{\mathrm{u}} \geq r_{\mathrm{f}} \Leftrightarrow \delta_{\mathrm{u}} \leq \delta_{\mathrm{f}}$. We denote by $G(r_{\mathrm{u}}, r_{\mathrm{f}})$ the base wage bargaining game with complete information about the players' discount rates in which the period length Δ shrinks to zero.

3.3 The Centralized Agreements

It can be shown that the bargaining game $G(r_{\mathrm{u}}, r_{\mathrm{f}})$ possesses a unique limiting subgame perfect equilibrium (SPE). Let $(U^*(r_{\mathrm{u}}, r_{\mathrm{f}}), \Pi^*(r_{\mathrm{u}}, r_{\mathrm{f}}))$ be the unique limiting SPE payoff vector of $G(r_{\mathrm{u}}, r_{\mathrm{f}})$, which is obtained when the length Δ of a single bargaining period approaches zero. Binmore *et al.* (1986) have shown that the unique limiting SPE of Rubinstein (1982) alternating-offer bargaining game approximates the Nash bargaining solution to the appropriately defined bargaining problem. Their result can be extended to our base wage bargaining game: the unique limiting SPE of $G(r_{\mathrm{u}}, r_{\mathrm{f}})$ approximates the asymmetric Nash bargaining solution to our bargaining problem $\langle Y, d \rangle$, where the parameter α (CU's bargaining power) is computed as follows:

$$\alpha = \frac{r_{\mathrm{f}}}{r_{\mathrm{u}} + r_{\mathrm{f}}}. \tag{12}$$

Thus the predicted wage is

$$w_{\mathrm{c}}^{\mathrm{SPE}} = \arg\max\nolimits_{w \in X} \left[N \cdot u(w, \overline{w})\right]^{\alpha} \left[N \cdot \Lambda(w, \overline{w})\right]^{1-\alpha} .$$

[3]The players' payoffs are discounted from period $t = 2$ since a base wage agreement cannot be reached earlier.

Simple computation gives us

$$w_{\mathrm{c}}^{\mathrm{SPE}} = \overline{w} + (a - \overline{w}) \frac{(N+1)\,\alpha - 2\lambda}{(N+1)\,2 - 2\lambda}, \tag{13}$$

where λ is the profit-sharing parameter and α is the CU's bargaining power. In other words, the more impatient the bargainer, the less powerful. Expression (13) tells us that, in complete information, the central base wage is a decreasing function of the profit-sharing parameter. Indeed, given the CU's bargaining power (α), increasing the profit-sharing parameter (λ) induces an increase in the CU's payoff which must be counterbalanced by a fall of the base wage. Thus the unique SPE payoff vector of $G(r_{\mathrm{u}}, r_{\mathrm{f}})$ is

$$\left(U^*\left(r_{\mathrm{u}}, r_{\mathrm{f}}\right), \Pi^*\left(r_{\mathrm{u}}, r_{\mathrm{f}}\right)\right) = \left(\frac{N\,(2-\alpha)\,\alpha}{4b\,(N+1-\lambda)}\,(a-\overline{w})^2\,, \frac{N\,(1-\lambda)\,(2-\alpha)^2}{4b\,(N+1-\lambda)^2}\,(a-\overline{w})^2\right).$$

However, both the asymmetric Nash bargaining solution and the Rubinstein's model predict efficient outcomes of the bargaining process (in particular agreement is settled immediately). This is not the case once we introduce incomplete information into the wage bargaining game, in which the first rounds of negotiation are used for information transmission between the two players.

The main feature of our base wage bargaining game is that players possess private information. They are uncertain about each others' discount rates. It is common knowledge between the players that player i's discount rate is included in the set $[r_i^{\mathrm{P}}, r_i^{\mathrm{I}}]$, where $0 < r_i^{\mathrm{P}} \leq r_i^{\mathrm{I}} < 1$, for $i =$u,f. The superscripts "I" and "P" identify the most impatient and most patient types, respectively. The players' types are independently drawn, with player i's discount rate drawn from the set $[r_i^{\mathrm{P}}, r_i^{\mathrm{I}}]$ according to the probability distribution p_i, for $i =$u,f. Letting $p = (p_{\mathrm{u}}, p_{\mathrm{f}})$, we denote by $G\,(p)$ the wage bargaining game of incomplete information in which the distribution p is common knowledge between the players (and in which the period length Δ shrinks to zero). Next we state some properties about the perfect Bayesian equilibria (PBE) of $G\,(p)$. The following lemma follows from Watson's (1996) analysis.

Lemma 1 *Consider the wage bargaining game $G\,(p)$. For any PBE of $G\,(p)$:*

- *The payoff of the CU (of type r_u) belongs to $\left[U^*\left(r_u^I, r_f^P\right), U^*\left(r_u^P, r_f^I\right)\right]$;*
- *The payoff of the CF (of type r_f) belongs to $\left[\Pi^*\left(r_u^P, r_f^I\right), \Pi^*\left(r_u^I, r_f^P\right)\right]$;*

for $r_i \in [r_i^P, r_i^I]$, $i =$ u,f.

Remember that $\left(U^*\left(r_{\mathrm{u}}, r_{\mathrm{f}}\right), \Pi^*\left(r_{\mathrm{u}}, r_{\mathrm{f}}\right)\right)$ is the unique limiting SPE payoff vector of $G(r_{\mathrm{u}}, r_{\mathrm{f}})$. For solving this wage bargaining game (with incomplete information), we could use a weaker solution concept, like *Iterative elimination of strictly conditionally dominated strategies*[4] (IECDS) for games with incomplete information, instead of the equilibrium approach (PBE). Mutual knowledge that both players will play a strategy that survives IECDS leads to bounds on the payoffs which may arise in the game; bounds which are the same as in Lemma 1 [see Vannetelbosch (1997) or Watson (1996)]. Lemma 1 is not a direct corollary to Watson (1996) Theorem 1 because Watson's work focuses on linear preferences, but the analysis can be modified to handle the present case. As Watson (1996) stated, Lemma 1 establishes that "each player will be no worse than he would be in equilibrium if it were common knowledge that he were his least patient type and the opponent were his most patient type. Furthermore, each player will be no better than he would be in equilibrium with the roles reversed". The next proposition follows from Lemma 1.

Proposition 1 *The base wage outcome at the industry-level, w_c^*, satisfies the following inequalities:*

$$\overline{w}+\frac{(N+1-2\lambda)\,r_f^P-2\lambda\,r_u^I}{2\,(N+1-\lambda)\left(r_u^I+r_f^P\right)}\,(a-\overline{w})\leq w_c^*\leq\overline{w}+\frac{(N+1-2\lambda)\,r_f^I-2\lambda\,r_u^P}{2\,(N+1-\lambda)\left(r_u^P+r_f^I\right)}\,(a-\overline{w}) \quad (14)$$

In the alternating-offer bargaining game $G(p)$ with incomplete information, PBE implies bounds on the centralized base wage outcome, w_{c}^*, which are given by expression (14). The lower (upper) bound is the base wage outcome of the complete information game, when it is common knowledge that the CU's type is $r_{\mathrm{u}}^{\mathrm{I}}$ $(r_{\mathrm{u}}^{\mathrm{P}})$ and the CF's type is $r_{\mathrm{f}}^{\mathrm{P}}$ $(r_{\mathrm{f}}^{\mathrm{I}})$. This lower (upper) bound is a decreasing function of CU's discount rate $r_{\mathrm{u}}^{\mathrm{I}}$ $(r_{\mathrm{u}}^{\mathrm{P}})$, an increasing function of CF's discount rate $r_{\mathrm{f}}^{\mathrm{P}}$ $(r_{\mathrm{f}}^{\mathrm{I}})$, an increasing function of the level of industry demand, parameterized by the intercept of the linear demand function, a decreasing function of the profit-sharing parameter λ and an increasing function of the reservation wage $\overline{w}$. Lemma 1 and Proposition 1 tell us that inefficient outcomes are possible, even as the period length shrinks to zero. The wage bargaining game may involve delay, but not perpetual disagreement, at equilibrium. Indeed, Watson (1996) has constructed a bound on delay in equilibrium which shows that an agreement is reached in finite time and that delay time equals zero as incomplete information vanishes. Expression (14) implies bounds on the firm's employment level l_{c}^* (as well as on the firm's output) at equilibrium.

[4] Fudenberg and Tirole (1991) were first to define the procedure of IECDS and the notion of *conditional dominance* but for games with complete information. Watson (1996) adapted the procedure of IECDS to games with incomplete information. Watson (1996) has also characterized the set of strategies that survive IECDS and shown how IECDS restricts the behaviour of the players in Rubinstein's alternating-offer bargaining game with two-sided incomplete information.

In complete information, the introduction of a profit-sharing scheme always decreases the wage level. But when the players possess private information, the complete information result does not necessarily hold. The necessary condition (which is also sufficient) to recover the complete information result is

$$\begin{aligned} \exists \lambda \quad &\in \quad [0,1] \text{ such that } \lambda > \frac{(N+1)\left[r_{\mathrm{f}}^{\mathrm{I}}\, r_{\mathrm{u}}^{\mathrm{I}} - r_{\mathrm{f}}^{\mathrm{P}}\, r_{\mathrm{u}}^{\mathrm{P}}\right]}{\left(r_{\mathrm{f}}^{\mathrm{I}} + r_{\mathrm{u}}^{\mathrm{P}}\right)\left(r_{\mathrm{f}}^{\mathrm{P}} + 2\, r_{\mathrm{u}}^{\mathrm{I}}\right)} \\ \Leftrightarrow \quad &\forall\, w_{\mathrm{c}}^{*}(\lambda \neq 0),\, w_{\mathrm{c}}^{*}(\lambda = 0) : w_{\mathrm{c}}^{*}(\lambda \neq 0) < w_{\mathrm{c}}^{*}(\lambda = 0). \end{aligned} \tag{15}$$

For a given profit-sharing parameter, this condition will be satisfied the smaller the number of firms in the industry and the smaller the uncertainty about the players' discount rates.

An indicator for the scope of potential inefficiency is the difference between the upper bound and lower bound on the base wage outcome. The larger is the difference between the upper bound and the lower bound on the base wage outcome, the larger is the potential inefficiency incurred during the negotiation. When bargaining takes place at the industry-level, our indicator of potential inefficiency, $\Psi_{\mathrm{c}}(\lambda)$, is given by the following expression.

$$\Psi_{\mathrm{c}}(\lambda) = \frac{(N+1)\left[r_{\mathrm{f}}^{\mathrm{I}}\, r_{\mathrm{u}}^{\mathrm{I}} - r_{\mathrm{f}}^{\mathrm{P}}\, r_{\mathrm{u}}^{\mathrm{P}}\right]}{2\,(N+1-\lambda)\left(r_{\mathrm{f}}^{\mathrm{I}} + r_{\mathrm{u}}^{\mathrm{P}}\right)\left(r_{\mathrm{f}}^{\mathrm{P}} + r_{\mathrm{u}}^{\mathrm{I}}\right)}\,(a - \overline{w}). \tag{16}$$

From expression (16) it is immediate that $\Psi_{\mathrm{c}}(\lambda \neq 0) > \Psi_{\mathrm{c}}(\lambda = 0)$. Therefore, we can state the following proposition.

Proposition 2 *If the base wage bargaining takes place at the industry-level, then the introduction of a profit-sharing scheme increases the potential bargaining inefficiencies.*

4 Local Wage Bargaining

At the firm-level, workers are represented by a local union representative (LU). The LU's objective function is to maximize the local union's utility. Inside each firm, the LU negotiates the local base wage level with the local firm representative (LF) whose objective function is to maximize its utility. All negotiations take place simultaneously and independently. That is, when negotiating the base wage level, each LU-LF pair takes all other wage settlements in the industry as given. Moreover, these LU-LF pairs always correctly anticipate the effect of wages on subsequent Cournot competition game. The bargaining process is always described by Rubinstein (1982) alternating-offer bargaining model [see Section 3]. Payoffs in the wage bargaining are now given by the vN-M utility functions U_n (for LU n) and Π_n (for LF n) defined by $U_n(w_n, t) \equiv \delta_{\mathrm{u}}^{t-2} \cdot u_n(w_n, \overline{w}, l_n^{*}(w_1^{*}, ., w_n, .))$ and $\Pi_n(w_n, t) \equiv \delta_{\mathrm{f}}^{t-2} \cdot \Lambda_n(w_n, \overline{w}, l_n^{*}(w_1^{*}, ., w_n, .))$ for every $(w_n, t) \in X \times T$, where $\delta_i \in (0,1)$ is player i's discount factor, for $i =$u,f. Perpetual disagreement payoffs are equal to zero for both players. Remember that all unions have the same discount factor δ_{u} and all firms have also the same discount factor δ_{f}.

4.1 The Decentralized Agreements

Let $\left(U_n^*\left(r_{\mathrm{u}}, r_{\mathrm{f}}\right), \Pi_n^*\left(r_{\mathrm{u}}, r_{\mathrm{f}}\right)\right)$ be the unique limiting SPE payoff vector at firm n of the decentralized wage bargaining game under complete information, which is obtained when the length Δ of a single bargaining period approaches zero. Therefore, in complete information, the decentralized wages are given by

$$\begin{cases} w_{1\mathrm{d}}^{\mathrm{SPE}} = \arg\max_{w_1 \in X}\left[u_1\left(w_1, \overline{w}, l_1^*\left(w_1, ..., w_N^*\right)\right)\right]^{\alpha}\left[\Lambda_1\left(w_1, l_1^*\left(w_1, ..., w_N^*\right)\right)\right]^{1-\alpha} \\ \vdots \\ w_{n\mathrm{d}}^{\mathrm{SPE}} = \arg\max_{w_n \in X}\left[u_n\left(w_n, \overline{w}, l_n^*\left(w_1^*, ., w_n, .\right)\right)\right]^{\alpha}\left[\Lambda_n\left(w_n, l_n^*\left(w_1^*, ., w_n, .\right)\right)\right]^{1-\alpha} \\ \vdots \\ w_{N\mathrm{d}}^{\mathrm{SPE}} = \arg\max_{w_N \in X}\left[u_N\left(w_N, \overline{w}, l_N^*\left(w_1^*, ..., w_N\right)\right)\right]^{\alpha}\left[\Lambda_N\left(w_N, l_N^*\left(w_1^*, ..., w_N\right)\right)\right]^{1-\alpha} \end{cases} \tag{17}$$

where α is the LU's bargaining power and it is given by expression (12). There is a unique solution to the expression (17) given by

$$\begin{aligned} w_{\mathrm{d}}^{\mathrm{SPE}} &= \overline{w} + \frac{\left[\alpha\left(N+1\right) - 2\lambda N\right]}{2\,N\left(N+1-\lambda\right) - \alpha\left(N+1\right)\left(N-1\right)}\left(a - \overline{w}\right) = w_{1\mathrm{d}}^{\mathrm{SPE}} = ... = w_{N\mathrm{d}}^{\mathrm{SPE}} \\ &= \overline{w} + \frac{\left(2\,\lambda\,N - N - 1\right)\,r_{\mathrm{f}} + 2\,\lambda\,N\,r_{\mathrm{u}}}{2\,\left(\lambda\,N - N^2 - N\right)\,r_{\mathrm{u}} + \left(2\,\lambda\,N - N^2 - 2\,N - 1\right)\,r_{\mathrm{f}}}\left(a - \overline{w}\right) \end{aligned} \tag{18}$$

Therefore, the SPE payoff vector (at firm n) is

$$\left(U_n^*\left(r_{\mathrm{u}}, r_{\mathrm{f}}\right), \Pi_n^*\left(r_{\mathrm{u}}, r_{\mathrm{f}}\right)\right) = \frac{N\ \left(2-\alpha\right)\left(a-\overline{w}\right)^2 \cdot \left[\alpha\left[N+1-\lambda N\right], \left(1-\lambda\right) N\ \left(2-\alpha\right)\right]}{b\left[2N\left(N+1-\lambda\right) - \alpha\left(N+1\right)\ \left(N-1\right)\right]^2} \tag{19}$$

Next we tackle the decentralized wage bargaining game with incomplete information about the players' discount rates. Given the symmetry of the model, we look for symmetric PBE, that is, an equilibrium in which $w_{1\mathrm{d}}^* = w_{2\mathrm{d}}^* = ... = w_{N\mathrm{d}}^* = w_{\mathrm{d}}^*$.

Lemma 2 *Assume each LU-LF pair n takes all other base wage settlements in the industry as given during the bargaining at firm n. Then, for any symmetric PBE:*

- *The payoff of the LU n (of type r_u) belongs to $\left[U_n^*(r_u^I, r_f^P), U_n^*(r_u^P, r_f^I)\right]$;*
- *The payoff of the LF n (of type r_f) belongs to $\left[\Pi_n^*(r_u^P, r_f^I), \Pi_n^*(r_u^I, r_f^P)\right]$;*

for $r_i \in [r_i^P, r_i^I]$, $i = u,f$.

Lemma 2 is the counterpart of Lemma 1 for the decentralized base wage negotiation. Following Lemma 2 and the complete information results we are able to state some properties about the decentralized wage outcomes.

Proposition 3 *The (symmetric) base wage bargaining outcome at the firm-level, w_d^*, satisfies the following inequalities:*

$$w_d^* \geq \overline{w} + \frac{\left[(2\lambda N - N - 1)\, r_f^P + 2\lambda N r_u^I\right](a - \overline{w})}{2\,(\lambda N - N^2 - N)\, r_u^I + (2\lambda N - N^2 - 2N - 1)\, r_f^P} \tag{20}$$

$$w_d^* \leq \overline{w} + \frac{\left[(2\lambda N - N - 1)\, r_f^I + 2\lambda N r_u^P\right](a - \overline{w})}{2\,(\lambda N - N^2 - N)\, r_u^P + (2\lambda N - N^2 - 2N - 1)\, r_f^I} \tag{21}$$

The lower (upper) bound is the base wage outcome of the complete information game, when it is common knowledge that LU's type is $r_{\mathrm{u}}^{\mathrm{I}}$ $(r_{\mathrm{u}}^{\mathrm{P}})$ and LF's type is $r_{\mathrm{f}}^{\mathrm{P}}$ $(r_{\mathrm{f}}^{\mathrm{I}})$. This lower (upper) bound is a decreasing function of LU's discount rate $r_{\mathrm{u}}^{\mathrm{I}}$ $(r_{\mathrm{u}}^{\mathrm{P}})$, an increasing function of LF's discount rate $r_{\mathrm{f}}^{\mathrm{P}}$ $(r_{\mathrm{f}}^{\mathrm{I}})$, an increasing function of the level of industry demand, and an increasing function of the reservation wage $\overline{w}$. Note that, even as Δ approaches zero, potential inefficiency is possible in presence of incomplete information. Expressions (20) and (21) imply bounds on firm's employment level l_{d}^* at equilibrium.

In complete information, the introduction of a profit-sharing scheme always decreases the wage level. But when the players possess private information, the complete information result is not always valid. The necessary condition (which is also sufficient) to recover the complete information result is

$$\begin{aligned} \exists\,\lambda \;\; &\in \;\; [0,1] \;\text{ such that }\; \lambda > \frac{(N+1)\left[r_{\mathrm{f}}^{\mathrm{I}}\, r_{\mathrm{u}}^{\mathrm{I}} - r_{\mathrm{f}}^{\mathrm{P}}\, r_{\mathrm{u}}^{\mathrm{P}}\right]}{N\,\left(r_{\mathrm{f}}^{\mathrm{I}} + r_{\mathrm{u}}^{\mathrm{P}}\right)\left(r_{\mathrm{f}}^{\mathrm{P}} + 2\, r_{\mathrm{u}}^{\mathrm{I}}\right)} \\ &\Leftrightarrow \;\; \forall\, w_{\mathrm{d}}^*\,(\lambda \neq 0)\,,\, w_{\mathrm{d}}^*\,(\lambda = 0) : w_{\mathrm{d}}^*\,(\lambda \neq 0) < w_{\mathrm{d}}^*\,(\lambda = 0)\,. \end{aligned} \tag{22}$$

A sufficient condition which satisfies (22) is $\lambda > (N+1)\,[2\,N]^{-1}$. So, under incomplete information, if the government or social planner wants to decrease wages, by introducing a profit-sharing scheme between LU and LF, and hence, promoting employment, a simple way is to fix a profit-sharing coefficient $\lambda > (N+1)\,[2\,N]^{-1}$, which is decreasing with the number of firms in the industry.

Proposition 4 *If* $\lambda > (N+1)\,[2\,N]^{-1}$ *then* $w_d^*(\lambda \neq 0) < w_d^*(\lambda = 0)$.

Under our profit-sharing system, the scope of potential inefficiency when bargaining takes place at the firm-level, $\Psi_{\mathrm{d}}(\lambda)$, is given by the following expression.

$$\Psi_{\mathrm{d}}(\lambda) = \left[\frac{[2N(N+1)(1+N-\lambda N)]\left[r_{\mathrm{f}}^{\mathrm{I}} r_{\mathrm{u}}^{\mathrm{I}} - r_{\mathrm{f}}^{\mathrm{P}} r_{\mathrm{u}}^{\mathrm{P}}\right](a-\overline{w})}{(2\lambda N - N^2 - 2N - 1)\, r_{\mathrm{f}}^{\mathrm{P}} + (\lambda N - N^2 - N)\, 2 r_{\mathrm{u}}^{\mathrm{I}}}\right] \cdot \left[\frac{1}{(2\lambda N - N^2 - 2N - 1)\, r_{\mathrm{f}}^{\mathrm{I}} + (\lambda N - N^2 - N)\, 2 r_{\mathrm{u}}^{\mathrm{P}}}\right] \quad (23)$$

From expression (23) it is immediate that, if $N \geq 3$ then $\Psi_{\mathrm{d}}(\lambda \neq 0) < \Psi_{\mathrm{d}}(\lambda = 0)$. Therefore, we can state the following proposition.

Proposition 5 *If the base wage bargaining takes place at the firm-level and the number of firms in the industry is greater than two, then the introduction of a profit-sharing scheme reduces the potential bargaining inefficiencies.*

On the contrary to the central wage bargaining, if the number of firms producing in the industry is greater than two, then a profit-sharing system reduces the potential inefficiencies under firm-level base wage negotiations.

The intuition behind Proposition 5 has to do with the competition on the product market. Indeed, when the base wage bargaining takes place at the firm-level, each LU-LF pair expects to be able to alter its relative wage position in the industry. Therefore, it results wage spillover effects: each LU-LF pair has an incentive to lower wages in order to increase its output level and the LF's profits, and to gain a larger share of the product market. This incentive is stronger once a profit-sharing scheme is introduced since now the LU attaches also some importance to the LF's profit. Therefore, it is not too surprising that, under incomplete information, the introduction of profit-sharing reduces the scope for delay and inefficiencies if there is enough competition (at least three firms competing in the industry) and the wage bargaining takes place at the firm-level.

4.2 Firm-Level vs Industry-Level Bargaining

But when the base wage bargaining takes place at the industry-level, these wage spillover effects are partially internalized, which implies that the base wage level is lower under firm-level bargaining than under industry-level bargaining when there is complete information. Is this result always true when bargainers possess private information? Comparing (14) with (20-21), we obtain the following result.

Proposition 6 *In an unionized oligopolistic industry with a profit-sharing system, if wage bargainers possess private information, then the firm-level base wage outcome will not necessarily be lower than the industry-level base wage outcome.*

This result is also obtained in the case without profit-sharing [see Vannetelbosch (1997)]. The following inequality (24) is the necessary and sufficient condition such that the base wage outcome is always strictly lower under firm-level bargaining than under industry-level bargaining.

$$\left(N^2-1\right)\left(r_{\mathrm{f}}^{\mathrm{P}} r_{\mathrm{f}}^{\mathrm{I}}+2 r_{\mathrm{u}}^{\mathrm{P}} r_{\mathrm{f}}^{\mathrm{P}}\right)-2\,(N-\lambda\, N+1)\left(r_{\mathrm{u}}^{\mathrm{I}} r_{\mathrm{f}}^{\mathrm{I}}-r_{\mathrm{f}}^{\mathrm{P}}\, r_{\mathrm{u}}^{\mathrm{P}}\right)>0 \tag{24}$$

Whether or not condition (24) is satisfied depends on two factors: the incomplete information or uncertainty about the players' discount rates and the number of firms in the industry. Incomplete information in the model takes into account two main features. The first one is the amount of private information in possession of the players. By the amount of private information we mean the size of the set in which player's discount rate is contained and which is common knowledge between the players. The second one is the uncertainty about who is the more patient player (i.e. who is the stronger player). When it is common knowledge that the union is stronger, this second feature disappears, and information tends to play a less crucial role in the process of the negotiation between firms and unions. Therefore, it is more likely to recover the complete information's result where the industry-level base wage outcome is always larger than the firm-level base wage outcome. As in the case without profit-sharing, a sufficient condition which satisfies (24) is $r_{\mathrm{u}}^{\mathrm{P}} \leq r_{\mathrm{u}}^{\mathrm{I}} < r_{\mathrm{f}}^{\mathrm{P}} \leq r_{\mathrm{f}}^{\mathrm{I}}$ and $N \geq 3$. This sufficient condition means that it is common knowledge among players that the union is stronger (more patient) than the firm, while discount rates remain private information, and the number of firms in the industry is greater than two.

Finally, we investigate the impact of profit-sharing on the relationship between the bargaining structure and the strike activity. Comparing (16) with (23), we obtain the following result: $\Psi_{\mathbf{c}}(\lambda) > \Psi_{\mathbf{d}}(\lambda)$. Intuition behind this result is similar to the case without profit-sharing [see Vannetelbosch (1997)], and has to do with the base wage spillover effects. These spillover effects are internalized at the industry-level, which increases the potential payoffs but, in expanding the payoff set, also rises the scope for delay or the strike activity.

Proposition 7 *In an unionized oligopolistic industry with a profit-sharing system, if wage bargainers possess private information, then potential inefficiency is larger if the base wage bargaining takes place at the industry-level rather than at the firm-level.*

This proposition, taken with Propositions 2 and 5, tells us that a profit-sharing system increases the disparity, in terms of potential inefficiencies, of both bargaining structures.

5 Concluding Remarks

During the recent years, profit-sharing schemes have become a major alternative form of compensation in France and in the U.K. However, Bhargava and Jenkinson (1992) or Cahuc and Dormont (1992,1993) have shown that the base wage does not decrease or even rises after the introduction of profit-sharing. These empirical results are inconsistent with Weitzman's argument in favor of profit-sharing schemes for reducing the unemployment level. Therefore, other motives for the introduction of profit-sharing and its growth have to be advanced.

One motive advanced is that the introduction of profit-sharing may increase worker productivity and firm profitability [see Cahuc and Dormont (1992,1993)]. In this paper, we have provided another motive why profit-sharing is introduced: profit-sharing may reduce bargaining inefficiencies, like strikes. We have developed a model of wage determination with incomplete information in a unionized Cournot oligopoly. The assumption of incomplete information allows the possibility of strikes, which waste industry ressources, at equilibrium. Facing such deadweight loss of wasting ressources, the government or the social planner may decide to adopt a policy, like a profit-sharing scheme. Under two different bargaining structures (firm-level vs industry-level), we have investigated the effects of adopting profit-sharing on the wage outcome and the bargaining inefficiencies, like strikes. Our main results are as follows. If the base wage bargaining takes place at the industry-level, then the introduction of a profit-sharing scheme increases the potential bargaining inefficiencies. But if the base wage bargaining takes place at the firm-level and the number of firms in the industry is greater than two, then the introduction of a profit-sharing scheme reduces the potential bargaining inefficiencies.

In addition to reduce the bargaining inefficiencies, the government or social planner may also be concerned by decreasing the product price and increasing the employment level. To achieve these objectives the government could support firm-level bargaining and introduce a profit-sharing scheme with a profit-sharing parameter (λ) close to $\frac{1}{2}$. But such a profit-sharing parameter would certainly encounter a strong opposition from the local firms. Moreover, the model is partial, and to give a fully satisfactory answer to whether profit-sharing is in fact beneficial for the rest of the economy, we should use a general equilibrium approach. However, the bargaining inefficiencies are reduced if there is enough competition on the product market and bargaining takes place at the firm-level.

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