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WAGE INDEXATION BARGAINING AND INFLATION

by Francesco Drudi (*) and Raffaela Giordano(**)

Abstract

Price versus productivity indexing is considered in a model of monetary policy with wage bargaining. The wage-indexing rule is negotiated in a first stage of the game between government, union and firm. In a perfectly price-indexed economy, the government has no temptation to create unexpected inflation and the inflationary bias associated with the credibility problem is completely eliminated. On the other hand, productivity indexing is more appropriate to dampen macroeconomic fluctuations when real disturbances are the causes. We show that productivity indexing alone guarantees both price and employment stability, provided the government's reputation is good enough and the union's bargaining power is not too high. This in turn implies that the equilibrium degree of price indexation decreases as the union gets weaker and the government's reputation improves. Productivity indexing generally increases with highly volatile productivity processes and relatively weak unions.

Contents

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1. Introduction[1]

Wage-bargaining systems and payment schemes differ substantially across countries and, within countries, across periods. While price indexing is an important component of some wage-setting arrangements (e.g. in Belgium, Italy, and Scandinavia in the 1970s and early 1980s), there exist several examples of economies in which price indexation is very limited (e.g. the US) or even prohibited by law (e.g. Germany). On the other hand, incentive pay systems, either in the form of wage premia and productivity bonuses or in the form of profit-sharing, are widespread in the US, less common in France and the UK, and almost absent in other industrialized economies. Across time, differences in wage-setting schemes are also notable. Between the first and the second oil crises, the rigidity of price-indexed systems for determining wage rates came under fire as the cause of the recession's depth and duration. The decade of the 1980s saw an intensification of employers' requests for more flexible and decentralized wage-setting procedures. Thus, while less and less attention has been devoted to price indexing in recent times, attempts to link wages to productivity indicators have been experienced in many countries. The decentralization of industrial relations and the increasing tendency to allow negotiations at the plant level may be partly thought of as a device to tie wages to productivity changes. The role played by the government in wage negotiation processes may vary, too. Government intervention

1 We would like to thank Maria Pia Mingarini for her unvaluable collaboration in editing the text and the tables.

generally ranges from arbitration to the determination of incomes policy, minimum wage and indexation rules.[2]

The focus of this paper is to investigate the emergence of alternative wage payment systems and indexation schemes, and their effect on government incentives to implement inflation policies.

Since the early 1970s economists have devoted considerable attention to the macroeconomic effects of wage indexation to price changes and, in particular, to the issue of the optimal degree of such indexation. Two different effects of wage indexation have been stressed. The standard optimal indexation literature (Gray, 1976; Fischer, 1977) emphasized the role of price indexation in stabilizing or destabilizing output in an economy randomly disturbed both by real and monetary shocks. The inadequacy of such indexation as a response to real disturbances led them to conclude that the optimal degree of price indexation is less than one and, in general, depends on the underlying stochastic structure of the economy. In contrast, informal policy discussions focused on the allegation that indexation is inflationary. Until recently economists lacked models of the sources of inflation so that it was difficult to formalize the effects of indexation on inflation. Starting in the late 1980s, formal models applied the insight of Barro and Gordon (1983) that, with discretionary policy, the employment gains from surprise inflation tempt the monetary authority to create positive

[2] A summary of wage-bargaining systems in selected OECD countries is reported in the Appendix.

trend inflation. Fischer and Summers (1989) stressed that policies which reduce the cost of inflation, such as indexation, cause Barro-Gordon policymakers to choose higher inflation. On the other hand, as Ball and Cecchetti (1991) pointed out, wage indexation reduces the employment effects of surprise inflation and therefore weakens the temptation of the government to inflate. Since indexation has one inflationary effect (lower costs of inflation) and one anti-inflationary effect (a steeper Phillips curve), the net effect appears ambiguous.

In this paper, we analyze the effects of different wage indexation schemes on both employment and inflation. Both price indexing and productivity indexing are considered. We assume that shocks to productivity affect employment but not prices. Therefore, each indexation mechanism addresses a specific source of disturbance. While price indexing serves to insulate real wages and employment from monetary shocks, productivity indexing prevents employment fluctuations in the presence of real shocks. Moreover, price indexation in our model has no effect on the cost of inflation. Hence, it unambiguously weakens the incentive of the government to create surprise inflation. Productivity indexation also may induce price stability, since it reduces the temptation of the government to inflate in the presence of bad productivity shocks. The wage-indexation rule is negotiated between the union and the firm, together with the government, in a first stage of the game. In the second stage, monetary policy and wages are determined by a repeated game between the government and the private sector. Union and firm bargain over the nominal wage, taking into account their expectations about the inflationary policy implemented by the government and the occurrence of a productivity shock. We assume that the private sector is incompletely informed about whether the government is inflationary or anti-inflationary. Moreover, output is affected by an exogenous stochastic productivity shock, whose distribution is known to the economy. The government decides the level of inflation after wage bargaining has taken place and after having observed the occurrence of the real shock. Therefore, equilibrium inflation is stochastically determined by the state of the economy together with the government's preferences. Uncertainty over inflation is somehow endogenized in our model, since shocks to the money supply may emerge only as a consequence of some equilibrium outcomes.

Section 2 presents the macroeconomic model. Section 3 analyzes the wage bargaining game and computes the equilibrium nominal wage as a function of the indexation parameters. Section 4 considers the optimal monetary policy.

We focus on equilibria in pure strategies only. Section 5.1 characterizes the pooling equilibrium. Section 5.2 describes the separating equilibrium. In Section 5.3 we present the "mixed" equilibrium, in which the government plays the pooling (separating) strategy if a positive (negative) productivity shock occurs. In order to investigate the welfare implications of alternative wage indexation rules, in Section 6 we numerically simulate the model. Section 7 analyzes the equilibrium in the first stage of the game. The wage indexation mechanism is endogenously selected by bargaining between the government and the private sector. Section 8 concludes the paper.

2. The model

The macroeconomy is described by two simple equations; an aggregate demand function:

(1) $$\frac{M_t}{p_t} = y_t$$

where M_t is the money supply, p_t is the price level and y_t is real output; and an aggregate supply function:

(2) $$y_t = F(L_t)$$

where $F(L_t)$ is the production function relating employment to output. The technology is given by a standard Cobb-Douglas:

(3) $$F(L_t) = \frac{A_t}{\alpha} L_t^{\alpha}$$

where, A_t represents the effect of a productivity shock. We assume that A_t moves exogenously according to the process:

$$A_t = 1 + \varepsilon_t$$

where

$$\varepsilon_t = \begin{cases} e & \text{with probability } 1/2 \\ -e & \text{with probability } 1/2 \end{cases}, \quad e \in (0,1).$$

The production function and profit-maximization yield demand for labor:

(4) $$L_t = \left(\frac{w_t}{A_t}\right)^{\frac{1}{\alpha-1}}$$

where $w_t = \frac{W_t}{p_t}$ is the nominal wage deflated by the general price index.

The private economy is represented by two agents: a firm and a union. They negotiate the nominal wage in each period so as to maximize, respectively:

(5) $$u_t^f = E_t\left[F(L_t) - w_t L_t\right]$$

and

(6) $$u_t^u = E_t\left[(w_t - \bar{u})L_t\right]$$

where E_t is the expectation operator conditional on the information set available to the public at time t.

Equation (5) says that the firm is a profit maximizer. The union has N identical members, which we assume comprises the entire labor force. L of them are employed and achieve a level of utility w. If not employed by the firm, the worker achieves a level of utility $\bar{u}$, which can be thought of as the utility from receiving unemployment benefits. We further assume that full employment is achieved at $w=\bar{u}$ (*i.e.* $\bar{u}^{-1/(\alpha-1)}=N$).[3] The union wishes to maximize $wL+(N-L)\bar{u}$, which can be written as $(w-\bar{u})L+N\bar{u}$. Since N and $\bar{u}$ are treated as data for the purpose of union wage setting, the problem can be summarized by saying that the union wishes to maximize its membership's aggregate gain from employment, over and above the utility $\bar{u}$ that every member starts with (equation (6)).

The government sets M_t to maximize:

$$u_t^g = E_t\left[-\Pi_t^2 - \lambda(N-L_t)^2\right], \qquad \lambda > 0 \tag{7}$$

where $\Pi_t = (p_t/p_{t-1}-1)$ is the rate of inflation in period t, and E_t denotes the expectation operator conditional on the information set available to the government at time t.

Equation (7) says that the government wants to keep inflation and unemployment as close as possible to zero. The parameter λ indicates the relative weight assigned by the government to the employment objective.[4]

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[3] Since $\bar{u}$ is the bargaining equilibrium wage when the union has no power, N can also be interpreted as the level of employment in a competitive labor market.

[4] Social welfare, defined as the sum of the utilities of the two representative agents in the economy, attains its maximum when $w=\bar{u}$. At this level of wages, unemployment is zero (i.e. $L=N$). We assume that the government measures the welfare loss from a deviation of

The game proceeds as follows. In a preliminary stage, the government, the union and the firm negotiate over a wage indexation mechanism which, if agreed upon, will prevail until the end of the game. In particular, they bargain over the degrees of price and productivity indexing. If the three parties fail to agree, then no indexation will ever apply.

Once the wage-indexation mechanism has been choosen, the game is repeated every period in the following way. At the beginning of each period, union and firm bargain over the nominal wage, given the indexation mechanism in place and taking into account their expectations about both the government's inflationary policy and the occurrence of the productivity shock in that period. The shock then occurs, and the government chooses its inflationary strategy conditional on the observation of the nominal wage set during the negotiation process and the realization of the productivity shock. Finally, the firm takes nominal wages as given by the bargaining outcome and sets employment and output according to equations (4) and (3), once the price level has become observable.

The conflict between government and private sector is generated by the hypothesis that the level of employment

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real wage from the efficient level of $\bar{u}$ by $(N\text{-}L)^2$, which is the deviation of employment from the efficient level of $\bar{u}^{1/(\alpha-1)}$. The cost of inflation can be justified by several arguments. In our context, a simple way to generate it would be by adding money to the production function. A quadratic loss for the deviation of inflation and employment from their efficient levels could then be thought of as an approximation of true costs, which are convex because of the concavity of the production function.

determined by the negotiated wage, which depends on the relative bargaining power of the parties, is below the level desired by the government. Hence, it has an incentive to inflate so as to lower the real wage and increase employment. But if the parties realize this, they will agree on a higher nominal wage during the wage bargaining process.

In order to find time-consistent equilibria, we solve the game starting from the second stage. Namely, we first solve the nominal wage setting problem together with the optimal inflationary policy of the government, for any given wage-indexation mechanism. We then look for the equilibrium wage-indexation mechanism (i.e. the mechanism which maximizes the product of the three parties' payoffs), given that nominal wages and inflation will be chosen according to the incentive compatibility constraints in the second stage.

3. Wage bargaining

The wage-bargaining situation we model is the following. At the beginning of each period the firm and the union have to reach an agreement on the nominal wage that will prevail until the end of that period. Once the wage is set, the firm unilaterally chooses the level of employment. The firm's payoff for the agreement is its profit, while that of the union is the total utility received by its N members.

We restrict agreements to nominal wages W where the profit of the firm is nonnegative and that are at least equal to the wage at which union members are indifferent between being employed and unemployed. If the two parties fail to agree, the firm obtains a profit of zero (since $F(0)=0$) and the union receives $N\bar{u}$, so that the disagreement utility pair is $d=(d^f,d^u)=(0,N\bar{u})$.

The equilibrium concept we focus on is the Nash asymmetric bargaining solution. The predicted nominal wage for our problem is then:

$$(8) \qquad W=\underset{W}{\operatorname{argmax}} E\left[(u^f-d^f)\right]^k E\left[(u^u-d^u)\right]^{1-\gamma}$$

where the parameter γ can be interpreted as the bargaining power of the firm, and $1-\gamma$ as the bargaining power of the union.

Let $a\in[0,1]$ denote the degree of wage indexation to productivity (i.e. the proportion of the wage which adjusts in response to productivity shocks), and $b\in[0,1]$ denote the degree of wage indexation to the price level. Then the real wage the parties will obtain, if they agree on nominal wage W is given by:

$$(9) \qquad \hat{w}=\frac{W(1+b\Pi)(1+\alpha\varepsilon)}{1+\Pi}.$$

In the analysis which follows, we will assume that the union and firm both believe that $\Pi=0$ occurs with probability q and $\Pi\neq 0$ with probability $(1-q)$. In the latter case, the parties expect $\Pi=\Pi_g$ if a positive productivity shock occurs,

$\varepsilon_t = e$, and $\Pi = \Pi_b$ if the productivity shock is negative, $\varepsilon_t = -e$ (the g and b subscripts stand for "good" and "bad" state, respectively).[5]

Therefore,

$$E\left[u^f - d^f\right] = \left(\frac{1-\alpha}{\alpha}\right) W^{\frac{\alpha}{\alpha-1}} C_1$$

$$E\left[u^u - d^u\right] = W^{\frac{\alpha}{\alpha-1}} C_1 - \bar{u} W^{\frac{1}{\alpha-1}} C_2$$

where

$$C_1 = \frac{q}{2}\left[(1+e)^{\frac{1}{1-\alpha}}(1+ae)^{\frac{\alpha}{\alpha-1}} + (1-e)^{\frac{1}{1-\alpha}}(1-ae)^{\frac{\alpha}{\alpha-1}}\right] +$$

$$\frac{1-q}{2}\left\{(1+e)^{\frac{1}{1-\alpha}}\left[\frac{(1+b\Pi_g)(1+ae)}{1+\Pi_g}\right]^{\frac{\alpha}{\alpha-1}} + (1-e)^{\frac{1}{1-\alpha}}\left[\frac{(1+b\Pi_b)(1-ae)}{(1+\Pi_b)}\right]^{\frac{\alpha}{\alpha-1}}\right\},$$

$$C_2 = \frac{q}{2}\left[(1+e)^{\frac{1}{1-\alpha}}(1+ae)^{\frac{1}{\alpha-1}} + (1-e)^{\frac{1}{1-\alpha}}(1-ae)^{\frac{1}{\alpha-1}}\right] +$$

$$\frac{1-q}{2}\left\{(1+e)^{\frac{1}{1-\alpha}}\left[\frac{(1+b\Pi_g)(1+ae)}{(1+\Pi_g)}\right]^{\frac{1}{\alpha-1}} + (1-e)^{\frac{1}{1-\alpha}}\left[\frac{(1+b\Pi_b)(1-ae)}{(1+\Pi_b)}\right]^{\frac{1}{\alpha-1}}\right\}.$$

The Nash equilibrium of this bargaining game gives the nominal wage

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[5] q, Π_g, Π_b will be endogenously determined in the equilibrium of the game between the government and the private sector.

$$(10) \qquad W = \frac{C_2 \bar{u}(\alpha\gamma + 1 - \gamma)}{C_1[\alpha\gamma + 1 - \gamma - (1-\alpha)(1-\gamma)]}.$$

4. Monetary policy

We characterize monetary policy as a repeated game between the government and the private sector. The game is solved for a finite horizon and assumes that the public has incomplete information about the parameter λ in the government objective function. For simplicity, it is assumed that λ can take one of two values: it may be $\lambda=0$, that is, the government behaves as if it is committed irrevocably to pursuing a zero-inflation policy, regardless of the unemployment level (a "tough" government); or $\lambda = \bar{\lambda} > 0$, that is, the government behaves as if it is rationally attempting to maximize utility function (7), taking into account both inflation and employment objectives (a "weak" government). If the government is in fact tough, its optimal strategy is simply to set M so as to have $\Pi=0$ in any period. If the government is weak, its optimal behavior is more sophisticated. As we saw in Section 3, the equilibrium nominal wage of the bargaining process depends on the private sector's beliefs about government preferences. Consequently, even a weak government may choose not to inflate. By resisting inflation it develops a reputation for being tough which it hopes will discourage future inflationary expectations. In this section we examine such a reputational equilibrium. The setting is the same as that in Kreps and Wilson (1982b), Backus and Driffill (1985), Barro (1986). The solution concept is Kreps and Wilson's (1982a) sequential equilibrium, which enables us to find the solution recursively, starting with the final period.

The game consists of the government choosing Π_t and the public choosing W_t, with payoffs to the government, the firm and the union given respectively by:

$$E_t \sum_{s=t}^{T} \delta^{s-t} u_s^g,$$

$$E_t \sum_{s=t}^{T} \delta^{s-t} u_s^f,$$

$$E_t \sum_{s=t}^{T} \delta^{s-t} u_s^u,$$

where $d \in [0,1]$ is the discount rate.[6]

The central feature of the model is the government's ability to manipulate its reputation. When the game starts, the public assigns a prior probability $\bar{x}$ to the event that λ=0, and a probability $(1-\bar{x})$ to the event that $\lambda = \bar{\lambda} > 0$. $\bar{x}$ is common knowledge. Let $x_t = Pr(\lambda=0)$ be the public's beliefs at time t; let $x_{i,t}^{*} = Pr(\Pi_t = 0 \| \lambda = \bar{\lambda})$ and $q_{i,t} = Pr(\Pi_t = 0)$, where i=g (i=b) if a positive (negative) productivity shock is observed at time t. Therefore, $q_{i,t}$ is the unconditional probability that

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[6] While the government faces an intertemporal optimization problem, since the action it takes in each period affects the outcomes in subsequent periods, the private sector solves the wage bargaining problem each period, independently of any consideration about past or future actions.

there will be no inflation at time *t*, and $x^{*}_{i,t}$ is the conditional probability of zero inflation, given that the government is weak. From these definitions it follows that:

(11) $q_{i,t} = x_t + (1 - x_t)x^{*}_{i,t}$.

The parties revise x_t according to Bayes' rule:

(12) $$xt+1 = \begin{cases} 0, & \text{if } \Pi_t \neq 0, \\ \dfrac{x_t}{x_t + (1-x_t)x^{*}_{i,t}} = \dfrac{x_t}{q_{i,t}} & \text{if } \Pi_t = 0 \end{cases}$$

(since x_{t+1} does not depend on the realization of the shock at time *t*+1 we omit the subscript *i*).

In the remainder of the analysis we restrict our attention to pure strategy equilibria only. In particular, we focus on three: the "pooling" equilibrium, which we define as one where in the first period the government chooses zero inflation with probability one, independently of the realization of the productivity shock ($x^{*}_{i,1} = 1$, $q_{i,1} = 1$, for $i = g, b$, and $x_2 = \bar{x}$); the "separating" equilibrium, where the optimal probability for the government to inflate in the first period is one, independently of the realization of the productivity shock ($x^{*}_{i,1} =$ 0, $q_{i,1} = \bar{x}$, for $i = g, b$, and $x_2 = 0$); and a "mixed" equilibrium in which in the first period the government implements a zero inflation policy if a positive shock occurs and inflates whenever the productivity shock is negative ($x^{*}_{i,1} = 1/2, q_{i,1} = 1/2 + \bar{x}/2$, for $i = g, b$, and $x_2 = \bar{x}$ $\quad (x_2 = 0))$. In the following section we describe the conditions under which each equilibrium type is attained.

5. The equilibrium in the second stage: nominal wages and inflation

The Nash equilibrium of the one-shot non-cooperative game can be computed as follows.[7] The government chooses Π to maximize:

$$(13) \qquad u^g = -\Pi^2 - \bar{\lambda}(N-L)^2,$$

where

$$L = \left(\frac{\hat{w}}{1+\varepsilon}\right)^{\frac{1}{\alpha-1}},$$

and $\hat{w}$ is given by (9).

Since it moves after the private sector, the government is forced to take nominal wages as given. Its first-order condition yields:

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[7] Although timing in this game is such that the government moves after the bargaining process has taken place, we assume that wage negotiation occurs at firm level so that, while choosing the nominal wage, the parties have to take inflation as given. The possibility of coordination among wage negotiation outcomes in different firms is not considered here. Consequently, the private sector, taken as a whole, behaves like a Nash player: it cannot choose its control variable strategically, by incorporating the government reaction function into its decision process.

$$(14) \qquad \Pi = \frac{\bar{\lambda}}{1-\alpha}\left[N - \left(\frac{\hat{w}}{1+\varepsilon}\right)^{\frac{1}{\alpha-1}}\right]\left(\frac{\hat{w}}{1+\varepsilon}\right)^{\frac{\alpha}{\alpha-1}} \frac{(1+\varepsilon)(1-b)}{W(1+b\Pi)^2(1+\alpha\varepsilon)},$$

where the left-hand side is the marginal cost of inflation and the right-hand side is the marginal benefit, in terms of the employment objective, of inflation. Equation (14) expresses optimal inflation as a function of the productivity shock, as well as of the wage indexation mechanism in place (parameters *a* and *b*). Let Π_g denote the optimal inflation when the government observes a positive productivity shock, and Π_b the optimal inflation associated with a negative realization of the shock. The private sector reaction function is the equilibrium outcome of the bargaining process, equation (10). Then the Nash equilibrium pairs $\left[W^N(q),\Pi_g^N(q)\right]$ $\left[W^N(q),\Pi_b^N(q)\right]$ are obtained by combining (10) and (14), respectively with ε=e and ε=-e.

In order to simplify the exposition, we illustrate the equilibrium of the two-period repeated game. Such a result, however, can be easily generalized to games repeated any finite number of periods.

Let the vector $\left[W_1^*,\Pi_{g,1}^*,\Pi_{b,1}^*,W_2^*,\Pi_{g,2}^*,\Pi_{b,2}^*\right]$ characterize the equilibrium of the two-period repeated game. Then the expected two-period indirect utility function of the government, for each realization of the productivity shock in the first period, will be given by:

$$\left[W_1^*,\Pi_{g,1}^*,\Pi_{b,1}^*,W_2^*,\Pi_{g,2}^*,\Pi_{b,2}^*\right] =$$

(15)

$$-(\Pi_{i,1}^*)^2-\bar{\lambda}\left[N-\left(\frac{\hat{w}_1^*}{1+\varepsilon_1}\right)^{\frac{1}{\alpha-1}}\right]^2+$$

$$\left\{\frac{\delta}{2}-(\Pi_{g,2}^*)^2-(\Pi_{b,2}^*)^2-\bar{\lambda}\left[N-\left(\frac{\hat{w}_{g,2}^*}{1+e}\right)^{\frac{1}{\alpha-1}}\right]^2-\bar{\lambda}\left[N-\left(\frac{\hat{w}_{b,2}^*}{1-e}\right)^{\frac{1}{\alpha-1}}\right]^2\right\},$$

where

$$w_{i,t}^*=\frac{W_t^*(1+b\Pi_{i,t}^*)(1+a\varepsilon_t)}{(1+\Pi_{i,t}^*)(1+\varepsilon_t)}$$

(i=g,b according to whether ε_t=e or ε_t=-e). In the following sections the vector:

$$\left[W_1^*,\Pi_{g,1}^*,\Pi_{b,1}^*,W_2^*,\Pi_{g,2}^*,\Pi_{b,2}^*\right]$$

will be specified for each equilibrium in pure strategy.

5.1 *The pooling equilibrium*

Let

$$V_i^P\left[W^N(1),0,W^N(\bar{x}),\Pi_g^N(\bar{x}),\Pi_b^N(\bar{x})\right]$$

(i=g,b) be the indirect utility function of the government if the pooling equilibrium is achieved.

Let

$$V_i^{PD}\left[W^N(1),\Pi_i^N(1),W^N(0),\Pi_{ig}^N(0),\Pi_b^N(0)\right]$$

(i=g,b) be the payoff to the government if it deviates optimally from the pooling strategy. Then a pooling equilibrium is attained iff

$$V_i^P,[.]>V_i^{PD}[.] \quad \text{for} \quad i=g,b.$$

If the weak government in the first period plays the pooling strategy, it always will set zero inflation, independently of the realization of the shock. The optimal response by the private sector will thus be the Nash equilibrium wage associated with a probability of observing zero inflation equal to one (q_1=1). In the final period the weak government will always inflate, since destroying its reputation can have no future consequences ($x_2^\bullet=0$). Furthermore, in the pooling equilibrium the parties do not learn by observing the government's action ($x_2=\bar{x}$). Hence, the optimal wage-inflation pair is given by the solution to the system of equations (10) and (14), where $q_2=x_2+(1-x_2)x_2^\bullet=\bar{x}$.

If instead the government chooses to deviate from the pooling strategy at time 1, it will produce inflation of $\Pi_i^N(1)$ $(1=g,b)$., which is the optimal response to the private sector choice of $W^N(1)$. In the second period the government's reputation is lost and the outcome coincides with the pair $\left[W^N(0),\Pi_i^N(0)\right]$ $(i=g,b)$.

The pooling equilibrium is attained if the cost to the government of losing its reputation (i.e. the punishment for cheating) exceeds the gain from creating surprise inflation (i.e. the temptation to cheat). The punishment for cheating obviously increases with the government's reputation. The temptation to cheat is stronger, the larger the distortion in the economy, namely the union's bargaining power, and in the presence of bad productivity shocks.

In the pooling equilibrium inflation is zero and unemployment is equal to its "natural" level.

5.2 ·*The separating equilibrium*

Let

$$V_i^S\left[W^N(\bar{x}),\Pi_i^N(\bar{x}),W^N(0),\Pi_g^N(0),\Pi_b^N(0)\right]$$

$(i=g,b)$ be the indirect utility function of the government if the separating equilibrium is achieved. Let

$$V_i^{SD}\left[W^N(\bar{x}),0,W^N(1),\Pi_g^N(1),\Pi_b^N(1)\right]$$

(i=g,b) be the payoff to the government of deviating optimally from the separating strategy. Then a separating equilibrium is attained if

$$V_i^S[.] > V_i^{SD}[.], \quad \text{for} \quad i = g,b.$$

In a separating equilibrium, the weak government inflates with probability one and the parties set wages according to their prior beliefs of facing a weak government $q_1 = \bar{x}$. Therefore, the first period equilibrium wage-inflation pair is given by $\left[W^N(\bar{x}), \Pi^N(\bar{x})\right]$. As the government action at time 1 reveals its type, in the last period $q_2 = 0$ and the one-shot equilibrium is $\left[W^N(0), \Pi^N(0)\right]$. The government may choose to deviate from the separating strategy and set inflation equal to zero in the first period. Given this behavior, in the second period the private sector expects the government to be tough; the private sector's optimal response will thus be $W^N(1)$ and the government will optimally set $\Pi^N(1)$.

The separating equilibrium is likely to occur whenever the one-shot employment gain from surprise inflation is larger than the cost of inflation's ruining the government's reputation; hence, in the presence of strong unions, negative productivity shocks and inflationary governments.

The separating equilibrium is inefficient, since no lasting reduction in the employment level is achieved at the expense of persistently positive inflation rates.

5.3 *The "mixed" equilibrium*

Let

$$V_g^M\left[W^N(q^m),0,W^N(\bar{x}),\Pi_g^N(\bar{x}),\Pi_b^N(\bar{x})\right]$$

and

$$V_b^M\left[W^N(q^m),\Pi_b^N(q^m),W^N(0),\Pi_g^N(0),\Pi_b^N(0)\right]$$

be the indirect utility functions of the government respectively if a positive and a negative productivity shock is realized, and the "mixed" equilibrium is achieved, where $q^m=(1+\bar{x})/2$. Further, let

$$V_b^{MD}\left[W^N(q^m),\Pi_b^N(q^m),W^N(0),\Pi_g^N(0),\Pi_b^N(0)\right]$$

and

$$V_b^{MD}\left[W^N(q^m),0,W^N(1),\Pi_g^N(1),\Pi_b^N(1)\right]$$

be the payoffs to the government if it deviates optimally from the "mixed" equilibrium strategy. Then a "mixed" equilibrium will be attained if

$$V_i^M[.] > V_i^{MD}[.], \quad \text{for} \quad i = g,\ b.$$

In a "mixed" equilibrium, at time 1 the weak government inflates with probability one if a negative productivity shock is observed and chooses zero inflation in presence of a positive shock. Therefore the parties set wages expecting zero inflation with probability $q^m = (1+\bar{x})/2$, since positive inflation occurs in equilibrium if a negative shock occurs and the government is weak. In the second period, the private sector's beliefs are revised according to Bayes' rule, in the same way as in the pooling (separating) equilibrium whenever a positive (negative) shock has occurred at time 1. A deviation by the government from the "mixed" equilibrium strategy at time 1 consists in setting zero inflation in the presence of a negative shock and playing the one-shot equilibrium inflation associated with a probability $q = q^m$ if the productivity shock is positive.

"Mixed" equilibria are likely to emerge when real shocks are highly volatile.

6. Some numerical results

To investigate the welfare implications of alternative wage indexation schemes, we simulate the model numerically. In this section, we focus on four extreme wage-indexing rules:

(i) neither productivity adjustment nor price indexation is allowed (i.e. a=0, b=0);

(ii) complete productivity adjustment is allowed but no price indexation (i.e. a=1, b=0);

(iii) total price indexation is allowed but no productivity adjustment (i.e. a=0, b=1);

(iv) both productivity adjustment and price indexation are allowed (i.e. a=1, b=1).

The macroeconomic scenario we postulate is the following. Labor's share, α, is assumed to be 0.7. The workers' reservation wage, $\bar{x}$, is normalized to 1. Therefore, full employment, N, equals 1. We suppose that the government assigns the same relative weight to the inflation and to the employment objectives. Thus, we choose $\bar{\lambda}$=1. Finally, the discount rate, δ , is set equal to 0.98. Given these parameter values, we simulate the model for different sizes of the productivity shock and relative bargaining powers of the parties. We present the result obtained with $e = \pm 0.03$, and two different measures of the bargaining power of the firm, γ=0.8 and γ=0.2. The possibility of having productivity shocks with higher variability $e = \pm 0.1$ is also considered in this section.

In figures 1-4 we present the range of values of the initial reputation of the government, $\bar{x}$, for which pooling and separating equilibria are attained. Only mechanisms that do not allow for price indexation are considered here, since under full price indexation the incentive of the government to create unexpected inflation is always nil. Figures 1 and 3 refer to the case of a weak union (i.e. γ=0.8); figures 2 and 4, the case of a strong union (i.e. γ=0.2). More precisely, in figures 1 and 2 we plot the differences between the government's expected utilities from playing the pooling strategy at *T*-1 and from deviating from it $\left(V_i^P - V_i^{PD}\right)$ against the reputation of the government at the beginning of the game $\bar{x} \in [0,1]$, respectively when γ=0.8 and γ=0.2. If such differences are greater than zero, then a pooling equilibrium is attained. The two external curves refer to the cases of a positive and a negative realization of the productivity shock in period *T*-1, when neither price indexation nor productivity adjustment is allowed. Of course, in the presence of a positive realization of the productivity shock, a pooling equilibrium is more likely to occur; that is, lower values of $\bar{x}$ are required for such an equilibrium to be attained. Therefore, the curve associated with a positive shock is above the one associated with a negative shock. For a pooling equilibrium to be sustainable independently of the realization of the shock, both curves must lie in the all-positive quadrant. When the bargaining power of the firm is high, γ=0.8, the pooling equilibrium is attained for values of $\bar{x} \geq 0.2$ (fig. 1). When γ=0.2, $\bar{x}$ must be at least 0.75 for a pooling equilibrium to occur (fig. 2). The middle curve (labeled by dots) applies when the wage indexation scheme in place implies total productivity adjustment (i.e. *a*=1, *b*=0). Under such an indexing rule, the range of parameter values for which a pooling equilibrium occurs results is larger. With a weak union (γ=0.8), even a government with initial reputation $\bar{x} = 0.15$

finds it optimal to choose the pooling strategy. In the presence of a stronger union (γ=0.2), the minimum value of $\bar{x}$ compatible with a pooling equilibrium rises to 0.7.

Figures 3 and 4 present the ranges of $\bar{x}$ for which a separating equilibrium is attained, when the bargaining power of the firm is 0.8 and 0.2 respectively (on the vertical axis: $V_i^S - V_i^{SD}$). Here, the curve associated with a positive shock is below that associated with a negative shock, since the temptation to deviate from the separating strategy is higher when real shock is positive.

When γ=0.8, a separating equilibrium is realized for $\bar{x} \leq 0.3$, if no indexation is in place; in the presence of complete productivity adjustment, it occurs for $\bar{x} \leq 0.35$. When γ=0.2, a separating equilibrium is never attained.

The parameter values assumed so far never sustain "mixed" equilibria. However, when the productivity shock is big, such an equilibrium too may be an outcome of the game. Figures 5, 6 and 7 show pooling, separating and "mixed" equilibria with $e = \pm 0.1$ and γ=0.8. Not surprisingly, in the presence of such a high volatility of the productivity process, the difference in terms of sets of sustainable equilibria between the cases of no indexation and complete productivity adjustment is much sharper. With no indexation, pooling equilibria are achieved for values of $\bar{x} \geq 0.6$ only. Under complete productivity adjustment, any $\bar{x} \geq 0.2$ sustains a pooling equilibrium. Separating equilibria occur for $\bar{x} \leq 0.2$, if no indexation is in place; for $\bar{x} \leq 0.3$, when productivity adjustment is allowed. Finally, in figure 7, the increasing (decreasing) curve represents the additional gain of the government from playing the "mixed" equilibrium strategy over the payoff it will get if it deviates from it, $V_g^M - V_g^{MD}\left(V_b^M - V_b^{MD}\right)$, when a good (bad) productivity shock occurs. A "mixed" equilibrium occurs when both curves lie in the all-positive quadrant. For γ=0.8, any value of $\bar{x} \in (0,0.7)$ sustains such equilibrium. A "mixed" equilibrium never occurs for γ=0.2.[8]

Having characterized the equilibria which occur when no price-indexing is in place, we are now able to analyze the welfare implications of each of the indexation rules described at the beginning of this section. Welfare is measured by the ex-ante two-period expected utilities of the government, the firm and the union. Table 1 shows the results of the case of a weak union $(\gamma = 0.8)$; Table 2 for a strong union $(\gamma = 0.2)$. Table 3, for a weak union $(\gamma = 0.8)$ and a highly volatile productivity shock $(e = \pm 1)$.

Let us first consider the utility of the government. Except in the case of a strong union, having both price and productivity indexation yields a higher level of welfare (lower disutility) than having just price indexation, because of the additional employment stabilization effect involved. Price indexing is desirable whenever the

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[8] The case of no indexation is the only one that can be addressed here since when complete productivity adjustment is in place the optimal strategy of the government is independent on the realization of the shock

reputation of the government is bad, since the credibility enforcement implied by such a negotiation structure prevents the parties from agreeing on high nominal wages and, consequently, the government from pursuing high inflationary policies.

Table 1

EX-ANTE UTILITIES OF THE GOVERNMENT, THE FIRM AND THE UNION (γ=0.8,e=$\pm$0.03)(in parentheses, the equilibrium type: p=pooling, s=separating)

	a=0,b=0			a=1,b=0			a=0,b=1			a=1,b=1		
	u_0^g	u_0^f	u_0^u	u_0^g	u_0^f	u_0^u	u_0^g	u_0^f	u_0^u	u_0^g	u_0^f	u_0^u
$\bar{x} = 0.2$	-.1999 (p)	.6900 (p)	.1271 (p)	-.1965 (p)	.6879 (p)	.1267 (p)	-.1228	.7029	.1295	-.1138	.7004	.1290
	-.3729 (s)	.6892 (s)	.1270 (s)	-.3761 (s)	-.6873 (s)	.1267 (s)						
$\bar{x} = 0.4$	-.1171 (p)	.6914 (p)	.1273 (p)	-.1122 (p)	.6892 (p)	.1270 (p)	-.1228	.7029	.1295	-.1138	.7004	.1290
$\bar{x} = 0.6$	-.0848 (p)	.6969 (p)	.1284 (p)	-0.792 (p)	-.6947 (p)	.1280 (p)	-.1228	.7029	.1295	-.1138	.7004	.1290
$\bar{x} = 0.8$	-0.740 (p)	.7005 (p)	.1290 (p)	-.0684 (p)	.6982 (p)	.1286 (p)	-.1228	.7029	.1295	-.1138	.7004	.1290

Table 2

EX-ANTE UTILITIES OF THE GOVERMENT, THE FIRM AND THE UNION (γ=0.2, e=$\pm$0.03) (in parentheses, the equilibrium type: p=pooling)

	a=0,b=0			a=1,b=0			a=0,b=1			a=1,b=1		
	u_0^g	u_0^f	u_0^u	u_0^g	u_0^f	u_0^u	u_0^g	u_0^f	u_0^u	u_0^g	u_0^f	u_0^u
$\bar{x}=0.2$	-	-	-	-	-	-	-.7747	.4280	.2550	-.7751	.4265	.2541
$\bar{x}=0.4$	-	-	-	-	-	-	-.7747	.4280	.2550	-.7751	.4265	.2541
$\bar{x}=0.6$	-	-	-	-	-	-	-.7747	.4280	.2550	-.7751	.4265	.2541
$\bar{x}=0.8$	-.6291 (p)	.4065 (p)	.2422 (p)	-.7435 (p)	.3963 (p)	.2361 (p)	-.7747	.4280	.2550	-.7751	.4265	.2541

Table 3

EX-ANTE UTILITIES OF THE GOVERNMENT, THE FIRM AND THE UNION (γ=0.8, e=$\pm$0.1) (in parentheses, the equilibrium type: p=pooling, s=separating, m=mixed)

	a=0,b=0			a=1,b=0			a=0,b=1			a=1,b=1		
	u_0^g	u_0^f	u_0^u	u_0^g	u_0^f	u_0^u	u_0^g	u_0^f	u_0^u	u_0^g	u_0^f	u_0^u
$\bar{x}=0.2$	-	-	-	-.1965 (p)	.6879 (p)	.1267 (p)	-.2159	.7276	.1340	-.1138	.7004	.1290
	-.3456 (s)	.7049 (s)	.1298 (s)	-.3761 (s)	-.6876 (s)	.1267 (s)						
$\bar{x}=0.4$	-	-	-	-.1122 (p)	.6892 (p)	.1270 (p)	-.2159	.7276	.1340	-.1138	.7004	.1290
	-.1652 (m)	.7110 (m)	.1310 (m)									
$\bar{x}=0.6$	-.1423 (p)	.7188 (p)	.1324 (p)	-.0792 (p)	-.6947 (p)	.1280 (p)	-.2159	.7276	.1340	-.1138	.7004	.1290
$\bar{x}=0.8$	-.1321 (p)	.7237 (p)	.1333 (p)	-.0684 (p)	.6982 (p)	.1286 (p)	-.2159	.7276	.1340	-.1138	.7004	.1290

For high values of $\bar{x}$, mechanisms which allow for price indexation are dominated by both schemes with no indexation at all and productivity adjustment only. The case of a weak union exhibits stronger superiority of the productivity adjustment scheme over all the others. In fact, when $\gamma=0.8$, productivity indexing is optimal for all values of $\bar{x} \in [0.4,1]$. Not surprisingly, the higher the variance of the real shock the higher the benefit (cost) of productivity indexing (price indexing) relative to the no-indexation case.

Unlike government preferences, the private sector's utility from alternative wage-indexation schemes exhibits a very clear pattern. Regardless of government reputation, relative bargaining powers and size of the productivity shock, both the firm and the union always prefer full price indexation to any other wage-indexing rule. Moreover, the payoffs of both the firm and the union are decreasing in the degree of productivity indexation. The insight behind this result is rather straightforward. Private sector's welfare, measured by the product of the firm and the union utilities, is locally concave at maximum. Rules which reduce uncertainty over the *ex-post* real wage are always preferred to those which increase wage randomness. In fact, while price indexation makes real wages independent of monetary shocks, productivity indexing causes wages to adjust to the uncertain realization of real shocks.[9]

[9] This result crucially relies on the presence of the union in the wage negotiation process (i.e. $\gamma<1$). Firm's preferences are convex in the real wage. Therefore, if the union had no power, the private sector's utility would instead be increasing in the degree of productivity indexation and decreasing in the degree of price

7. The equilibrium in the first stage: wage-indexation bargaining

Union, firm and government may all find it advantageous to index nominal wages to price and/or productivity shocks. We assume that, in the first stage of the game, the union and the firm, together with the government, negotiate over the wage-indexation mechanism which is going to prevail until the end of the game.[10] We define agreements to be pairs (a,b), $a\varepsilon[0,1]$ and $b\varepsilon[0,1]$, such that, the *ex-post* nominal wage (i.e. the nominal wage that is actually paid to workers, once the productivity shock and the price level have been observed) is

$$(1-a)\left[b(1+\Pi)+(1-b)\right]W+a(1+\varepsilon)\left[b(1+\Pi+(1-b)\right]W.$$

Thus, *a* and *b* represent the fractions of nominal wage which adjust in response to productivity and price shocks, respectively.

Let u_0^f, u_0^u and u_0^g characterize the two-period *ex-ante* utilities of the firm, the union and the government as a function of the indexation-mechanism parameters. That is,

$$u_0^f = E_0\left[u_1^f(a,b)\right]+\delta E_0\left[u_2^f(a,b)\right] \tag{16}$$

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indexation. This would dramatically affect the equilibrium in the first stage of the game.

[10] The "tough" government is indifferent between alternative wage-indexation rules. Therefore, the outcome of the bargaining in the first stage does not reveal government type.

(17) $$u_0^u = E_0\left[u_1^u(a,b)\right] + \delta E_0\left[u_2^u(a,b)\right]$$

(18) $$u_0^g = E_0\left[u_1^g(a,b)\right] + \delta E_0\left[u_2^g(a,b)\right]$$

where E_0 is the expectation operator conditional on information available in the first stage of the game. Then, the payoffs of the parties for the agreement are their *ex-ante* two-period utility functions, equations (16), (17) and (18). If the parties fail to reach an agreement, then no indexation will ever take place and the parties obtain payoffs (16), (17) and (18), evaluated at a=0 and b=0. We denote such disagreement utility values with d_0^f, d_0^u, and d_0^g.

The equilibrium concept we refer to is the Nash bargaining solution. The predicted degrees of wage indexation to productivity and prices are then, respectively

(19) $$a = \arg\max_a \left(u_0^f - d_0^f\right)\left(u_0^u - d_0^u\right)\left(u_0^g - d_0^g\right)$$

(20) $$a = \arg\max_a \left(u_0^f - d_0^f\right)\left(u_0^u - d_0^u\right)\left(u_0^g - d_0^g\right).$$

Table 4 shows the equilibrium values of *a* and *b* obtained by simulating the model under three different sets of parameter values. For each set, we report the results that correspond to values of the initial reputation of the government for which a pooling equilibrium is attained in the second stage of the game. The first rows refer to the case of a weak union (γ=0.8) and low variability of the productivity shock ($e\pm0.03$). As expected, in the presence of a government with bad reputation the equilibrium prescribes full price indexation. As the government's reputation improves, the degree of price indexation tends to decrease. A union with high bargaining power makes productivity indexing completely unappealing to the government, since the nominal wage that will be negotiated by a strong union under such an indexation rule will be extremely high. Therefore, the government's willingness to trade price for productivity indexation is low under this setup. As a matter of fact, when $\gamma=0.2$ and $e=\pm0.03$, the government maximizes its utility at the disagreement point (see table 2), so that bargaining over wage-indexation mechanisms does not actually need to take place in the first stage. Thus, the equilibrium implies $a=0$ and $b=0$. Finally, with highly volatile productivity processes ($e=\pm0.1$), productivity indexing becomes more important to the government. In equilibrium, higher indexation to productivity is obtained in exchange for higher indexation to prices.

Table 4

OPTIMAL DEGREES OF WAGE INDEXATION TO PRODUCTIVITY AND PRICES

Parameter values		a	b
γ=0.8, e=±0.03	$\bar{x}=0.2$	0.25	1
		0.75	1
	$\bar{x}=0.2$		
	$\bar{x}=0.2$	0.30	0.10
	$\bar{x}=0.2$	0.15	0.05
γ=0.2, e=±0.03	$\bar{x}=0.8$	0	0
γ=0.8, e=±0.03	$\bar{x}=0.6$	0.45	1
	$\bar{x}=0.8$	0.25	0.5

The payoffs that the parties obtain in case of disagreement play a crucial role in the determination of the equilibrium wage-indexation rule. Different specifications of the disagreement outcome may alter the result dramatically. It is therefore important to investigate how the equilibrium indexation mechanism is responsive to alternative bargaining situations. We now briefly address two extreme specifications of the disagreement outcome.

(i) In case of disagreement, the government can enforce the wage-indexation rule by law. The outcome would typically imply a pair (a,b), $a \in (0,1)$ and $b \in (0,1)$, which maximizes the government's *ex-ante* utility function. Such an equilibrium pair would depend on the government's reputation, the relative bargaining powers of the firm and the union in the wage-bargaining process, and the volatility of the productivity shock;

(ii) the firm and the union can reach an agreement over the wage-indexation mechanism without the need for government intervention. Or, equivalently, the government's loss from disagreement is infinitely large (e.g. the government is not able to remain in power). In equilibrium, the private sector's utility would be maximised at $a=0$ and $b=1$.[11]

8. Concluding remarks

In this paper we consider a reputational model where monetary policy is characterized as a repeated game between

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[11] It would be easy to design a scheme of tax incentives or deterrents which the government might find profitable to implement in order to reduce the benefits from price indexation (e.g. highly progressive tax rates) and/or to lower the costs associated with indexation to productivity (e.g. tax-exempt bonuses linked to improvements in some measure of labor productivity).

the government and the private sector. The government wishes to stabilize prices and employment around certain desired levels. The private sector is represented by a wage formation mechanism which incorporates the behavior of two agents: a union and a firm. They bargain over the nominal wage taking into account their expectations about the inflation policy implemented by the government and the occurrence of a stochastic productivity shock.

This setup enables us to focus on the welfare implications of different wage negotiation schemes. In particular, price and productivity indexing are compared. In a perfectly price-indexed economy, the government has no incentive to create unexpected inflation and the inflationary bias associated to the credibility problem is completely eliminated. On the other hand, negotiation mechanisms which allow wages to respond to productivity shocks seem to be more appropriate for dampening macroeconomic fluctuations caused by real disturbances.

The analysis suggests that, provided the reputation of the government is good enough and the relative bargaining power of the union is not too high, wage-indexation schemes which allow for productivity adjustments only are able to guarantee both price and employment stability, since the employment stabilization effect incorporated in this kind of wage determination structure sufficiently reduces the government's incentive to create unexpected inflation.

We assume that, in a first stage of the game, the firm and the union, together with the government, negotiate over the wage-indexation mechanism that will prevail until the end of the game.

We show that the equilibrium degree of price-indexation decreases as the government's reputation improves. It tends to increase with the relative bargaining power of the union, since zero inflation (pooling) equilibria are less likely to occur in the presence of a strong union. However, if the union were extremely powerful, government would find it optimal to forbid any form of indexation.

Productivity indexing becomes more desirable to the government in the presence of highly volatile productivity processes and relatively weak unions. Under this setting the government's willingness to exchange price for productivity indexation is greater. As a result, in equilibrium higher degrees of wage indexation to both monetary and real shocks are likely to occur.

APPENDIX

Wage-bargaining systems in selected OECD countries[12]

Belgium

Coverage high
Bargaining system
- Industry-level bargaining applying by law to all workers in the sector.
- Supplementary firm-level bargaining.

Wage indexing
- 1982: the government suspends indexation.

France

Coverage high
Bargaining system
- Industry-level bargaining applying by law to all workers in the sector.
- Most pay above this level determined at employer's discretion (*interessement* and profit-sharing have become more common in the 1980s).

Wage indexing
- 1982: the government promulgates a wage policy which ties wage increases to inflation rates in a prior period.

Germany

Coverage high
Bargaining system
- Industry-level bargaining in each region, frequently extended by law to all workers in the sector.
- Supplementary firm-level bargaining.

Wage indexing
- Prohibited by law.

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[12] Source: Layard, Nickell and Jackman (1991).
For coverage, "high" = above 75 per cent, "medium" = 25-75 per cent, "low" = under 25 per cent.

Italy

Coverage high
Bargaining system
- Industry-level bargaining applying by law to all workers in the sector.
- Supplementary firm-level bargaining; in the private sector increasing interest is being shown for new types of incentives (mainly in the form of premiums and productivity bonuses).

Wage indexing
- 1976-78: full indexation in return for presumption of low wage settlements and reasonable strike behavior.
- 1984: government proposal for reduction of permitted degree of indexation in the "scala mobile"; rejected by CGIL; confirmed by *referendum* in 1985.
- 1993: "scala mobile" suppressed.

Scandinavia

Coverage high
Bargaining system
- National bargain between trade union federation and employers' federation.
- Supplementary industry-level and firm-level bargaining.

Wage indexing
- Indexation suspended (Denmark, in 1983; Finland, in 1986).

United Kingdom

Coverage high
Bargaining system
- Some industry-level bargaining. Majority of private-sector workers covered by firm-level bargaining. Increasing adoption of pay incentive systems. In 1990 the proportion of workplaces where profit-sharing schemes were in place was 43 per cent; participation in share-ownership programs averaged 34 per cent.

Wage indexing
- Nil.

United States

Coverage low

Bargaining system

- Firm-level bargaining; three general types of pay incentive systems: capital gain-sharing, profit-sharing, employee share ownership plans; rare in collective bargaining agreements.

Wage indexing

- Explicit COLAs are rare in non-union employment agreements.

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