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Central bank independence, centralization of wage bargaining, inflation and unemployment: Theory and some evidence

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Abstract

This paper proposes a conceptual framework to investigate the effects of central bank independence, of the degree of centralization of wage bargaining and of the interaction between those institutional variables, on real wages, unemployment and inflation, in a framework in which unions are averse to inflation. This aversion moderates unions' wage demands as they attempt to induce the central bank to inflate at a lower rate. An increase in the degree of centralization of wage bargaining (a decrease in the number of unions) triggers two opposite effects on real wages, unemployment and inflation. It reduces the substitutability between the labor of different unions and therefore the degree of effective competition between them. This 'reduced competition effect' raises real wages, unemployment and inflation. But the decrease in the number of unions also strengthens the moderating effect of inflationary fears on the real wage demands of each union. This 'strategic effect' lowers real wages, unemployment and inflation. For sufficiently inflation averse unions the interaction between those two effects produces a Calmfors–Driffill type relation between real wages and centralization. The paper analyzes the effects of central bank independence on the position and the shape of this relation, as well as on inflation and unemployment.

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The paper features two mechanisms, one of which is novel, through which monetary institutions have real effects. The model implies that if there is a single union social welfare is maximized when the central bank attaches a zero weight to inflation. But when the number of unions is larger than one this result is no longer true in general. Empirical evaluation of some of the theoretical implications, using data from 19 developed economies, is for the most part supportive of those implications.

JEL classification: E50; E58; J50; J51

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1. Introduction

This paper takes a step towards the integration of the literature on strategic monetary policy with the literature on the degree of centralization of wage bargaining in the economy. Integration of those traditionally separate strands of thought makes it possible to investigate the effects of monetary policy and of labor market institutions on macroeconomic performance. More specifically, the paper develops a framework that delivers theoretical predictions regarding the effects of central bank independence (CBI), of the centralization of wage bargaining (CWB), and of their interaction, on inflation, unemployment and real wages. Some of those implications are then subjected to a preliminary empirical investigation using data on CBI, CWB, inflation and unemployment.

In the presence of perfect information the strategic interaction between nominal wage setters and a monetary authority that cares about *both* employment and price stability creates excessive inflation without having any effect on the level of employment. This is the well known Kydland and Prescott (1977) – Barro and Gordon (1983) inflationary bias result. The bias can be reduced by delegating authority to a central banker whose relative concern for price stability is larger than that of society (Rogoff, 1985). Delegation of authority to such a 'conservative' central bank reduces the inefficient inflationary bias without having any effect on average employment and is therefore welfare improving.[1] This point of view is at the root of the theoretical argument in favor of delegating authority to a central bank (CB) that, by nature or by law, possesses a stronger preference for price stability than the general public.

[1] This statement abstracts from the welfare cost due to the fact that a more ('weight') conservative central bank stabilizes employment shocks to a lesser extent. This abstraction is deliberate since one of the points of the paper is that, even when there is no need to use monetary policy for stabilization purposes, the degree of conservativeness of the central bank may *also* affect the average level of employment.

Those results abstract from the institutional structure of labor markets and from the possibility that, particularly when they are large, unions take into consideration the strategic impact of their wage decisions on monetary policymakers and on inflation. Building on the work of Bruno and Sachs (1985), Calmfors and Driffill (1988) and others have emphasized the effects of the degree of CWB on real wages and through them on economic performance.[2] They argue that there is more wage restraint in economies characterized by either high or low levels of CWB than in economies with intermediate levels of centralization of wage bargaining. As a consequence unemployment should be lower at extreme than at intermediate levels of CWB producing a hump shaped relation between unemployment and CWB.

Decentralized systems are expected to deliver a favorable macroeconomic performance through the effects of competition among labor suppliers. At the other extreme, the more centralized is wage bargaining, the more likely it is that unions internalize the effects of their bargaining posture on macroeconomic performance. Hence, unions are likely to be less militant the higher the degree of centralization of wage bargaining. In particular, it is likely that under centralized wage setting, the (single) union will take into consideration the effect of its actions not only on the real wage and the employment of its members, but also on the general rate of inflation. Union members dislike inflation for the same reasons that the public at large does. One important reason is that their pensions and other savings are not fully indexed. As a matter of fact, in many countries they are not indexed at all.[3]

The nature of equilibrium in a modified Barro–Gordon framework where unions dislike inflation is investigated by Cubitt (1992, 1995) and Agell and Ysander (1993), who consider the strategic interaction between a *single* union and a policymaker concerned with employment and price stability. As in Chapter 3 of Cukierman (1992), there is a basic conflict between the monetary policymaker and the union with regard to the real wage. A remarkable feature of the resulting discretionary equilibrium is that, unlike in conventional monetary policy games, employment is higher than the level desired by the union when it takes price stability as being unconditionally assured. The reason is that, since the union dislikes inflation, it is willing to compromise somewhat on its real wage objective in order to induce the monetary authority to produce a lower inflation.[4] But most existing research has limited the analysis to the case of

[2] One of the first to notice the potential link between macroeconomic performance and the industrial organization of labor markets (or 'corporatism') was Tarantelli (1982), who tragically lost his life due to his professional position on those matters.

[3] Gruner and Hefeker (1999) report that the representatives of German labor unions recently demanded that inflation continue to be low under the European Monetary Union.

[4] A similar insight appears in Gruner and Hefeker (1999), Gylfason and Lindbeck (1994), Jensen (1997), Skott (1997), and Yashiv (1989).

a single all encompassing union. Two notable exceptions are the paper by Skott (1997) and the companion paper by Velasco and Guzzo (1999) that appears in this issue of the Review. The similarities and differences between the two papers are discussed in Section 6.

This paper develops a theoretical framework for the analysis of economic performance that incorporates institutional features of both labor markets and of monetary policy institutions. This is done by introducing the degree of CWB in the economy, as well as unions' inflation aversion, explicitly into a monetary policy framework of the Barro–Gordon type. This framework makes it possible to examine how inflation and unemployment relate to the degree of CWB, to the degree of CBI and to their interaction. The analytical framework nests existing models of the strategic interaction between the central bank and unions as particular cases. Those models include Barro and Gordon (1983), Chapter 3 of Cukierman (1992), and Cubitt (1992, 1995).[5] The framework also explicitly recognizes that the labor of different unions is differentiated and that the number of different bargaining units in the economy affects the elasticity of demand for the labor of each individual union and, through it, competitiveness in the labor market.

Existing evidence on the effects of CWB and of CBI on macroeconomic performance is mixed but provocative. Hall and Franzese (1996) produce evidence from 17 OECD countries which supports the view that macroeconomic performance as measured by inflation and unemployment depends on *both* CBI and the degree of coordination of wage bargaining.[6] In particular they find, contrary to conventional wisdom, that when the coordination of wage bargaining is sufficiently low, a higher level of CBI is associated with higher unemployment.[7] Bleaney (1996), on the other hand, working with a similar sample finds no effect of CBI on employment.

In spite of those mixed results, and perhaps because of them, it is important to identify conditions under which we should expect to observe a link between CBI and unemployment. Accordingly, the main purpose of this paper is to investigate conceptually the consequences, for unemployment and inflation, of the strategic interaction between central banks possessing various degrees of CBI (or of 'effective' conservativeness) and of labor markets characterized by various

[5] Bleaney (1996) and Forteza (1998) also present a game between a *number* of unions and a CB as is done here. However in their framework inflation does not enter the unions' objective function and firms have sufficient market power to set prices as a markup over wages. By contrast in our framework firms have no market power.

[6] The *coordination* of wage bargaining is an indicator which accounts both for the structure of *unions* and for that of *firms* in the wage negotiating process. Although it is related to the concept of CWB, the main difference is that the latter concept focuses only on the industrial organization of unions.

[7] They also find significant interactions in the effects of labor market and monetary institutions on the economy. For instance, they find that higher CBI is more effective in reducing inflation the lower the coordination of wage bargaining and that there is no significant relation between CBI and unemployment at high levels of coordination of wage bargaining.

degrees of CWB.[8] One important implication of the analysis is that the shape and position of a Calmfors–Driffill type relation between real wages and centralization depends on CBI. A subsidiary objective of the paper is to take a preliminary broad look at the degree of conformity between some of the implications of the theory and available evidence.

Our paper, in conjunction with a recent paper by Alesina and Perotti (1997), can be viewed as generally investigating the interactions between the industrial organization of labor markets and macroeconomic policies. Alesina and Perotti focus on the interactions between the effects of labor taxation and the number of unions, whereas this paper focuses on the interactions between the latter and the structure of monetary policy institutions as characterized by CBI.

The paper is organized as follows. Section 2 presents the structure of labor markets and of the strategic interaction between a number of unions and the CB. Section 3 characterizes equilibrium real wages, unemployment and inflation. Section 4 discusses the consequences of CBI and of CWB for unemployment and inflation. The results amplify and qualify previous literature by identifying conditions for the existence of: (1) a Calmfors–Driffill type relation between real wages and the CWB; (2) interactions between monetary institutions and unemployment; (3) a negative impact of CBI on inflation. Implications for the optimal degree of CB 'conservativeness' are also derived. The paper's framework implies that in a fully centralized labor market social welfare is maximized when the CB is 'ultra-liberal' in the sense that it does not care at all about price stability. But, as bargaining becomes more decentralized this result is no longer true in general, and an intermediate central banker who has some concern for price stability is optimal.[9]

In Section 5 we use institutional and macroeconomic data on 19 developed economies to conduct a preliminary empirical examination of some of the implications of our theoretical framework. The institutional data includes indices of CWB based on OECD (1997) and indices of CBI from Cukierman et al. (1992). This is followed by a brief comparison to recent literature in Section 6 and by concluding remarks.

2. A simple game between n independent unions and the central bank

The economy consists of n independent unions and of a CB whose degree of inflation aversion is characterized by a parameter I.[10] The typical union likes

[8] The effective degree of conservativeness already takes into consideration both the relative objectives of the central bank as well as its ability to conduct policy so as to attain these objectives. A distinction between conservativeness and independence was first drawn by Lohmann (1992) and elaborated further by Cukierman (1994) and Lippi (1999, forthcoming).

[9] A similar insight appears in Skott (1997).

[10] An independent union is a union that has the authority to decide its wage policy in an independent manner.

high wages and low unemployment for its members and also dislikes inflation to some extent. This is captured by the loss function

$$\Omega_j \equiv -2w_{rj} + Au_j^2 + B\pi^2 \tag{1}$$

where u_j is the rate of unemployment among members of union j, $\pi \equiv p - p_{-1}$ is the rate of inflation (defined by the difference in the log of the price level) and A and B are positive parameters. The first two arguments reflect the union's sectorial interest and are conventional in the theory of trade unions' behavior. [11] The third one reflects the union's aversion to inflation.

The CB is concerned with aggregate unemployment (u) and price stability. More precisely, the objective of the CB is to minimize the following loss function:

$$\Gamma \equiv u^2 + I\pi^2 \tag{2}$$

where I is a measure of the relative inflation aversion of the CB. This parameter is also known as the degree of (multiplicative) CB conservativeness.[12] We consider a two-stage game and solve it by backward induction. In the second stage, the CB chooses inflation, taking the nominal wages previously set by all the unions as given, so as to minimize its loss function. In the first stage each union chooses its nominal wage rate so as to maximize its objectives, taking the nominal wage rates chosen by all other unions and the subsequent central bank reaction as given. (The sequence of events is illustrated in Fig. 1.) In this framework, CBI is proxied by the central bank (effective) degree of conservativeness, I, and the CWB by $1/n$ which increases when the number of unions bargaining independently decreases.

2.1. The labor market

Total labor supply in the economy is L. All labor is (effectively) unionized and is evenly distributed over the n unions. Although the labor of any given union can be usefully employed in all industries it is not perfectly substitutable for the labor of other unions.[13] Labor of a given union is supplied completely inelastically and is mobile across industries. The demand for the labor of workers in union j is given by

$$L_j^d = \left[\frac{\alpha}{n}(d - w_{rj}) - \gamma(w_{rj} - \bar{w}_r)\right]L \tag{3}$$

[11] See for example Oswald (1982).

[12] I should be interpreted as the *effective* degree of conservativeness that takes into consideration both the relative objectives of the CB as well as its ability to realize those objectives (see also footnote 8). Since existing measures of CBI aim at measuring the combined effect of those two elements we use the terms conservativeness and CBI interchangeably in the remainder of the paper.

[13] The notion underlying this specification is that labor is generally differentiated.

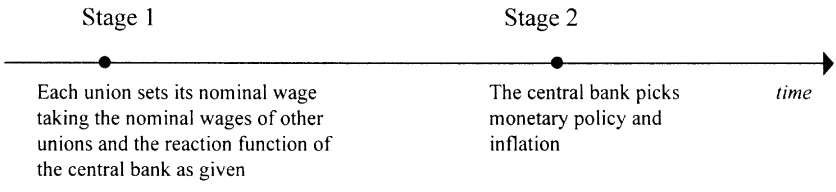

Fig. 1. Timing of moves.

where L_j^d is demand for the labor of that union, w_{rj} is the (logarithm) of the real wage obtained by its members, $\bar{w}_r \equiv \sum_{j=1}^{n} w_{rj}/n$ is the (arithmetic) mean of w_{rj} over all unions in the economy and d, α and γ are positive parameters. This demand function states that the share (in total labor force) of labor demand facing union j is decreasing in its own real wage and increasing in the average real wage in the economy. This demand emanates, in general, from all industries although the demand for the labor of a particular union may be dominated by the demands of a smaller number of industries. The specification of demand presumes that each worker is affiliated with only one union. Summing over unions, aggregate demand for labor in the economy is given by

$$L^d \equiv \sum_{j=1}^{n} L_j^d = \alpha(d - \bar{w}_r)L\,. \tag{4}$$

Eq. (4) states that aggregate demand for labor depends (negatively) *only* on the *average* real wage $\bar{w}_r$. In particular aggregate demand for labor *does not* depend on the number of unions in the economy. Eq. (3) implies that any union that sets its real wage equal to the average real wage in the economy obtains $1/n$ of aggregate labor demand. When it sets the real wage above (below) the mean wage its total share of aggregate demand is lower (higher) than $1/n$. But since labor is differentiated deviations of the real wage of a particular union from the economy wide average do not induce a total loss of demand or an infinite demand. For a given number of unions the parameter γ measures the degree of substitutability between the labor of different unions.

Eq. (3) implies that the absolute value of the elasticity of labor demand facing union j, η_j, with respect to the (level of the) real wage set by the union is

$$\eta_j = \frac{\alpha + \gamma(n-1)}{\alpha(d - w_{rj}) - n\gamma(w_{rj} - \bar{w}_r)}\,. \tag{5}$$

This elasticity is increasing with the degree of decentralization of wage bargaining as measured by n provided w_{rj} does not deviate too much, in an upwardly

direction, from the mean real wage.[14] Thus, Eq. (3) implies that, although *total* labor demand does not depend on the degree of centralization of wage bargaining, the extent of wage competition among unions is larger when the labor force is spread over a larger number of bargaining units. This is the competition effect of more decentralization discussed by Calmfors and Driffill (1988) and Calmfors (1993).

3. Characterization of equilibrium

In the second and last stage of the game the CB takes the nominal wages set by unions as given and chooses the rate of inflation so as to minimize the losses in Eq. (2). We thus focus on discretionary monetary policy. In the first stage each union chooses its nominal wage taking as given the nominal wages of all other unions and the reaction function of the CB. We assume for simplicity that all unions are identical in size, so each of them possesses a total labor supply of $L_j = L/n$.

3.1. Choice of inflation by the central bank

Reformulating the labor demand equation in terms of nominal wages and inflation leads to the following aggregate unemployment equation:

$$u \equiv \frac{L - L^d}{L} = \alpha(\bar{w} - \pi - p_{-1} - w_r^c) \tag{6}$$

where $\bar{w} \equiv \sum_{j=1}^{n} w_j/n$ is the average nominal wage, p_{-1} is the (log of the) previous period price-level and $w_r^c \equiv d - 1/\alpha$ is the market clearing real wage, at which $u = 0$.[15] The central bank's problem is to choose the inflation rate to minimize the loss function in Eq. (2), subject to Eq. (6), taking $\bar{w}$ as given. This yields the following monetary policy reaction function:

$$\pi = \frac{\alpha^2}{\alpha^2 + I}(\bar{w} - w_r^c - p_{-1}). \tag{7}$$

[14] The sign of the partial derivative of η_j with respect to n is determined by the sign of

$$\alpha(d - \bar{w}_r) - \gamma(w_{rj} - \bar{w}_r)$$

which is positive if and only if

$$w_{rj} < \bar{w}_r + \frac{\alpha}{\gamma}(d - \bar{w}_r).$$

Provided aggregate labor demand is positive, $d - \bar{w}_r$ is positive as well implying that as long as the real wage chosen by an individual union is not 'too much' above the economy wide real wage η_j is increasing in n. As will become apparent later this condition is always satisfied in equilibrium.

[15] Given the assumption of identical labor supplies across unions the competitive real wage is the same for all unions.

Eq. (7) can be rewritten, splitting the nominal wage into its real and expected price-level components ($\bar{w} = \bar{w}_r + Ep$) as

$$\pi = \frac{\alpha^2}{\alpha^2 + I}(\bar{\phi} + E\pi), \quad \bar{\phi} \equiv \bar{w}_r - w_r^c . \tag{8}$$

Since it represents the excess of the average equilibrium real wage over the competitive real wage we refer to $\bar{\phi}$ as the (real) wage premium. The CB reaction function in Eq. (8) implies that the CB partially accommodates the average wage premium as well as expected inflation. In particular, the more militant are unions on average (the higher $\bar{\phi}$), the higher is the rate of inflation produced by the CB. For given values of expected inflation and of unions' militancy the extent of accommodation is larger the higher is the response of aggregate labor demand to the average real wage, α, and the lower the conservativeness of the CB, I. Since there is no uncertainty and expectations are rational the rate of inflation is forecasted perfectly by unions at contracting time. Imposing the rational expectations condition that $\pi = E\pi$ in Eq. (8) the equilibrium expression for inflation is:

$$\pi = \frac{\alpha^2}{I}\bar{\phi} \tag{9}$$

which shows the well known Kydland and Prescott (1977) and Barro–Gordon (1983) result that inflation is positive when the 'natural' unemployment rate is above the desired rate (zero in our case).[16] It also appears that, for a given wage premium, inflation is lower the higher is I.

3.2. Choice of wage rates by unions

In the first stage each union chooses the nominal wage w_j so as to minimize the loss function in Eq. (1), taking nominal wages of other unions and the reaction function of monetary policy to nominal wages (Eq. (7)) as given. The unemployment rate among union's j workers is given by[17]

$$u_j \equiv \frac{L_j - L_j^d}{L_j} = \alpha(w_j - \pi - p_{-1} - w_r^c) + \gamma n(w_j - \bar{w}). \tag{10}$$

[16] Unemployment is positive when the real wage exceeds the competitive level (i.e. for all $\bar{\phi} > 0$).

[17] This formulation assumes that labor contracts are such that each union picks the wage rate, leaving the expost determination of employment to management. This is sometime known as the 'right to manage' contract. As illustrated by the work of McDonald and Solow (1981, 1985), this is not the only theoretically plausible contract. But, as argued by Clark (1990), many actual labor contracts are of the 'right to manage' type.

Using Eq. (10) in Eq. (1) the optimization problem of a typical union can be formulated as

$$\min_{w_j} E\{-2(w_j-\pi-p_{-1}) + A[\alpha(w_j-\pi-p_{-1}-w_r^c)+\gamma n(w_j-\bar{w})]^2+B\pi^2\} \tag{11}$$

where E is the expectations operator. It is shown in the appendix that the solution to this typical union problem leads to the following equilibrium average real wage premium:

$$\bar{\phi}=\frac{Z}{\alpha\{(1-Z)B\alpha/I+A[\alpha Z+\gamma(n-1)]\}}=\phi_j\,,\quad \forall j\text{'s}\,, \tag{12}$$

where

$$Z\equiv 1-\frac{\mathrm{d}\pi}{\mathrm{d}w_j}=1-\frac{\alpha^2}{(\alpha^2+I)n},\quad j=1,\ldots,n.$$

This is also the wage premium of each individual union since the problem is symmetric. Note that the wage premium is lower, and employment higher, the higher the parameters A and B. Z is the impact of a one unit increase in the nominal wage rate on the typical union's real wage rate taking into consideration the reaction function of the CB. Thus Z is a measure of the effectiveness of changes in the nominal wage in bringing about changes in the real wage. For finite values of CB conservativeness and of the number of unions this effectiveness is smaller than one. This implies that in order to raise its real wage by one unit the union has to raise its nominal wage rate by more than one unit. The expression for Z suggests that this effectiveness is lower the smaller the number of unions and the more liberal is the CB (the lower I). It can be shown that, other things the same, the wage premium is an increasing function of Z. Substituting the expression for Z into Eq. (12) and rearranging, the wage premium can be expressed as

$$\bar{\phi}=\frac{I[(n-1)\alpha^2+nI]}{\alpha\{B\alpha^3+AI[\alpha((n-1)\alpha^2+nI)+\gamma(n-1)n(\alpha^2+I)]\}}=\phi_j\,,\quad \forall j\text{'s}. \tag{13}$$

The equilibrium rate of unemployment is, from Eq. (6),

$$u=\alpha\bar{\phi}. \tag{14}$$

It appears from Eq. (13) that the equilibrium average wage premium is positive, and therefore so are unemployment and inflation (from Eqs. (9) and (14)). The first two results are a consequence of the fact that each union is willing

to inflict some unemployment on its members in order to raise the real wage of the employed members above the competitive level. The last result is due to the policymaker's incentives under discretionary policy.

4. Features of equilibrium outcomes

Eq. (13) shows that the equilibrium wage premium depends on a number of structural parameters, such as the degree of CBI (I) and of CWB ($1/n$), unions' preferences (A, B) and on the degree of labor substitutability across unions as characterized by γ. This section presents several comparative statics experiments that study how equilibrium outcomes vary when some of those parameters change. Examination of Eq. (13) yields the following:

Proposition 1. For a finite number of unions, the more unions care about price stability (the higher is B) and/or the higher is substitutability between different types of labor (the higher is γ), the lower is the equilibrium real wage premium and, correspondingly, the lower are unemployment and inflation. Both effects become negligible as $n \to \infty$.

Unions' concern with price stability *moderates* their wage demands. The reason is that each union realizes that by raising its wage it increases the CB incentive to inflate in order to reduce unemployment. When unions dislike inflation, the recognition of the CB incentives moderates wage demands. A similar result is produced by a higher degree of labor substitutability. This increases the elasticity of the labor demand faced by unions, and therefore induces a less aggressive wage behavior.

The moderating effect of unions' inflation aversion is strongest when there is only one union since a single union *fully* internalizes the effect of its wage decisions on the subsequent rate of inflation. As the number of unions increases each union internalizes only a fraction of the effect of its own wage decisions on subsequent inflation. As a consequence the moderating effect of unions' inflation aversion on their wage demands is weaker and tends to vanish as unions become atomistic (i.e. as n tends towards infinity). Similarly, the impact effect of different degrees of labor substitutability becomes negligible as n becomes large, due to the fact that labor market competition reduces the wage premium towards zero for any (strictly positive) degree of substitutability.[18]

[18] Formally this can be seen by noting that as n becomes large the partial derivatives of the premium with respect to both B and γ converge to zero.

4.1. The effects of CWB on inflation and unemployment

A change in the degree of centralization $(1/n)$ of wage bargaining triggers two opposite effects on the level of real wages: A competition effect and a strategic effect. Consider, for concreteness, a reduction in the degree of centralization of wage bargaining (an increase in n). By increasing the elasticity of demand facing a typical union (see Eq. (3) and its discussion) such a change reduces the market power of the typical union. Taken in isolation this enhanced competition effect reduces real wages. But the increase in n also reduces the extent to which each individual union internalizes the strategic effect of its own actions on price stability through the reaction of the CB. This reduces the moderating effect of inflationary fears on unions' wage demands and pushes real wages up. As explained below, the conjunction of those two opposing effects may produce a hump shaped relation between the real wage and the CWB.

Calmfors and Driffill (1988) and Calmfors (1993) have hypothesized that the competition effect dominates when centralization is low and that the strategic effect dominates when centralization is high making the level of real wages relatively high (low) at intermediate (extreme) levels of centralization. This led them to conjecture that the relation between the level of real wages and centralization is hump shaped.[19] Eq. (13) gives the total relationship between the equilibrium real wage premium and the degree of centralization of wage bargaining taking both the competition and the strategic effects into account. Differentiating with respect to n and rearranging:

$$\frac{\partial \bar{\phi}}{\partial n} = \frac{I(\alpha^2 + I)}{\alpha D^2}\left[B\alpha^3 - AI\gamma(In^2 + \alpha^2(n-1)^2)\right] \tag{15}$$

where D is the expression in the curly bracket appearing in the denominator of Eq. (13). This leads to

Proposition 2. (i) *If* $B < AI^2\gamma/\alpha^3 \equiv B_c$, $\partial\bar{\phi}/\partial n < 0$ *at all* n. (ii) *If* $B > B_c$, $\partial\bar{\phi}/\partial n > 0$ *at low* n *and* $\partial\bar{\phi}/\partial n < 0$ *at high* n.

Proof. The sign of the derivative is determined by the sign of the expression in the square bracket, which is monotonically decreasing in n. Therefore, if the

[19] To be precise, the strategic effect in Calmfors and Driffill is somewhat different from ours since there is no CB and general inflation in their framework. Their mechanism operates through the effect that a change in n has on the degree of internalization by an individual union of price level effects of own wage increases on real wages of other unions (reducing the real wage of others through relative price change). Although this effect also appears in our model, it is not sufficiently strong to produce a hump-shaped relation by itself (we also need to postulate trade unions' inflation aversion to produce that result). However, since the spirit of our hypothesis is similar to theirs, we refer to the hump shaped relation between real wages and centralization, that we obtain, as the 'Calmfors–Driffill' curve.

expression is negative for $n = 1$ (which occurs when $B < B_c$) it is negative at all n. Otherwise, the expression becomes negative for sufficiently large n. □

Intuitively the proposition says that when unions have little concern for price stability (B is small) the competitive effect dominates the strategic effect at all levels of centralization. As a consequence real wages increase monotonically with the degree of centralization. But when unions' aversion to inflation is larger than some threshold the competition effect dominates at low levels of centralization (high n) and the strategic effect dominates at high levels of centralization (low n). Fig. 2 illustrates the two possible cases.

Eqs. (9) and (14) imply that inflation and unemployment are positively related to the equilibrium wage premium. This leads to

Proposition 3. The qualitative relation between inflation and unemployment, on one hand, and the CWB, on the other, is the same as the qualitative relation between the equilibrium wage premium and the CWB. In particular, the conditions that govern this relation are identical to the conditions that determine the relation between the wage premium and the CWB in Proposition 2.

Thus, inflation and unemployment increase monotonically with centralization, or display a hump-shaped relation with it, depending on whether unions' inflation aversion is lower than, or higher than, the threshold B_c.

The threshold level $B_c \equiv AI^2\gamma/\alpha^3$ implies that an inverted U relation between real wages and centralization (the reciprocal of n) is more likely to arise the lower the substitutability between the labor of different unions (lower γ), the lower I and the less unions care about unemployment among their members (the lower A).

It is possible to use Eq. (15) to find the peak of the Calmfors–Driffill curve (CDC). Equating to zero and solving for n, the value of decentralization that maximizes the average real wage is

$$n^* = \frac{\alpha^2 + \sqrt{B\alpha^3(\alpha^2 + I)/(AI\gamma) - I\alpha^2}}{\alpha^2 + I}. \tag{16}$$

Analysis of the expression in Eq. (16) reveals that n^* is lower the higher is I.[20] Thus, the higher CBI the larger the range of centralization levels for which further decentralization is beneficial in the sense that it is likely to reduce both inflation and unemployment. Conversely, the lower CBI, the larger the range of levels of centralization for which further centralization is beneficial since it reduces inflation and unemployment. An increase in CBI also shifts the entire

[20] The existence conditions for an economically meaningful peak (i.e. $n^* > 1$) requires that $B > B_c$, which obviously indicates that the peak exists only when the relation is hump shaped.

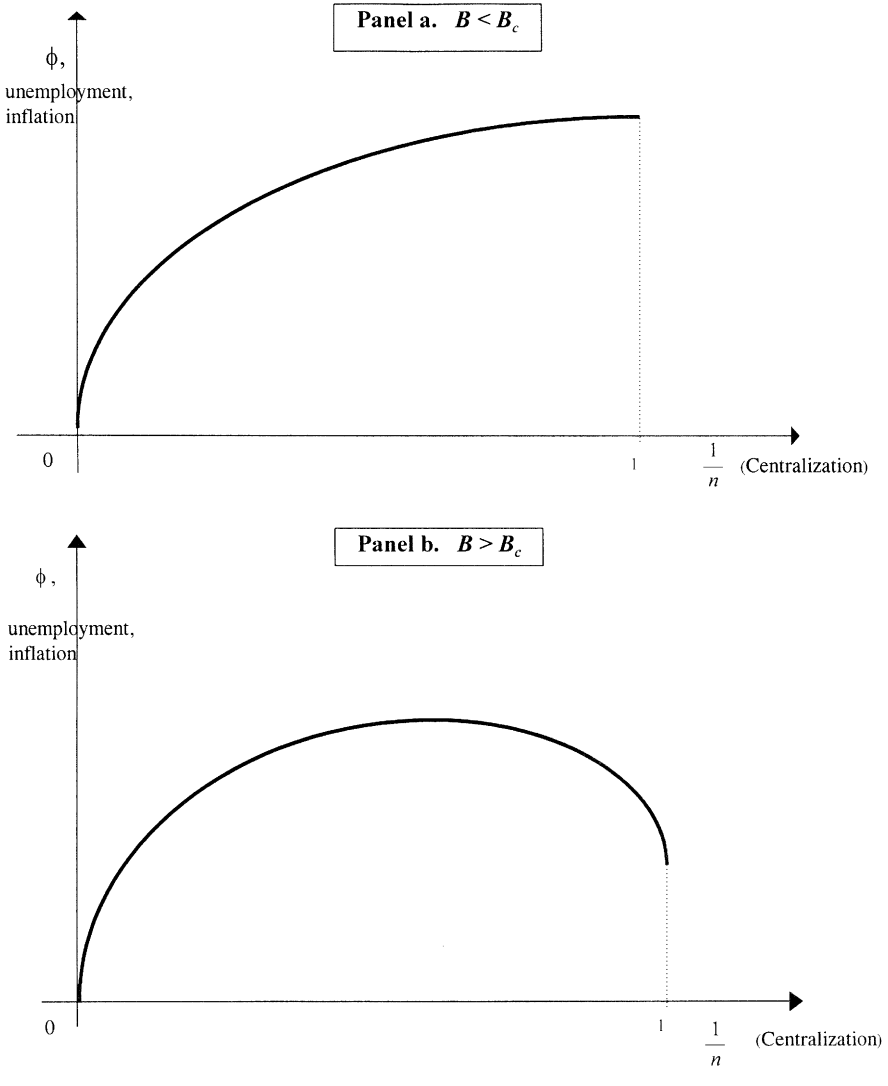

Fig. 2. The effects of centralization on real wages, unemployment and inflation.

curve up (see the next subsection). This is illustrated in Fig. 3. Note also that the peak of the CDC occurs at a higher level of centralization, the larger is B and the lower are γ and A.

For the case in which the relation between inflation and unemployment, on one hand, and centralization on the other is humped shaped, it is of interest to compare the performance of a totally centralized system of wage bargaining

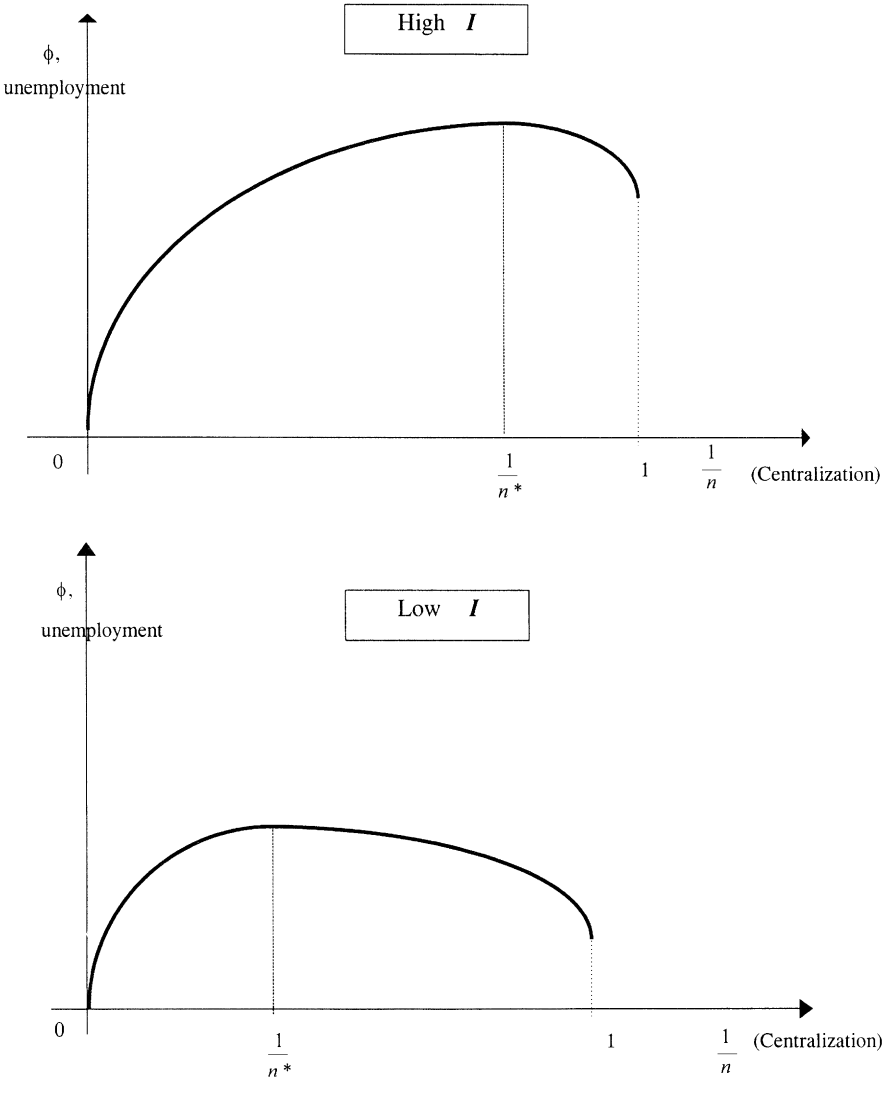

Fig. 3. The effects of central bank independence (I) on the Calmfors–Driffill curve.

(where $n = 1$) with that of a fully decentralized one (where $n \to \infty$). Eq. (13) implies that in a fully decentralized system the wage premium is zero. It follows that inflation and unemployment are also zero in a fully decentralized system. At the other extreme, when $n = 1$, the wage premium is positive and so are unemployment and inflation. The intuition underlying this result is simple. Full

decentralization of bargaining in the labor market completely eliminates the monopoly power of unions by increasing the elasticity of labor demand facing each individual bargaining unit. Since the existence of union's monopoly power is the original (and sole) source of unemployment and (consequently) of inflation in the model, a competitive labor market eliminates both problems, irrespectively of the degree of CBI. Under full centralization, on the other hand, the single union retains some degree of monopoly power. This produces a positive wage premium which leads to positive inflation and unemployment. These observations are summarized by

Proposition 4. Both unemployment and inflation are lower in a fully decentralized labor market than in a fully centralized one, as long as the weight attached to inflation by the CB is non-zero.

Proof. Note from Eq. (13) that $\lim_{n\to\infty} \bar{\phi} = 0$ and that $\bar{\phi} = I^2/\{\alpha^2[B\alpha^2 + AI^2]\}$ at $n = 1$. Since both inflation and unemployment are increasing in $\bar{\phi}$, it follows from Eqs. (9) and (14) that inflation and unemployment are smaller for $n \to \infty$ than for $n = 1$, $\forall I > 0$. □

4.2. The effect of CBI on unemployment

An important feature of the equilibrium is that the structure of monetary policy institutions affects real macroeconomic variables like unemployment in spite of the fact that, from a purely economic point of view, money is neutral. Since this is due to the strategic interaction between unions and the monetary authority we refer to those non-neutralities as 'strategic'. These strategic non-neutralities operates through two distinct channels. The first is due to the fact that, since unions are averse to inflation, they moderate their real wage demands in order to moderate the inflationary temptations of the monetary authority. The second is due to the fact that a one unit change in a union's nominal wage, taking the CB reaction into consideration, has marginal impacts on its real wage and on its relative wage which depend on the level of CBI. The second non-neutrality is operative only in the presence of more than one union. Whereas the first channel has appeared in some of the recent literature (footnote 3) the second channel is novel. A fuller intuitive discussion appears after the following proposition.

Differentiating Eq. (13) with respect to I yields

$$\frac{\partial \bar{\phi}}{\partial I} = \frac{\alpha}{D^2}\left[(\alpha^2(n-1) + 2In)B\alpha + AI^2\gamma n(n-1)\right]. \tag{17}$$

This leads to

Proposition 5. An increase in the degree of central bank conservativeness raises the rate of unemployment if at least one of the following conditions holds:

(i) $B > 0$ (*unions are averse to inflation*) *or*

(ii) $\gamma > 0$ *and* $n > 1$ (*there are at least two unions and some degree of substitutability in the demands for their labor*).

As unions become very small ($n \to \infty$) *this effect becomes negligible.*

The two conditions in the proposition correspond to the two different strategic non-neutralities mentioned above. The first one operates through trade unions' concern about price stability ($B > 0$). In particular, the higher is the inflation aversion of the CB the smaller are the inflationary consequences of a higher wage premium. Hence a more conservative central bank induces unions to demand higher real wages (as this triggers a lower inflationary reaction).

Provided there is more than one union in the economy, there is a second source of 'strategic non-neutrality' which operates even when unions are not concerned with price stability ($B = 0$). It is due to the fact that under nominal contracting, the trade-off between the real wage and the relative wage facing the individual union depends on the level of CBI. More precisely, the marginal impact of a unit increase in a union's nominal wage rate on its real wage depends (positively) on CBI whereas its impact on the relative wage does not depend on CBI. As a consequence, to obtain a unit increase in its real wage rate, the union has to accept an increase in its relative wage that is larger the smaller CBI. Thus, a less inflation averse central bank leads unions to perceive a given increase in their own real wage as more costly in terms of competitiveness (relative wage). We therefore refer to this second strategic non neutrality as a 'competition induced strategic non-neutrality' (CISNN). The CISNN moderates unions' real wage demands in comparison to a situation in which wages are fully indexed. Since the CISNN vanishes in the presence of full indexation it makes a difference whether wage contracting is in nominal or in real terms.[21]

The impact of CBI on the magnitude of the CISNN can be seen more sharply by noting the following. The marginal impact of an increase in the union nominal wage on the real wage rate is given by Z in the expression immediately following Eq. (12) and is an increasing function of CBI. Hence the higher CBI, the narrower the divergence between the marginal impact of an increase in the nominal wage rate on the relative wage and on the absolute real wage, and the weaker therefore the moderating impact of the CISNN. At the other extreme, when I is low, the moderating effect is strong since the individual union has to incur a higher deterioration in competitiveness for a one unit increase in its real

[21] In the presence of full wage indexation the marginal impact of a change in the nominal wage rate on the real wage does *not* depend on CBI. As a consequence there is no moderating effect on equilibrium real wages under full indexation.

wage rate. Note that when the CB is concerned only about inflation ($I \to \infty$) this moderating effect vanishes as well. The implications of Proposition 5 for the Calmfors–Driffill curve, when such a curve exists, are illustrated in Fig. 3.

These results concerning non-neutralities contrast with most of the literature on monetary policy games under perfect information in which CBI affects inflation but does not affect real variables. Neutrality reappears, however, even when conditions (i) and (ii) hold, when n is large since in this case each individual union basically neglects the effect of its own actions on inflation.[22] The conventional Barro and Gordon result in which unions disregard the strategic impact of their actions on inflation can therefore arise even when unions dislike inflation provided their number is large. The structure of labor markets in the US, in which wage bargaining is highly decentralized, appears to conform with this particularization of the model.

4.3. The effect of CBI on inflation

Examination of Eq. (9) reveals that CBI (or effective conservativeness) has two opposing effects on the rate of inflation.[23] Given the wage premium, $\bar{\phi}$, an increase in conservativeness reduces equilibrium inflation as in Rogoff (1985). But, as can be seen from Eq. (13), the increase in I also raises the wage premium which tends to increase the rate of inflation. The mechanism underlying the second effect is that, since a more conservative CB inflates less at *any* level of wages, unions can raise real wages and bear smaller inflation costs while doing that. The total effect of an increase in independence on inflation can be obtained from the derivative of Eq. (9) with respect to I:

$$\frac{\partial \pi}{\partial I} = \frac{\alpha^2}{I^2}\left[\frac{\partial \bar{\phi}}{\partial I} I - \bar{\phi}\right]$$

$$= \frac{\alpha^2\left\{n\alpha^2 B + n(n-1)\alpha A\gamma I - A[(n-1)\alpha^2 + nI]\left[(n-1)\left(n\gamma\left(\frac{I+\alpha^2}{\alpha}\right) + \alpha^2\right) + nI\right]\right\}}{D^2}. \tag{18}$$

The main implication of Eq. (18) is summarized in the following:

Proposition 6. The sign of the partial derivative of inflation with respect to the inflation aversion of the CB is negative for a sufficiently large n, but may be positive for given values of n if B is sufficiently large.

[22] This can be seen by noting that expression (17) converges to zero as n tends to infinity (a higher power of n appears in the denominator than in the numerator).

[23] The reader is reminded that, for reasons that are elaborated in footnotes 8 and 11, we use CBI and effective conservativeness as equivalent concepts.

Proof. The sign of the derivative is determined by the sign of the expression in the curly brackets in the numerator. This expression is a sum of three terms, the first two of which are positive and the last one negative. When n increases the negative term grows at a faster rate than the two positive terms. Hence, for a sufficiently large n the whole expression eventually becomes negative. For a given n, the expression is positive if B is sufficiently large. □

The proposition implies that the marginal impact of CBI on inflation may be positive at high levels of centralization but that it is always negative for sufficiently low levels of centralization. The reason is that, at high levels of centralization, the inflationary impact of an increase in the real wage premium due to an increase in CBI may dominate the direct negative effect of higher CBI on inflation. As the number of unions becomes large, however, the latter effect eventually dominates. This happens since smaller unions internalize inflation changes to a lesser extent into their wage decisions. Thus, a sufficiently large number of unions delivers the 'traditional' result that higher central bank conservatism (or 'independence') reduces inflation.

4.4. *The 'Ultra liberal CB' – a fable for social welfare maximizers*

We shall refer to a central banker that cares only about unemployment ($I = 0$) as 'ultra liberal'. Examination of equation (13) immediately reveals that if $I = 0$ the average real wage premium is zero, and hence so is (through equation (14)) unemployment. It would seem at first blush that since the real wage premium is zero inflation should be zero as well. But as can be seen from Eq. (9) I also appears in the denominator of the expression for the rate of inflation. As a consequence, depending on the relative speed with which the numerator and the denominator of the expression for equilibrium inflation tend to zero, inflation may or may not tend to zero when I goes to zero. Substituting Eq. (13) into Eq. (9) and letting I converge to zero (from above) yields the rate of inflation under an 'ultra-liberal' central banker, which is equal to:

$$\lim_{I \to 0^+} \pi(I) = \frac{n-1}{B}. \tag{19}$$

Thus, if there is only one economy-wide union, the rate of inflation is zero too. But it is non zero whenever the number of unions is larger than one, and strictly increasing in their number.

If, as in Rogoff (1985) and others, a 'social' welfare function is specified in terms of inflation and unemployment as: $\Gamma_{soc} \equiv u^2 + I_{soc} \cdot \pi^2$ (where $I_{soc} > 0$), it follows:

Proposition 7. If there is only one monopoly union the (*no shocks*) *social welfare is maximized when the central banker is 'ultra-liberal'* ($I = 0$).

What is the intuition underlying this (initially) surprising result? Since the 'ultra-liberal' CB cares *only about unemployment* it produces very high inflation even when unemployment is mildly positive. Even if it is moderately averse to inflation (in the sense that B is small but strictly positive) the *single* union strongly dislikes such high inflation. Since the union knows that even the slightest level of unemployment will induce the CB to inflate at an extremely high rate, it reduces its wage premium to zero in order to avoid this calamity. And, indeed the CB has no reason to inflate. An ultra-liberal CB thus delivers both zero inflation and zero unemployment. The proposition implies that if the main reason for unemployment is the market power of the monopoly union an ultra-liberal CB has a comparative advantage in preventing it from using this power by effectively threatening it with unbearable inflation whenever the union sets the real wage above the competitive level. In other words an ultra liberal CB manages to fully neutralize the market power of an inflation averse monopoly union.[24]

But when the CB is ultra liberal and there is more than one union the rate of inflation is positive, as can be seen from Eq. (19), so that social welfare is not necessarily maximized when she is in office. The intuition underlying these different welfare implications can be understood by reference to the expression for the real wage premium and for Z in Eq. (12). Z is the impact of a one unit increase in a union's own nominal wage on its real wage, taking the reaction function of the CB into consideration, as perceived by an individual union. Not surprisingly the real wage premium is an increasing function of Z.

In particular, when there is only one union and the CB is ultra-liberal, Z is zero so that the union perceives that it cannot raise its real wage by increasing the nominal wage because the ultra liberal CB fully neutralizes the effect of the increase in the nominal wage on the union's real wage. Since the marginal benefit of an increase in the nominal wage is zero the deterring effect of high inflation by the ultra-liberal CB is full. But when there is more than one union the effect of each union's nominal wage on the average nominal wage (to which the CB reacts, see Eq. (7)) is only fractional. As a consequence Z is positive even when the CB is ultra-liberal. This implies that, when inflation is zero and the real wage is at its competitive level, the marginal benefit to the individual union of raising its nominal wage exceeds the combined costs of lower employment and higher inflation. Obviously this cannot be an equilibrium since the ultra-liberal CB reacts to the resulting higher than competitive real wage by producing a positive rate of inflation. Equilibrium (at the competitive real wage) obtains when inflation is sufficiently high to raise its marginal cost for the individual union to the level necessary to equate this marginal cost to the marginal benefit of a higher real wage.

Thus, if there is more than one union in the economy, as I tends to zero inflation remains positive. Technically, this occurs because the real wage premium decreases more slowly than the tendency of the CB to inflate goes up, in

[24] A related, but not quite identical, result appears in Skott (1997).

comparison to the case of a monopoly union. This implies that welfare is no longer necessarily maximized under an ultra liberal CB.

What is the more general lesson from the result of this subsection? Although an ultra liberal CB is socially optimal only in the extreme case of a single union it does suggests that, when the number of unions is small, the appointment of a central banker that is more liberal (although not necessarily ultra liberal) than society may be socially optimal. But this is less likely to be the case as the number of unions increases.

5. Some evidence

The main empirical implication of the theoretical model is that, in addition to direct effects, there may be significant interactions between the effects of labor market and of monetary institutions on unemployment and inflation. From this perspective, one testable implication of the model concerns the hump-shaped relation between unemployment and the CWB hypothesized by Calmfors and Driffill (1988). Existing evidence concerning this relation appears to be mixed.[25] Our analysis qualifies the Calmfors and Driffill proposition by indicating that whether a hump-shape relation between unemployment and CWB will be *observed* depends, among other things, on the level of CBI.[26] This suggests that a possible reason for the mixed empirical findings of previous studies is that they did not control for possible interactions in the effects of CBI and of CWB on unemployment. Moreover, the model suggests the possibility that (for finite n) CBI may have a positive impact on unemployment and (for n not too small) a negative impact on inflation.

A preliminary investigation of the effects of CBI and CWB on macroeconomic performance, which accounts for interactions between those institutional variables, is attempted here. The empirical proxies for the degree of CWB and of CBI required for the empirical analysis are discussed in the next subsection. There are several difficulties involved with the precise measurement of the concepts used in the theoretical model. Before presenting the proxies for these institutional variables, it has to be stressed that the possibility of measurement errors and the limited availability of data pose some limits to the robustness of the analysis. Additional efforts to tackle these problems are an important task for future empirical work.

[25] For instance, Bean (1994), Grier (1997), Soskice (1990) and OECD (1997) find no evidence in favor of the hump-shape hypothesis. On the other hand supportive evidence appears in Calmfors and Driffill (1988), Bleaney (1996) and Scarpetta (1996). For a more comprehensive survey of the empirical results of previous studies see OECD (1997).

[26] This statement is true for a given range of variation of n. More generally there will always be a hump if $B > B_c$ (cf. Proposition 2). However, for a given range of variation of n, the downward segment of the hump may not be observable for a 'sufficiently large' I.

Table 1
CEN, CBI and economic performance

CTRY	Period	Centralization (CEN)	Legal independence (CBI)	Inflation	Unemployment
Australia	1980	3	0.31	10.1	6.3
	1990	3	0.31	4.9	8.1
	1994	1	0.31	1.8	10.4
Austria	1980	3	0.58	5.6	2.1
	1990	3	0.58	3.3	4.8
	1994	3	0.58	3.0	5.8
Belgium	1980	3	0.19	5.3	9.0
	1990	3	0.19	3.3	9.7
Canada	1980	1	0.46	9.4	8.4
	1990	1	0.46	3.4	9.0
	1994	1	0.46	1.2	11.0
Denmark	1980	3	0.47	9.4	7.9
	1990	2	0.47	3.2	9.9
	1994	2	0.47	1.8	11.9
Finland	1980	3	0.27	9.7	5.7
	1990	3	0.27	4.6	6.4
	1994	3	0.27	1.6	16.5
France	1980	2	0.28	11.2	6.5
	1990	2	0.28	3.0	9.6
Germany	1980	2	0.66	4.4	4.2
	1990	2	0.66	3.5	7.0
	1994	2	0.66	3.0	8.7
Italy	1980	2	0.22	17.8	6.0
	1990	2	0.22	6.8	9.4
Japan	1980	1	0.16	3.9	2.2
	1990	1	0.16	2.0	2.2
	1994	1	0.16	0.4	2.5
Netherlands	1980	2	0.42	5.2	5.1
	1990	2	0.42	2.0	6.3
	1994	2	0.42	1.8	6.5
New Zealand	1980	2	0.27	15.2	2.6
	1990	1	0.27	4.3	8.2
Norway	1980	2	0.14	10.6	2.0
	1990	3	0.14	3.2	4.9
	1994	3	0.14	1.9	5.8
Portugal	1980	2	0.47	20.9	7.9
	1990	3	0.40	12.3	4.8
Spain	1980	3	0.10	15.6	11.6
	1990	2	0.21	7.0	17.6
Sweden	1980	3	0.27	9.8	2.4
	1990	3	0.27	6.5	2.6
	1994	2	0.27	2.2	7.2
Switzerland	1980	2	0.55	4.5	0.3
	1990	2	0.68	4.1	1.0
	1994	2	0.68	1.8	3.9

Table 1 (*continued*)

CTRY	Period	Centralization (CEN)	Legal independence (CBI)	Inflation	Unemployment
UK	1980	2	0.31	13.0	6.4
	1990	2	0.31	6.2	7.5
	1994	1	0.31	3.1	9.8
USA	1980	1	0.51	8.3	7.3
	1990	1	0.51	3.8	6.1
	1994	1	0.51	2.5	6.8

Note: Centralization (Source: OECD, 1997) indicates the predominant level at which wage bargaining occurs (1 = firm/plant level, 2 = sector/industry level, 3 = national level). The index of legal central bank independence (LVAU) is taken from Cukierman et al. (1992). Inflation (unemployment) is the five-year average centered on the corresponding period. See text description in Section 5.1 for further discussion of these variables.

5.1. The measurement of CWB, CBI, and of economic performance

The empirical analysis is based on a set of indicators for the structure of collective bargaining recently constructed by the OECD (1997). All variables are shown in Table 1. In order to proxy the theoretical concept of CWB, we use the OECD index of the degree of *centralization* of wage bargaining. Centralization indicates the predominant level at which wage negotiations occur: economy wide level, sectorial level or local level. It is natural to assume, at least as a first approximation, that as wage bargaining becomes more decentralized (e.g. as it switches from the national level to the local level), the number of negotiating units which bargain in an uncoordinated manner (i.e. playing Nash) increases. This corresponds to an increase of n in the theoretic model. Hence, centralization can be interpreted as a proxy for $1/n$. We use the OECD index of centralization to build the index CEN which groups countries into three broad categories according to whether the wage-bargaining process is predominantly decentralized (firm/plant level), intermediate (sectorial/industry level) or centralized (national level).[27] Decentralized systems, such as Canada, Japan and the US, are at the bottom of the scale (score 1), centralized systems, such as Austria and Finland, are at the top of the scale (score 3). Some countries move between groups over time as the structure of bargaining evolves. For instance, shifts towards decentralization occurred in Australia, New Zealand and the UK, while

[27] The original OECD measure assigns a value of centralization between 1 and 3 to each country. However $\pm$ signs are sometimes used to qualitatively differentiate between countries with the same CEN value (cf. Table 3.3 in OECD, 1997). The variable CEN assigns score 1 (decentralized) to countries which are given a centralization value smaller or equal to 1.5 by the OECD; score 3 (centralized) is given to countries classified as 2+, 2.5 or 3 by the OECD; score 2 (intermediate) to all the others.

an increase of centralization occurred in Norway. Thus, in spite of the fact that most of the variation in CEN is cross sectional there still is some degree of over time variation in some countries.

To measure the degree of independence of the central bank we use the legal index of CBI (LVAU) developed by Cukierman et al. (1992) and Cukierman (1992). A legal CBI index (rather than a behavioral index of independence) is chosen because that seems to be more appropriate for developed economies (Cukierman, 1992). The index ranges *continuously* between zero (least independent) and one (most independent). This index covers all of the 19 countries studied by the OECD and (unlike most other indices) is available for different decades.

Economic performance is measured as the average of inflation (GDP deflator) and of the rate of unemployment over the five-year period for which the date of the CWB measurement represents the midpoint.[28] The OECD measures cover 19 OECD countries at three different points in time: 1980, 1990 and 1994. In principle, this provides us with 57 observations. However, since there have been changes in the degree of CBI during the early 1990s in several countries, six observations are dropped from the last period.[29] This leaves us with a sample of 51 observations for the development of the full sample analysis.

5.2. A preliminary look at the data

It is useful to examine whether any clear pattern emerges in a simple classification of the data. The relation between economic performance and both CEN and CBI is shown in Tables 2 and 3. Observations are grouped according to country scores on CEN and CBI. For the latter variable, the cutoff point LVAU < 0.4 is chosen to identify a group of *low-CBI* countries. Table 2 (3) shows the results obtained by pooling together the observations on unemployment

[28] For instance, the unemployment performance corresponding to the 1980s measure of CWB is given by the average of the unemployment rate over the five-year period 1978–1982. We also constructed two alternative performance measures for the observation of 1980 and 1990: a ten-year average (where, as before, the midpoint is the year of institutional measurement) and an 'after-measurement average' that spans the five years beginning in the year of the institutional measurement. The results reported below are not significantly affected by the choice of performance measure. We chose to present results in terms of the first measure (five-year centered average) since this makes our results comparable to those obtained in the OECD (1997) study.

[29] The degree of CBI has been upgraded in Belgium, France, Italy, New-Zealand, Portugal and Spain. For the other countries the measure of CBI for 1994 is set equal to that for the nineties. The elimination of some *high-CBI* countries might in principle lead to the selection of a biased sample. However, empirical results similar to the ones obtained here using the full sample of observations are obtained when the analysis is confined to the first two periods (1980 and 1990).

The LVAU values that are matched with the CEN values centered in 1980 and 1990 refer to the decades of the seventies and the eighties respectively. Given data availability this is the matching procedure that maximizes the period overlap between the two indices.

Table 2
Unemployment: Pooled observations from the first, second, and third period (51 observations)[a]

		Centralization[b]			
		Low	Intermediate	High	
Low-CBI[c]	Average unemployment	5.9	7.5	7.4	7.1
	('Filtered')	(−1.5)	(1.3)	(0.8)	(0.5)
	# observ. per cell	6	10	12	28
High-CBI[c]	Average umemployment	8.1	6.1	5.1	6.4
	('Filtered')	(1.2)	(−0.9)	(−1.6)	(−0.5)
	# observ. per cell	6	12	5	23
		7.0	6.7	6.7	
		(−0.2)	(0.0)	(0.1)	
		12	22	17	

[a] Unemployment (inflation) values reported in the cells are averages of the observations from Table 1, obtained pooling together observations with the same values of CBI (Low or High) and CEN (Low, Intermediate or High). The entries of each cell are the following (where, e.g. ausl_3 indicates the observation for Australia in the third period and jap_1,2,3 indicates the observations for Japan in all three periods):
Low-CBI and *Low-CEN* = ausl_3; jap_1,2,3; nzl_2; uk_3;
Low-CBI and *Int-CEN* = fra_1,2; ita_1,2; nor_1; nzl_1; spa_2; swe_3; uk_1,2;
Low-CBI and *High-CEN* = ausl_1,2; bel_1,2; fin_1,2,3; nor_2,3; spa_1; swe_1,2;
High-CBI and *Low-CEN* = usa_1,2,3; can_1,2,3;
High-CBI and *Int-CEN* = ger_1,2,3; den_2,3; ned_1,2,3; por_1; swi_1,2,3;
High-CBI and *High-CEN* = aus_1,2,3; den_1; por_2;
Periods 1, 2 and 3 refer, respectively, to five-year periods that are centered on 1980, 1990 and 1994.
[b] Centralization is classified as Low if bargaining occurs predominantly at the firm/plant level, as High if it occurs predominantly at the national/economy wide level (see note to Table 1 and Section 5.1 for further discussion).
[c] Observations are included in the *Low-CBI* group if the legal independence index of Table 1 is smaller than 0.4. This cutoff value divides the sample into two groups of similar size (as can be seen from the last column of each table, 28 (23) observations fall in the Low (High) CBI group).

(inflation) using data from all three periods. For example, the 5.9 figure in the upper left cell of Table 2 indicates the average unemployment rate recorded by countries that score low on both independence and centralization. Since this data pools together observations from three different periods, we also construct a measure of the average unemployment (inflation) rate for country i ($i = 1, 2, \ldots, 19$) in period t ($t = 1, 2, 3$) in deviations from period t average unemployment (inflation). This 'filtered' performance measure, reported in parenthesis below the simple averages, diminishes the weight of observations drawn from periods of above or below average unemployment (inflation).

It appears from Table 2 that at low CBI (upper row of the table) there is a hump-shaped relation between unemployment and centralization. A similar, hump shaped, relation between inflation and centralization is supported by the

Table 3
Inflation: Pooled observations from the first, second, and third period (51 observations)[a]

		Centralization[b]			
		Low	Intermediate	High	
Low-CBI[c]	Average Inflation	2.6	10.1	6.4	6.8
	('Filtered')	(−1.6)	(2.5)	(−0.1)	(0.4)
	# observ. per cell	6	10	12	28
High-CBI[c]	Average inflation	4.8	4.5	6.7	5.0
	('Filtered')	(−0.8)	(−0.8)	(0.5)	(−0.5)
	# observ. per cell	6	12	5	23
		3.7	6.8	6.5	
		(−1.2)	(0.6)	(0.1)	
		12	22	17	

[a] Unemployment (inflation) values reported in the cells are averages of the observations from Table 1, obtained pooling together observations with the same values of CBI (Low or High) and CEN (Low, Intermediate or High). The entries of each cell are the following (where, e.g. ausl_3 indicates the observation for Australia in the third period and jap_1,2,3 indicates the observations for Japan in all three periods):
Low-CBI and *Low-CEN* = ausl_3; jap_1,2,3; nzl_2; uk_3;
Low-CBI and *Int-CEN* = fra_1,2; ita_1,2; nor_1; nzl_1; spa_2; swe_3; uk_1,2;
Low-CBI and *High-CEN* = ausl_1,2; bel_1,2; fin_1,2,3; nor_2,3; spa_1; swe_1,2;
High-CBI and *Low-CEN* = usa_1,2,3; can_1,2,3;
High-CBI and *Int-CEN* = ger_1,2,3; den_2,3; ned_1,2,3; por_1; swi_1,2,3;
High-CBI and *High-CEN* = aus_1,2,3; den_1; por_2;
Periods 1,2 and 3 refer, respectively, to five-year periods that are centered on 1980, 1990 and 1994.
[b] Centralization is classified as Low if bargaining occurs predominantly at the firm/plant level, as High if it occurs predominantly at the national/economy wide level (see note to Table 1 and Section 5.1 for further discussion).
[c] Observations are included in the *Low-CBI* group if the legal independence index of Table 1 is smaller than 0.4. This cutoff value divides the sample into two groups of similar size (as can be seen from the last column of each table, 28 (23) observations fall in the Low (High) CBI group).

evidence in Table 3 at low independence levels. On the other hand, the relation between unemployment (or inflation) and centralization shows no clear pattern at high levels of CBI. These relationships appear more clearly when 'filtered averages' are used.[30]

The tables also suggest that the sign and magnitude of the relation between inflation and unemployment, on one hand, and CBI, on the other, varies across different levels of centralization. In particular, comparison of the first and second rows in Table 3, points to the existence of a relatively large negative impact of CBI on inflation at intermediate CEN, but the sign of the impact is

[30] A similar picture emerges if the third period is excluded from the sample (see Cukierman and Lippi, 1998, Tables 3 and 4).

unclear at other levels of centralization. It can be seen from the last column of Table 3 that, without controlling for centralization, the well documented negative correlation between inflation and CBI appears.

5.3. Regression analysis

An attempt to provide a statistical assessment of the relations displayed in Tables 2 and 3, that controls for other variables, is performed by means of regression analysis. As the centralization measure has a completely discrete nature, we use three dummy variables to measure the effects of low, intermediate and high centralization without imposing an a-priori spacing on the effects of different centralization levels.[31] The typical regression that is performed for both unemployment and inflation has the following specification:

$$y = \sum_{j=1}^{3} (\beta_j + \gamma_j \cdot \mathrm{CBI}) DC_j + \sum_h \kappa_h \cdot control_h + \varepsilon, \tag{20}$$

$$DC_j = \begin{cases} 1 & \text{if CEN} = j, \\ 0 & \text{otherwise,} \end{cases} \quad j = 1, 2, 3,$$

where y is equal to either inflation or unemployment, CBI is the central bank independence index described before, the three dummies DC_j capture the different centralization levels (e.g. $DC2 = 1$ if CEN $= 2$ and zero otherwise), $control_h$ indicates some control variables described below (among which two period dummies, *Dumper1* and *Dumper2*, when data for more than one period are used) and ε is the error term of the equation. The interaction terms between CBI and DC_j allow the relation between economic performance and centralization to depend on the degree of central bank independence, as suggested by the theory.[32]

5.3.1. Estimation results

Tables 4 and 5 report the results of the regression analysis for unemployment and inflation, respectively. Before testing the specification in Eq. (20), a benchmark regression that does not include interaction terms between DC_j and CBI (i.e. $\gamma_j = 0$) was estimated. The results are reported in the first column of each

[31] In principle the same reasoning applies to the CBI index. However, this has a more continuous nature in the [0–1] interval and its classification into dummies would require an arbitrary definition of classes of CBI levels which we avoid here.

[32] We also experimented with two alternative specifications. One where the variable CEN, and its squared value, were used directly as explanatory variables, accounting for their interactions with the *CBI* index (see Cukierman and Lippi, 1998). Another used a modified measure of centralization, which rearranges the values of CEN so as to create an expected linear relation between these and economic perfomance. This method has been followed by Calmfors and Driffill (1988) and by Bleaney (1996). Overall, the results are qualitatively similar to the ones reported here.

Table 4
Unemployment[a]

Eq. number	(4.1)	(4.2)	(4.3)	(4.4)	(4.5)	(4.6)
DC1	8.0	3.4	−1.9	1.9	2.5	−6.9
	(6.6)	(1.3)	(0.6)	(0.7)	(0.9)	(−1.7)
DC2	8.2	12.0	10.9	9.3	11.2	4.0
	(7.1)	(5.6)	(5.4)	(5.4)	(4.3)	(1.4)
DC3	8.3	11.4	9.9	7.6	8.6	1.3
	(6.6)	(5.6)	(4.9)	(4.2)	(2.1)	(0.5)
DC1 CBI		13.8	14.1	14.1	14.9	16.5
		(2.0)	(1.8)	(2.1)	(2.7)	(1.6)
DC2 CBI		−8.2	−9.0	−6.0	−4.8	−9.2
		(−2.0)	(−2.0)	(−1.6)	(−1.2)	(−1.4)
DC3 CBI		−8.4	−9.3	−3.5	−2.5	−5.9
		(−1.6)	(−1.8)	(−0.7)	(−0.2)	(−0.7)
dumPer1	−2.8	−3.4	−1.9	−1.8	−1.9	
	(−2.2)	(−2.8)	(−1.8)	(−2.2)	(−2.3)	
dumPer2	−1.1	−1.5				
	(−0.9)	(−1.3)				
dumSpain				7.9	7.3	
				(3.9)	(3.9)	
Repl.Ratio					0.1	
					(2.1)	
Lab. Taxation					−0.1	
					(−1.8)	
Adj. R^2	0.02	0.16	0.15	0.41	0.60	0.04
# Obs.	51	51	38	38	28	16

[a] The dependent variable is the unemployment variable of Table 1 in all equations except in Eq. (4.6) where the 'filtered' value is used. Coefficients are estimated by OLS. *t*-Statistics are reported in parentheses below the coefficient.

table (Eqs. (4.1) and (5.1)). The estimated coefficients of the centralization dummies do not indicate the existence of a hump-shaped relation between unemployment and centralization and show only a weak one in the case of inflation. An *F*-test reveals that in neither equation it is possible to reject (at the ten per cent level) the null joint hypothesis that there are no significant differences across centralization levels ($\beta_1 = \beta_2 = \beta_3$). This confirms the results of the OECD (1997) where, using basically the same data, no evidence of a hump-shaped relation between centralization and unemployment is found.

The second column of each table shows the full-sample estimates of Eq. (20) when the interaction terms are used. It appears that these terms significantly improve the explanatory power of the regression (particularly for unemployment) and, more importantly, reveal some differences between centralization levels. In both Eqs. (4.2) and (5.2) the coefficient of *DC2* is statistically different (and larger) than the coefficient of *DC1* (the *F*-test rejects the null hypothesis of

Table 5
Inflation[a]

Eq. number	(5.1)	(5.2)	(5.3)	(5.4)	(5.5)
DC1	1.0	−1.0	−0.1	−0.1	−4.7
	(0.9)	(−0.4)	(−0.0)	(−0.0)	(−1.9)
DC2	2.8	7.0	10.0	10.0	5.1
	(2.6)	(3.4)	(4.3)	(6.0)	(2.8)
DC3	2.4	3.5	6.2	6.4	−0.7
	(2.0)	(1.8)	(2.6)	(3.8)	(−0.4)
DC1 CBI		6.4	8.3	8.1	8.2
		(1.0)	(0.9)	(1.2)	(0.2)
DC2 CBI		−9.4	−11.7	−13.5	−12.0
		(−2.3)	(−2.2)	(−3.5)	(−3.0)
DC3 CBI		−2.4	−4.2	−7.5	−0.3
		(−0.5)	(−0.6)	(−1.5)	(−0.1)
dum Per1	7.6	7.0	5.0	5.0	
	(6.3)	(5.9)	(4.2)	(5.9)	
dum Per2	2.3	1.9			
	(1.9)	(1.7)			
dum Portugal				10.5	
				(5.4)	
Adj. R^2	0.49	0.53	0.39	0.68	0.35
# Obs.	51	51	38	38	16

[a] The dependent variable is the inflation variable of Table 1 in all equations except in Eq. (5.5) where the 'filtered' value is used. Coefficients are estimated by OLS. *t*-Statistics are reported in parentheses below the coefficient.

identical coefficients at the 1% level). For the inflation equation there is also evidence that the coefficient of *DC3* is significantly smaller than that of *DC2*. This provides evidence supporting the existence of a Calmfors–Driffill type relation (i.e. $\beta_2 > \beta_3 > \beta_1$), in contrast to the evidence reported in Eqs. (4.1) and (5.1), in which interaction terms were not used. Moreover, the interaction terms between CBI and the centralization dummies appear statistically significant, particularly at the intermediate centralization levels for the inflation equation and at the low and intermediate centralization levels for the unemployment equation (the *F*-test on the joint significance of the γ_j coefficients rejects the null hypothesis of zero coefficients at the one per cent level in Eq. (4.2) and at the ten per cent level in Eq. (5.2)). This is consistent with the theory which implies that the relation between economic performance and centralization varies with the degree of CBI.

5.3.2. Sensitivity

These results are basically unchanged when the estimation is limited to the first two periods (Eqs. (4.3) and (5.3)) and when dummy variables are used to control for outlier observations. In Eq. (4.4) a dummy variable is added to the

unemployment equation to control for the unusually high Spanish unemployment rate. Similarly, in the inflation Eq. (5.4) a dummy for the high average inflation of Portugal is used.[33] It appears that neither the sign nor the statistical significance of the coefficients is affected by controlling for outliers. We also controlled the unemployment equation for the potential effects of other institutional variables. In particular, Daveri and Tabellini (1997) find unemployment to be significantly related to replacement ratios and effective tax rates on labor income in a sample of 14 OECD countries over the 1965–1985 period.[34] Nickell (1997) reports similar results. To account for those effects we added the Daveri and Tabellini measures of those variables as regressors in Eq. (4.5). Data availability restricts observations to 14 countries and two time periods (1980, 1990).[35] In line with their findings, a positive correlation is detected between the unemployment rate and the replacement ratio. No significant correlation emerges between unemployment and the effective tax-rates on labor income. More importantly for the purposes of this paper, the statistical significance and the signs of the CBI and the centralization coefficients are not affected by the addition of these variables.

Finally, we estimated Eq. (20), for both unemployment and inflation, on each period separately, to obtain pure cross sectional estimates of the coefficients.[36] The results are qualitatively similar to those obtained from the pooled cross-section time-series data. The hump-shaped Calmfors–Driffill pattern appears in the β_j coefficients of all equations (i.e. $\beta_2 > \beta_3 > \beta_1$) except in the unemployment equation in the first period (1980) where at low CBI there is a significant upward sloping relation between unemployment and centralization. To get a summary measure of the implications of the pure cross-sectional variation in the data we also ran 'average' cross-sectional regressions in which each country's observations are represented by the, over periods, average of the 'filtered' performance measure (i.e. inflation, or unemployment, in deviations from the

[33] Italy, Portugal and Spain have average inflation rates that are much higher than those of other countries in the sample. To allow for the possibility that this is due to factors other than those on which we focus here, the inflation equation was reestimated using dummy variables for each of these countries, either one at a time or as a group. For example, when all three countries are dummied out the results are essentially unchanged and the β's and γ's coefficients maintain sign and significance.

[34] This is a summary measure of the ratio between unemployment benefits and previous earnings adjusted for a variety of circumstances (period of unemployment, family situation, previous level of earnings). The original source is the OECD Jobs Study.

[35] Daveri and Tabellini (1997) perform a panel-data analysis using non-random fixed effects for each country. Given the limited time-series variation of our institutional observations, we only performed simple cross-country analysis. These differences are important in comparing the results of their regressions with ours. Morover, since their data are five-year averages ending in 1985, we used their last available observations (i.e. the average of 1981–1985) to match our second period (1988–1992) observations. Consequently, first period observations (1978–1982) were matched with data measuring 1971–1975 average effective labor taxation and replacement ratios. Despite the existence of obvious improvements to this procedure this compromise is imposed by lack of more appropriate (alternative) data.

[36] The results for the period by period regressions are not reported here for reasons of space.

period-averages) and of CBI, using only those observations where the CEN level is constant for at least two periods.[37] The results, based on 16 'summary' observations, are reported in the last columns of Tables 4 and 5 (Eqs. (4.6) and (5.5)). The β_j coefficients of both equations suggest the existence of a Calmfors–Driffill pattern, although this effect is clearly significant only in the inflation equation (the F-test rejects the joint hypothesis of equal β coefficients at the 1% level for inflation and at the 10% level for unemployment). Moreover, consistently with the evidence presented before, CBI has a significant negative impact on inflation at intermediate centralization levels, while the sign of its impact on unemployment is unchanged (but not significant).

5.3.3. Theory and evidence

As the theory predicts that economic performance varies with both CBI and centralization, we use the estimated equations to examine the consistency between the empirical evidence and the theory presented before. Panel a of Table 6 presents the simulated unemployment and inflation values predicted by Eqs. (4.5) and (5.4) when all control variables are set to zero.[38] When centralization is equal to j ($j = 1, 2, 3$), the inflation (unemployment) rate implied by the estimated equation is thus given by $(\hat{\beta}_j + \hat{\gamma}_j \cdot \text{CBI})$, which is the value reported in each cell of the table.

It appears that, at low CBI levels, a hump shaped relation between unemployment (inflation) and the degree of centralization is clearly in evidence. The joint hypothesis that the predicted values of unemployment and inflation are identical across centralization levels at low CBI (i.e. at CBI ≤ 0.3) is strongly rejected by the data for both the unemployment and the inflation equations.[39] However, the same hypothesis cannot be rejected at higher CBI levels (i.e. at CBI ≥ 0.4). This evidence appears to be consistent with Proposition 2 which implies that a hump-shaped relation of the Calmfors–Driffill type is more likely to be observed at low (rather than at high) CBI levels. Moreover, as suggested by Proposition 3, inflation and unemployment display a similar qualitative relation with centralization once CBI is controlled for. A similar picture emerges from Panel b of Table 6, where the inflation and unemployment values are generated from the pure cross-sectional equations (4.6) and (5.5).

Table 5 also indicates that the correlation between CBI and inflation is negative in two out of three cases (but is statistically different from zero only

[37] We are thankful to a referee who suggested this procedure. We avoid averaging over different CEN levels because of the expected non-linearity between CEN and economic performance. Similar results are obtained when the summary measure is constructed using the non-filtered performance measure.

[38] A similar picture emerges from the predictions of the other estimated equations.

[39] We test the null joint hypothesis: $\beta_1 + \gamma_1 \cdot \text{CBI} = \beta_2 + \gamma_2 \cdot \text{CBI} = \beta_3 + \gamma_3 \cdot \text{CBI}$ at various CBI levels using the Wald test for linear restrictions. The results are reported in the shaded columns of Table 6.

Table 6
Unemployment and inflation at different centralization and independence levels
Panel a: Unemployment and inflation implied, respectively, by Eqs. (4.5) and (5.4) (pooled cross-section time-series data) at different CBI and CEN levels

		Unemployment				Inflation		
		Centralization				Centralization		
CBI	W-test	Low	Int.	High	W-test	Low	Int.	High
0.1	***	4.0	10.7	8.3	***	0.7	8.7	5.7
0.2	**	5.5	10.2	8.0	***	1.5	7.4	4.9
0.3	*	6.9	9.7	7.8	**	2.3	6.0	4.2
0.4	No	8.4	9.2	7.5	No	3.2	4.7	3.5
0.5	No	9.9	8.7	7.2	No	4.0	3.3	2.7
0.6	No	11.4	8.3	7.0	No	4.8	2.0	2.0

Panel b: 'Filtered' unemployment and inflation (in deviations from period averages) implied, respectively, by Eq. (4.6) and (5.5) (cross-section data) at different CBI and CEN levels

		Unemployment (filtered)				Inflation (filtered)		
		Centralization				Centralization		
CBI	W-test	Low	Int.	High	W-test	Low	Int.	High
0.1	*	− 5.2	3.1	0.7	***	− 3.9	3.9	− 0.7
0.2	*	− 3.6	2.2	0.1	***	− 3.1	2.7	− 0.8
0.3	No	− 1.9	1.2	− 0.5	**	− 2.2	1.5	− 0.8
0.4	No	− 0.3	0.3	− 1.1	No	− 1.4	0.3	− 0.8
0.5	No	1.4	− 0.6	− 1.7	No	− 0.6	− 0.9	− 0.9
0.6	No	3.1	− 1.5	− 2.2	No	0.2	− 2.1	− 0.9

Note: Each cell shows the value of unemployment (inflation) predicted by the corresponding estimated equation at various levels of independence and centralization (setting control variables to zero). When centralization is equal to j ($j = 1, 2, 3$) this amounts to $\beta_j + \gamma_j \cdot \text{CBI}$, which is the value reported in each cell at various CBI levels (see Section 5.3.3). The 'W-test' shows the level of significance at which the joint linear restriction $\beta_1 + \gamma_1 \cdot \text{CBI} = \beta_2 + \gamma_2 \cdot \text{CBI} = \beta_3 + \gamma_3 \cdot \text{CBI}$ is rejected by a Wald test (the test is performed at six alternative CBI levels, from 0.1 to 0.6). One, two or three asterisks indicate that the null hypothesis of identical coefficients is rejected at the 10%, 5% or 1% level, respectively. 'No' indicates that the joint test on the equality of coefficients cannot be rejected.

at intermediate CEN). This is not inconsistent with the model's prediction (Proposition 6). Moreover, it appears from Table 4 that CBI has a positive impact on unemployment at low centralization (which is consistent with Proposition 5) and a negative impact at intermediate centralization, but only the

former effect is significant under different specifications of the equation (see, e.g. Eqs. (4.4) and (5.4)).

Overall, the empirical evidence does not contradict the broad implications of our model concerning the existence of interaction effects between CWB, CBI and macroeconomic performance. We also find that higher CBI reduces inflation, particularly at intermediate centralization levels, and that it tends to increase unemployment, particularly at low centralization levels.

6. Brief comparison to recent literature

Although most of the literature on strategic monetary policy abstracts from the inflation aversion of unions and of the moderation in wage demands that it induces, there is a small literature, mainly from the nineties, that analyzes this effect in the context of a single union (references appear in footnote 4). Bleaney (1996) and Forteza (1998) consider a game between the CB and a *number* of unions but without taking the inflation aversion of unions into account. This paper, the one by Skott (1997) and the companion paper by Velasco and Guzzo (1999) (discussed below) are the first to consider both of those factors in a unified framework.

This paper qualifies and extends previous literature. For example, Cubitt (1992) and Agell and Ysander (1993) simply assume that when wage bargaining is centralized unions care more about inflation. This paper derives this as a result, from a framework in which unions' inflation aversion is basically independent of the degree of CWB, but in which their actions are more strongly affected by their inflation aversion the smaller their number. Both atomistic (e.g. Barro and Gordon, 1983) and non-atomistic unions' models can be seen as special cases of our model. Differentiating between the economic impact of CWB and that of unions' inflation aversion is important since each of these structural parameters generally may vary independently of the other.

This paper would not be complete without a comparison with the closely related article by Velasco and Guzzo (1999) that appears in this issue of the Review. Both papers propose frameworks that are designed to clarify the effects of CWB and of CBI on the performance of the economy in the presence of inflation averse unions. But some of the primitive assumptions of the two models differ. We work with a specification of labor demand facing the individual union in which the wage elasticity rises with the number of unions (in a symmetric equilibrium). In particular, the elasticity tends to infinity as the number of unions becomes large. Velasco and Guzzo (VG henceforth) start from a production function that utilizes all available types of workers in the economy. Their specification implies that the wage elasticity of labor demand facing the individual union may be either increasing or decreasing in the number of unions, depending on the magnitude of the elasticity of substitution between the different types of workers. In either case the elasticity of labor demand converges

towards the (finite) elasticity of substitution between labor types (σ in their model) as n goes to infinity.

In spite of those modeling differences both papers obtain some common results the most notable of which is that employment is decreasing in CBI. But the framework of VG implies that welfare is maximized when the CB is ultra liberal. Our paper shows that this is the case when there is a single union, but that this is not necessarily true when the number of unions is larger than one. Another major difference is that in VG *employment* is either monotonically increasing with centralization, or humped shaped in it (a reverse Calmfors–Driffill curve) for all levels of CBI. We obtain diametrically opposed results: employment is either monotonically decreasing with centralization or U shaped in it as hypothesized by Calmfors and Driffill. Since in both papers employment and real wages are negatively related, this difference in results also carries over to the relation between real wages and centralization, appropriately adjusted for the change in sign.

The underlying assumptions about the labor demand elasticity are responsible for the different results of those papers. In both papers the relationship between the real wage and centralization is jointly determined by a strategic effect (or, in VG terminology, 'internalization effect') and by a competition effect. In our model the competition effect always dominates the strategic effect at low centralization levels; in VG the opposite occurs. This is mainly due to the different implied behavior of the elasticity of labor demand.

Our empirical finding that *unemployment* is hump shaped in centralization at low levels of CBI is inconsistent with the 'reverse Calmfors–Driffill curve' implication of the VG model. Also, the positive and significant relation between unemployment and centralization detected in the first period (see Section 5.3.2) is consistent with our model (see panel a of Fig. 2), while the evidence never shows significantly lower unemployment rates at intermediate centralization levels (as suggested by the VG model). Thus, while the theoretical results of VG are, as they put it (Velasco and Guzzo, 1999, p. 1334), in 'stark contrast with conventional wisdom and the arguments of Calmfors and Driffill (1988)' the theory and the evidence presented in this paper are rather supportive of this 'conventional wisdom'.

The interactions between CBI and the industrial organization of labor markets might obviously have important implications for the economic effects of EMU. Gruner and Hefeker (1999) present an interesting analysis along those lines within a framework that features *one* inflation averse union in each country.[40] The theoretical framework of our paper can be used to extend the analysis of Gruner and Hefeker (1999) to the case of many unions in each country. Cukierman and Lippi (1998a) provide a preliminary analysis of this case. A basic intuitive factor that underlies the analysis in both papers is that, by altering the relative size of unions (making all of them more numerous in their

[40] Iversen (1998) and Jimeno (1998) also analyze how the effects of the EMU establishment are related to the organization of the labor market.

strategic interaction with the central bank), the formation of a monetary union induces trade unions to be more aggressive.

To this point all the discussion has abstracted from open economy considerations. In the presence of such considerations there are additional interactions between centralization and the equilibrium terms of trade facing a country. In particular, Rama (1994) shows that, in an open economy facing a less than infinitely elastic demand, the degree of centralization also affects the extent to which unions internalize the effect of their wage decisions on their country's terms of trade.[41]

7. Concluding remarks

This paper proposes a conceptual framework that makes it possible to investigate the effects of CBI, CWB, and of the interaction between those institutional variables, on inflation, unemployment and real wages. The accepted view in the strategic literature on monetary policy is that, in the presence of perfect information (including, in particular, the absence of unanticipated real shocks that could be stabilized by means of monetary policy), real wages and unemployment are independent of the organization of monetary institutions. The theory developed here suggests instead a number of channels through which labor market performance is also influenced by CBI and by its interaction with the CWB. This implies that, in the presence of non-atomistic unions, it may be misleading to study the effects of labor market variables (such as CWB) without controlling for the type of monetary regime (and vice versa).

One specific corollary of this general observation is that a Calmfors–Driffill hump-shaped relation between unemployment (inflation) and CWB is more likely to arise when CBI is sufficiently small, when labor unions are sufficiently averse to inflation and the lower the effect of more competition in the labor market on real wages. The hump-shaped relation of our model is the consequence of two opposite effects of centralization. On one hand, centralization reduces the degree of competition in the labor market. On the other hand it increases the extent to which each union internalizes the consequences of its wage choice on aggregate inflation.[42] While the model shows that a

[41] Some related work for open economies has been undertaken by Jensen (1997) and Zervoyianni (1997).

[42] Our model can therefore be viewed as a precise characterization of the free rider problem discussed in De Grauwe (1992, p. 22): '[⋯] individual unions that bargain for higher nominal wages know that the effect of these nominal wage increases on the aggregate price level is small, because these unions only represent a small fraction of the labor force. In equilibrium this non-cooperative game will produce a higher nominal wage than the cooperative (centralized) game.' The main differences between his (informal) discussion and our framework are that we explicitly introduce the role of competition between unions in the labor market and that we study a world without shocks. As a matter of fact, the latter issue could be examined by introducing supply shocks into our framework.

hump-shaped relation of the Calmfors–Driffill type may exist, it also predicts that the hump-shaped relation should gradually weaken, and eventually become monotonically increasing in centralization, as CBI increases. This implies that, in countries with highly independent central banks, decentralization of bargaining in the labor market is likely to reduce real wages, unemployment and inflation.

A second set of results concerns the conditions under which CBI may be expected to have an impact on unemployment. Two channels are identified. First, if trade unions care about inflation, central bank conservatism influences wage-setting decisions by affecting unions' perception of how inflationary their individual actions are. Hence, a more conservative central bank induces more aggressive wage behavior on the part of unions by reducing the impact of their wage setting decisions on inflation.

If there is more than one union in the economy there is a second 'competition induced strategic non-neutrality' that operates independently of whether unions are or are not averse to inflation. This is due to the fact that the trade-off between the real wage and the relative wage facing the individual union depends on the inflation aversion of the central bank. We showed that the increase in the relative wage that a union has to undergo to obtain a unit increase in its real wage is larger if the central bank is less inflation averse. This implies that the perceived reduction in competitiveness caused by a higher real wage is decreasing in the level of CBI. The magnitude of this non neutrality thus depends on the degree of labor substitutability and on the effective conservatism of monetary policy. Even when unions are not inflation averse this non-neutrality moderates unions' real wage demands in comparison to a situation in which wages are fully indexed. Both types of non-neutralities exist due to the fact that unions are non-atomistic and perceive the macroeconomic consequences of their actions. As unions become atomistic these (strategic) non-neutralities vanish. The first strategic non-neutrality has been noticed in some of the recent literature, mostly within the context of a single union (footnote 4). The second one is novel and appears only when there is more than one union in the economy.[43]

Examination of the evidence using data from nineteen OECD countries during the eighties and the early nineties provides support for some of the implications of the theory. In particular, for low levels of CBI, the evidence identifies a clear hump-shaped relation between unemployment and inflation, on the one hand, and between centralization on the other. This relation vanishes at high levels of CBI. Both findings are consistent with the predictions of our model. They may shed light on why evidence on the existence of a hump-shaped relation was mixed. Previous studies, for instance OECD (1997) and others (see

[43] Although the model in Skott (1997) also features more than one union, unemployment is unrelated to the conservativeness of the CB in his model when unions are indifferent to inflation. Hence the second non-neutrality appears to be absent from Skott's framework.

footnote 25), did not control for CBI (and for its interactions with the CWB) when estimating the relation between CWB and economic performance. When CBI is deliberately omitted from the set of explanatory variables, our data replicates the OECD result that points to the lack of evidence in favor of a hump-shaped relation.[44]

The evidence also shows that the inflation-reducing impact of CBI on inflation is largest when centralization of wage bargaining is at intermediate levels and that there is a significant and positive effect of CBI on unemployment at low levels of centralization. These results appear robust to a number of alternative specifications. Since the over time variation of the institutional variables is relatively limited those findings mainly reflect cross-country differences. Overall, the empirical analysis indicates that the interaction effects between CBI and CWB suggested by the theory receive some support from the data.

In order to present our basic arguments we have assumed, for simplicity, that labor supplies are completely inelastic, that all unions have the same number of members, and that firms behave as wage takers in the labor market. We also abstracted from the structure of final goods markets and from open economy considerations. The investigation of these issues will provide a check of robustness and further insights into the properties of CBI and CWB. This is left for future work.

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[44] In terms of our theory, the OECD procedure may have led them to pool observations over which the relation exists (those from the *low-CBI* group) with observations over which it does not exist (those from the *high-CBI* group).

Appendix. Derivation of the equilibrium wage premium

Differentiating with respect to w_j, the first-order condition for the typical union's problem is

$$2E\{ -Z + A[\alpha(w_j - \pi - p_{-1} - w_r^c) + \gamma n(w_j - \bar{w})](\alpha Z + \gamma(n-1)) + B\pi(1-Z)\} = 0. \quad \text{(A.1)}$$

Noting that $\phi_j = w_j - \pi - p_{-1} - w_r^c$, and that there is perfect information, this first-order condition can be rewritten as

$$-Z + A[\alpha\phi_j + \gamma n(\phi_j - \bar{\phi})]\Big(\alpha Z + \gamma(n-1)\Big) + B\pi(1-Z) = 0. \quad \text{(A.2)}$$

Eq. (12) in the text is obtained by summing Eq. 21 over all unions, dividing the resulting expression by n, using Eq. (9), and rearranging.

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