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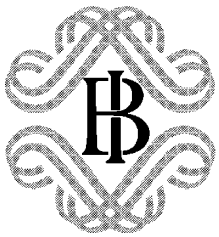
by Alex Cukierman and Francesco Lippi



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CENTRAL BANK INDEPENDENCE, CENTRALIZATION OF WAGE BARGAINING, INFLATION AND UNEMPLOYMENT: THEORY AND EVIDENCE (*)

by Alex Cukierman (**)and Francesco Lippi (***)

Abstract

This paper proposes a conceptual framework that makes it possible to investigate the effects of central bank independence, the degree of centralization of wage bargaining and the interaction between those institutional variables on the real wage, unemployment and inflation. This is done by considering a two-stage strategic interaction between a central bank (CB) with a given degree of conservativeness and a number of unions each of which sets its own nominal wage taking the nominal wages of other unions and the reaction-function of the CB as given. In the second stage the CB picks inflation so as to minimize the combined costs of inflation and unemployment, taking union's wage rates as given. Since unions are averse to inflation they partly moderate their wage demands in order to induce the CB 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. The decrease in the number of unions reduces the substitutability between the workers 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. The interaction between those two effects produces a Calmfors-Driffill type relation between real wages and centralization.

The paper analyzes the effects of centralization and independence on the position and the shape of this Calmfors-Driffill relation as well as on inflation and unemployment. Some of the resulting implications are tested empirically using data from nineteen developed economies. Implications for the optimal degree of conservativeness and for EMU are also discussed.

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Contents

1 Introduction[1]

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 tested empirically 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.[2] 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

[1]We would like to thank, without implicating, Ignazio Angeloni, Yael Artstein, Michael Bleaney, Lars Calmfors, Robin Cubitt, Robert Dur, Eugenio Gaiotti, Andrea Gerali, Bertold Herrendorf, Andrew Oswald, Assaf Razin, Peter Skott, Robert Solow and seminar participants at the Banca d'Italia and at Bologna, Cattolica (Milan), Erasmus, Tilburg and Tel Aviv Universities for useful comments on previous versions of the paper. The views expressed in the paper are those of the authors and should not be attributed to the institutions with which they are affiliated.

[2]This statement abstracts from the welfare cost due to the fact that a more conservative central bank stabilizes employment shocks to a lesser extent. This abstraction is deliberate since one of the main 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.

general public.

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.[3] 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 very 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.

The nature of equilibrium in a modified Barro-Gordon framework where unions dislike inflation is investigated by Cubitt (1992), who considers 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.[4] A remarkable feature of the resulting discretionary

[3]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.

[4]Although Cubitt (1992) formally models the union's preferences in terms of a desired output level rather

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.[5] But Cubitt limits his analysis to the case of a single all encompassing union.

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), Cubitt (1992, 1995), and Lawler (no date).[6] 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.[7]

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than in terms of a real wage, the two concepts are interchangeable since in his model -like in ours- there is a one to one correspondence between real wages, output and employment.

[5] A similar insight appears in Yashiv (1989) and in Lawler (no date).

[6] Bleaney (1996) also presents a game between a **number** of unions and a CB as is done here. But since inflation does not enter the unions' objective functions, equilibrium unemployment in his framework does not depend on CBI by construction. Another difference is that in his framework firms have sufficient market power to set prices as a markup over wages. By contrast in our framework firms have no market power.

[7] The **coordination** of wage bargaining is an indicator which accounts both for the behavior of **unions**

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.[8] 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 conceptually conditions under which we should expect (and conditions under which we should not expect) to observe a link between CBI and unemployment. Accordingly, the first 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 labor markets characterized by various degrees of CWB.[9] 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. The second objective of the paper is to test the predictions of the theory concerning the effects of CBI and of CWB on economic performance empirically.

Our paper, in conjunction with a recent paper by Alesina and Perotti (1994), 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.

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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 does not focus on the firms' side.

[8]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.

[9]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 Eijffinger and Hoeberichts (1996) and by Lippi (forthcoming, Chapter 7).

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 a CB whose degree of conservativeness may differ from that of society. Section 3 characterizes equilibrium real wages, unemployment and inflation. Section 4 discusses the consequences of CBI and of CWB for unemployment and inflation. This section also presents an analysis of the factors that determine the existence and the position of a Calmfors-Driffill type relation between real wages and the CWB. Section 5 investigates interactions in the effects of CBI and CWB on inflation, unemployment and real wages.

Section 6 derives the optimal degree of CB "conservativeness". Surprisingly, the conventional social welfare function is maximized when the CB is "ultra-liberal" in the sense that it is concerned only with unemployment but not with inflation. But when the social welfare function is modified so as to allow a positive weight on the welfare of unions the socially optimal degree of conservativeness may be either positive or negative depending on the relative size of this weight.

Section 7 presents empirical tests of the theory using institutional and macroeconomic data on nineteen developed economies. The institutional data includes indices of CWB based on OECD (1997) and indices of CBI from chapter 19 of Cukierman (1992) and from Cukierman, Webb and Neyapti (1992). The implications of the theory are broadly supported except for two that are contradicted by the evidence. Section 8 offers a possible explanation for those two inconsistencies and argues that they do not necessarily invalidate the usefulness of the model as a stylized description of reality. Implications for European Monetary Union (EMU) are briefly discussed in Section 9. This is followed 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 conservativeness is characterized by a parameter c.[10] The typical union likes high wages and low unemployment for its members and also dislikes inflation to some extent. The CB is concerned with aggregate unemployment and price stability.

We consider a two-stage game in the first stage of which each union chooses its nominal wage rate so as to maximize its objectives, taking the wage rates chosen by all other unions as given. In the second stage, the CB chooses inflation, taking the nominal wages previously set by all the unions as given, so as to maximize its objectives.[11] In this framework, CBI is measured by the Bank's (effective) degree of conservativeness, c, and the CWB by the number of (independent) unions, n.

2.1 The structure of labor markets and unions' objectives

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.[12] 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:[13]

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

[11] In section 9 we comment on the consequences of a different timing-of-events (which corresponds to precommitment of monetary policy) for the nature of equilibrium and relate it to previous literature that has addressed this issue.

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

[13] This demand may emanate, in general, from all industries altough 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.

Later we impose conditions which assure that equilibrium employment is positive for every union.

$$L_j^d = \left[\frac{\alpha}{n}(d - w_{rj}) - \gamma(w_{rj} - \overline{w}_r)\right] L \tag{1}$$

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 and $\overline{w}_r$ is the (unweighted) mean of w_{rj} over all unions in the economy. 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. Summing over unions, aggregate demand for labor in the economy is given by:

$$L^d \equiv \sum_{j=1}^{n} L_j^d = \alpha(d - \overline{w}_r)L. \tag{2}$$

Equation (2) states that aggregate demand for labor depends (negatively) **only** on the **average** real wage $\overline{w}_r$. In particular aggregate demand for labor **does not** depend on the number of unions in the economy. This seems like an essential requirement, or at least a reasonable first approximation. Equation (1) 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.

Equation (1) 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:

$$\eta_j = \frac{\alpha + \gamma(n-1)}{\alpha(d - w_{rj}) - n\gamma(w_{rj} - \overline{w}_r)}. \tag{3}$$

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, equation (1) implies that, although **total** labor demand does not depend on the degree of centralization of wage bargaining, the extent of wage competition among

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

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).

The typical union prefers a higher real wage rate for its members, dislikes unemployment among its members and also dislikes inflation. This is captured by the following loss function

$$\Omega_j \equiv -2w_{rj} + Au_j^2 + B\pi^2 \tag{4}$$

where u_j is the rate of unemployment among members of union j, π is the rate of inflation 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.[15] The third one reflects the union's aversion to inflation.

2.2 Social objectives

The socially optimal levels of employment and of inflation are equal to the market clearing levels and to zero respectively and any deviations from those levels are socially costly. The social loss function is given by:

$$\Gamma \equiv u^2 + \lambda\pi^2 \tag{5}$$

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

which is positive if and only if

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

Provided aggregate labor demand is positive, $d - \overline{w}_r$ 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] See for example Oswald (1982).

where u is the economy wide rate of unemployment. This function states that social losses increase at an increasing rate with the average rate of unemployment and with inflation.[16] The multiplicative weight, λ, on inflation generally differs from the analogous weight in union's j objective function. An important difference between union objectives and social objectives concerns the unemployment terms. While social welfare depends on aggregate unemployment, union objectives depend only on the rate of unemployment among its own members.

2.3 The monetary authority

Monetary policy is conducted by a CB which embraces social objectives, except that the relative importance that the Bank assigns to inflation may be different than in the social welfare function. Thus, as in Rogoff (1985), CBI is characterized by the Bank's degree of conservativeness, c. More precisely the objective of the CB is to minimize the following loss function:

$$\Gamma_c \equiv u^2 + (\lambda + c)\pi^2. \tag{6}$$

Note that the only difference between the objective function of the CB and the social objective function is that the CB may be more (or less) inflation averse.

2.4 A competitive benchmark

Using equation (1) and the fact that the supply of labor by members of union j is L/n the (logarithm of the) competitive real wage rate in that segment of the labor market is:

[16] Although it abstracts from the objectives of unions this type of social welfare function has been widely used in the strategic monetary policy literature. Examples are Rogoff (1985), Walsh (1995) and Svensson (1997). Recent extensive microdata on a sample of over 250.000 people in 12 European countries supports the view that "public happiness" is inversely related to unemployment and inflation (Di Tella, MacCulloch and Oswald, 1997). We provisionally adopt such a specification for benchmark purposes and then suggest a generalization in the section on the socially optimal CB.

$$w_{rj}^c = d - \frac{1}{\alpha} \equiv w_r^c, \ \forall \ j's \tag{7}$$

implying that the competitive real wage rates in the different segments of the labor market are identical. This is not surprising in view of the symmetric specification of the model. It is convenient to express the actual real wage rate in labor market j as a premium, ϕ_j, over the market clearing real wage rate, w_r^c so that:

$$w_{rj} = w_r^c + \phi_j \ . \tag{8}$$

Let w_j and p be respectively the (logarithms of the) nominal wage in labor market j and the price level. By definition:

$$w_{rj} \equiv w_j \ - p \tag{9}$$

and

$$\overline{w}_r = \overline{w} \ - p \tag{10}$$

where $\overline{w}$ is the (simple) mean nominal wage in the economy. Using equations (9) and (10) in the individual union labor demand:

$$L_j^d = \left[\frac{\alpha}{n}(d - w_j + p) - \gamma(w_j - \overline{w})\right] L, \ \forall \ j's. \tag{11}$$

When the union aims at real wage w_{rj} and expects a price level Ep it will demand the nominal wage:

$$w_j = w_{rj} + Ep = w_r^c + \phi_j + Ep, \ \forall \ j's. \tag{12}$$

Similarly

$$\overline{w} \equiv \frac{1}{n}\sum_{j=1}^{n} w_j = w_r^c + \overline{\phi} + Ep. \tag{13}$$

where

$$\overline{\phi} \equiv \frac{1}{n}\sum_{j=1}^{n} \phi_j \tag{14}$$

is the average wage premium. Using equations (7), (12) and (13) in equation (11) yields:

$$L_j^d = \left[\frac{\alpha}{n}(\frac{1}{\alpha} - \phi_j + \pi - E\pi) - \gamma(\phi_j - \overline{\phi})\right] L, \ \forall \ j's \tag{15}$$

where $\pi = p - p_{-1}$ and p_{-1} is the (logarithm of the) price level in the previous period. Thus, the demand for the labor of union's j workers is directly related to surprise inflation and inversely related to the wage premium demanded by the union as well as to the deviation of this premium from the economy wide average wage premium.

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 equation (6). In the first stage each union picks its premium over the competitive wage rate taking as given the nominal wage rates of all other unions and the reaction function of the CB.

3.1 Choice of inflation by the central bank

Summing equation (15) over unions and using the resulting expression in the definition of unemployment, the equilibrium economy wide rate of unemployment is:

$$u \equiv \frac{L - L^d}{L} = \alpha\left(\overline{\phi} - (\pi - E\pi)\right). \tag{16}$$

Inserting this expression into the CB loss function, the CB problem is to choose inflation so as to minimize

$$\alpha^2 \left(\overline{\phi} - (\pi - E\pi)\right)^2 + (\lambda + c)\pi^2. \tag{17}$$

Differentiating with respect to π, equating to zero, and rearranging we obtain:

$$\pi = \frac{\alpha^2}{\alpha^2 + (\lambda + c)} \left(\overline{\phi} + E\pi\right). \tag{18}$$

This equation is the CB reaction function. It 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 $\overline{\phi}$), 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, c.

Since there is no uncertainty and expectations are rational the rate of inflation is forecasted perfectly by unions at contracting time. Using this fact in equation (18) and rearranging, equilibrium inflation is:

$$\pi = E\pi = \frac{\alpha^2 \overline{\phi}}{(\lambda + c)}. \tag{19}$$

3.2 Choice of wage rates by unions

Equation (15) implies that the rate of unemployment among union's j members is:[17]

$$u_j \equiv \frac{L_j - L_j^d}{L_j} = \alpha \left(\phi_j - (\pi - E\pi)\right) + \gamma n(\phi_j - \overline{\phi}),\ \forall\ j's. \tag{20}$$

Using (8) and (20) in equation (4), union's j loss function is:

[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.

$$\underset{\phi_j}{Min}\ \ E\left\{-2(w_r^c+\phi_j)+A\left(\alpha\left(\phi_j-(\pi-E\pi)\right)+\gamma n(\phi_j-\overline{\phi})\right)^2+B\pi^2\right\}. \tag{21}$$

Differentiating with respect to ϕ_j, taking note of the fact that actual and expected inflation are equal and that their common value is given by equation (19), the first order condition for the typical union's problem is:

$$2\left\{-1+A\left(\alpha\phi_j+\gamma n(\phi_j-\overline{\phi})\right)\left(\alpha+\gamma(n-1)\right)+\frac{B\alpha^4\overline{\phi}}{n(\lambda+c)^2}\right\}=0,\quad j=1...n \tag{22}$$

Summing over all unions, dividing by n, and rearranging, the equilibrium average wage premium is:

$$\overline{\phi}=\frac{(\lambda+c)^2 n}{\alpha\left[B\alpha^3+A(\lambda+c)^2(\alpha+\gamma(n-1))n\right]}=\phi_j\ ,\ \forall\ j's. \tag{23}$$

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. We assume that the typical union's aversion to unemployment and to inflation, as characterized by these parameters, is sufficiently large to make the equilibrium level of employment positive. The equilibrium rate of unemployment is, from equations (16) and (23):

$$u=\alpha\overline{\phi}=\frac{(\lambda+c)^2 n}{B\alpha^3+A(\lambda+c)^2(\alpha+\gamma(n-1))n}. \tag{24}$$

The last two equations imply that the average wage premium, and therefore unemployment, are positive. This is 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.

When unions do not care about price stability ($B=0$) the wage premium becomes:

$$\overline{\phi}=\frac{1}{\alpha A(\alpha+\gamma(n-1))}. \tag{25}$$

This expression is always larger than the corresponding expression when unions care about price stability ($B > 0$). It follows that, when unions care about price stability, equilibrium real wages are above their competitive level but below the level they would have been at when unions are not concerned about price stability (correspondingly, the rate of unemployment is positive but below the level it would have been at when unions do not care about macroeconomic stability).

The concern of unions with price stability, thus, **moderates** their wage demands. The reason is that each union realizes that by raising its real wage further it increases the incentive of the CB to inflate in order to reduce the higher rate of unemployment induced by the higher real wage. This moderating effect is stronger when the number of unions is small. In the limit, when there is only one union, it fully internalizes the effect of its wage decisions on the subsequent rate of inflation. But when the number of unions is large 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.

4 First Order Effects of Centralization on Real Wages, Inflation and Unemployment, and the Calmfors - Driffill Hypothesis

A change, in the degree of centralization of wage bargaining triggers two opposing 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 equation (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 produces 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 low at extreme levels of centralization and relatively high at moderate levels of centralization. This hypothesis led them to conjecture that the relation between the level of real wages and centralization is hump shaped. 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.[18] But since the spirit of their hypothesis and of ours is similar we refer to the hump shaped relation between real wages and centralization, that we obtain, as the "Calmfors - Driffill" curve.

4.1 Implications for the Calmfors - Driffill hypothesis

Equation (23) 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:

$$\frac{\partial \overline{\phi}}{\partial n} = \frac{(\lambda + c)^2}{\alpha D^2} \left(B\alpha^3 - A(\lambda + c)^2 \gamma n^2 \right) \tag{26}$$

where D is the denominator of the expression in equation (24).[19] This leads to the following proposition:

Proposition 1 *: i. If* $B < \frac{A(\lambda+c)^2\gamma}{\alpha^3} \equiv B_c$, $\frac{\partial \overline{\phi}}{\partial n} < 0$ *at all levels of centralization of wage bargaining.*

[18] 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). See also Zervoyianni (1997) for a similar mechanism in an international context.

[19] $D \equiv \left[B\alpha^3 + A(\lambda + c)^2(\alpha + \gamma(n-1))n \right] > 0.$

ii. If $B > B_c$, $\frac{\partial \overline{\phi}}{\partial n} < 0$ *at low levels of centralization (high* n*) and* $\frac{\partial \overline{\phi}}{\partial n} > 0$ *at high levels of centralization of wage bargaining (low* n*).*

Proof. Immediate from (26). ■

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 and the strategic effect dominates at high levels of centralization. As a consequence real wages increase with centralization at low levels of centralization and decrease with it at high levels of centralization. Figure 1 illustrates the two possible relations between the real wage and the degree of centralization.

The analysis implies that an inverted U relation between real wages and centralization is more likely to arise the lower the impact of higher competition on the demand for labor facing each individual union (lower γ), the lower CBI (lower c) and the less unions care about unemployment among their members (the lower A). This case is illustrated in panel b of Figure 1. The higher are those parameters, the more likely it is that further centralization will increase wages, at all levels of centralization, as is the case in panel a of Figure 1.

It is possible to use equation (26) 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:

$$n^* = \sqrt{\frac{B\alpha^3}{\gamma A}} \left(\frac{1}{\lambda + c} \right). \tag{27}$$

Note that n^* is lower the higher CBI as measured by c. Thus, the higher CBI the larger the range of levels of centralization 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 curve up. Those results are illustrated in Figure 2. Note also that the peak of the CDC occurs at a higher level of centralization, the larger are B and α and the lower are γ and A.

The statement of proposition 1 and the discussion following it presumes that the number of unions, n, varies within the full range between 1 and infinity. However, within a particular sample, the range of variation of n may be substantially smaller. In terms of Figures 1 and 2 this means that only subranges of the interval (0,1) for centralization are observed. Thus even if the structure of the economy is such that we would have observed a CDC when the empirical range of n is full it may not be observed in practice if n is bounded from above. We may, in such a case, observe only the decreasing part of the CDC. In a similar spirit, if the smallest value of n in a given sample is sufficiently above one, we may observe only the increasing part of the CDC.

4.2 The effect of centralization of wage bargaining on inflation and unemployment

This subsection investigates the effect of the degree of centralization of wage bargaining, as measured by $1/n$, on inflation and unemployment. The main result follows almost immediately from the discussion in the previous subsection.

Equation (19) implies that inflation is positively related to the equilibrium wage premium. Similarly, equation (24) implies that the rate of unemployment is positively related to the wage premium. This leads to the following proposition.

Proposition 2 *: 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 1.

Thus, inflation and unemployment increase monotonically with centralization, or display a hump shape relation with it, depending on whether unions' inflation aversion is lower than or higher than the threshold $B_{c.}$

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 (where $n = 1$) with that of a fully decentralized one (where $n \to \infty$). Equation (23) implies that in a fully decentralized system the wage premium is zero. It follows, using equations (19) and (24), 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 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 in the following proposition:

Proposition 3 *: 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 equation (23) that $\lim_{n\to\infty} \bar{\phi} = 0$ and that $\bar{\phi} = \frac{(\lambda+c)^2}{\alpha^2[B\alpha^2+A(\lambda+c)^2]}$ at $n = 1$. Since both inflation and unemployment are increasing in $\bar{\phi}$, it follows from equations (19) and (24) that inflation and unemployment are smaller for $n \to \infty$ than for $n = 1$, $\forall\ c > -\lambda$. ■

4.3 The effect of CBI on inflation and unemployment

Examination of equation (19) reveals that CBI (or conservativeness) has two opposing effects on the rate of inflation. Given the wage premium, $\overline{\phi}$, an increase in conservativeness reduces equilibrium inflation as in Rogoff (1985). But, as can be seen from equation (23), the

increase in c 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 equation (19) with respect to c:

$$\frac{\partial \pi}{\partial c} = \frac{\alpha}{D^2} n \left[B\alpha^3 - A(\lambda + c)^2 \left(\alpha + \gamma(n-1)\right) n \right]. \tag{28}$$

The main implication of equation (28) is summarized in the following proposition:

Proposition 4 *: If the inflation aversion of unions is sufficiently small, or if the number of unions is sufficiently large or if both conditions hold, an increase in CB conservativeness reduces equilibrium inflation at all levels of centralization of wage bargaining.*

We turn next to the effect of CBI on unemployment. It is easily seen from equation (24) that unemployment is increasing in c.[20] Hence:

Proposition 5 *: Other things the same, the rate of unemployment is larger the higher the degree of conservativeness of the CB provided $B > 0$.*

The intuition underlying this proposition is relatively simple. When CBI is higher the moderating effect of unions' inflation scares on their wage demands is smaller. They consequently demand and obtain higher real wages and this raises the rate of unemployment.

This result contrasts with most of the literature on monetary policy games under perfect information in which CBI affects inflation but does not affect real variables. The source of the non neutrality here is directly traceable to unions' inflation aversion ($B > 0$).[21] When unions do not mind inflation, as in conventional models of monetary policy, the neutrality result

[20] The partial derivative of unemployment with respect to c is equal to: $\frac{\partial u}{\partial c} = \frac{n}{D^2}(\lambda + c)(2B\alpha^3) > 0$.

[21] This result has already been noticed, within a single union framework by Yashiv (1989) and by Lawler (no date). It was mentioned intuitively by Nissan Liviatan in private conversation with Cukierman as early as 1987.

reappears. Neutrality also reappears even for $B > 0$ when n is large since, in this case, each individual union largely neglects the effect of its own actions on inflation. 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.

5 Interaction Effects between Central Bank Independence and the Centralization of Wage Bargaining

Proposition 5 states that an increase in CBI raises unemployment. An interesting question in this context is how strong is this effect at different levels of CWB. The answer to this question involves the cross derivative of unemployment with respect to c and n and is addressed in the following proposition:

Proposition 6 *: When the marginal impact of CBI on inflation is negative the adverse (positive) effect of CBI on unemployment is stronger at high levels than at low levels of centralization of wage bargaining.*

Proof. From equation (24) the cross derivative of unemployment with respect to CBI and the level of CWB is given by:

$$\frac{\partial^2 u}{\partial n \partial c} = \frac{2B(\lambda + c)\alpha^3}{D^3}\left[B\alpha^3 - A(\lambda + c)^2(\alpha + \gamma(3n - 1))n\right] \tag{29}$$

Comparison of this expression with equation (28) reveals that it is negative whenever the expression in equation (28) is negative. Hence if the impact of c on π is negative the cross partial of unemployment with respect to c and n is negative as well. ■

The intuition underlying the proposition follows. From the point of view of an individual union, a higher degree of CBI exogenously decreases the marginal impact of the union's wage policy on inflation, thus raising the union's incentive to increase its wage premium

and therefore unemployment. However, the extent to which the change in this marginal impact affects the union's wage-setting decision depends on the union's perceived impact of its wage-setting decision on the subsequent rate of inflation. This perceived impact, as it appears in the first order conditions of the union's problem (equation 22), is scaled down by $1/n$ since, as the number of unions increases, the impact of each union's individual wage decision on monetary policy diminishes. Hence, when wage bargaining is less centralized the marginal impact of CBI on unions' wage decisions and, therefore, on unemployment is smaller.

We have seen above that, for sufficiently low levels of centralization, higher CBI is associated with lower equilibrium inflation. But the magnitude of this (negative) marginal effect of CBI on inflation differs across centralization levels. The following proposition addresses this issue:

Proposition 7 *: If*

$$3B\alpha^2 > A(\lambda + c)^2 > \frac{1}{3}B\alpha^2 \tag{30}$$

the relation between the absolute value of the (presumed negative) marginal impact of CBI on inflation and centralization is hump shaped. That is, this marginal impact is larger at intermediate levels of centralization than at either very high or very low centralization levels.

Proof. Differentiating equation (28) with respect to n:

$$\frac{\partial^2 \pi}{\partial n \partial c} = \frac{\alpha}{D^3}\left[(B\alpha^3)^2 + \gamma n^3(\alpha + \gamma(n-1))Z^2 - 3B\alpha^3 n(\alpha + \gamma(2n-1))Z\right] \tag{31}$$

where $Z \equiv A(\lambda + c)^2$. For sufficiently large n (i.e. low centralization) this expression is always positive. For $n = 1$, the expression in equation (31) reduces to:

$$\frac{\partial^2 \pi}{\partial n \partial c}(n=1) = \frac{\alpha}{D^3}\left[B\alpha^4\left(B\alpha^2 - 3Z\right) + \gamma\alpha Z\left(Z - 3B\alpha^2\right)\right]. \tag{32}$$

The relation between the (absolute value of the) marginal impact of CBI on inflation and centralization will be hump shaped provided this expression is negative. Since the terms

multiplying each of the two terms in parenthesis on the right hand side of equation (32) are positive, jointly sufficient (but not necessary) conditions for the negativity of this equation are that each of the two terms inside the parenthesis is negative. The condition in equation (30) is obtained by rearranging these two requirements. ■

What is the intuition underlying proposition 7? As shown in equation (19), inflation is proportional to the product of the wage premium and to the reciprocal of the central bank inflation aversion parameter, $I \equiv \lambda + c$. Therefore, the total impact of an increase in CBI on inflation is a combination of two effects: a direct, negative effect, brought about by the change in conservativeness, and an indirect positive effect, related to the change in the wage premium triggered by the change in CBI (analytically: $\frac{\partial \pi}{\partial c} = \alpha^2 \cdot \frac{1}{I}\left\{\overline{\phi}_c - \frac{\overline{\phi}}{I}\right\}$, where the first term in the curly bracket is the indirect effect and the second term is the direct effect). Note that the direct effect may be humped in the degree of centralization (since, from proposition 1, $\overline{\phi}$ may be humped in n) and that the indirect effect is increasing in centralization (since, from proposition 6, the impact of CBI on the wage premium decreases with n). If the relation between $\overline{\phi}$ and centralization is humped, the absolute value of the (negative) impact may reach a maximum at intermediate levels of centralization when, due to large $\overline{\phi}$ values, the direct effect dominates the indirect effect.

The condition in equation (30) can also be related to the existence of a hump-shaped relation between the **level** of the wage premium and CWB established in proposition 1. The inequality that delivers the hump shaped relation in that proposition can be rewritten as $(\frac{\alpha}{\gamma})B\alpha^2 > A(\lambda + c)^2$. Given the existence of this humped relation the left hand inequality in equation (30) is satisfied when $\frac{\alpha}{\gamma} > 3$. It follows that when the wage premium is a humped function of centralization, the absolute impact of CBI on inflation is more likely to also be a humped shaped function of centralization if $\frac{\alpha}{\gamma}$ is sufficiently large.

We conclude this section with two observations regarding proposition 7. First, the condition for the hump in proposition 7 is overly strong. Second, there obviously are combinations of parameters for which there is no hump in the relation between the impact of CBI on inflation and centralization. In such cases the (absolute value of the) marginal impact of

independence on inflation is a monotonically increasing function of centralization.

6 The Ultra-liberal and the Ultra-conservative Central Bankers: two Fables for Social Welfare Maximizers

We saw in section 4 that, even in the absence of stabilization policy, CBI has a benefit and a cost. Higher independence, or conservativeness, reduces inflation (under reasonable conditions) but also increases the rate of unemployment. This raises the following natural question: What is the degree of central bank (CB) conservativeness (or liberalism) that maximizes social welfare? It is important to realize that, unlike in Rogoff (1985), the tradeoff underlying this optimal degree does not involve flexibility since we deliberately abstract from the potential anticyclical function of monetary policy. Formally it corresponds to a world in which there are no shocks to employment.

Using equations (19) and (24) in the social loss function (equation(5)) it can be shown that:

$$\Gamma(c) = \alpha^2 \left(1 + \alpha^2 \frac{\lambda}{(\lambda + c)^2}\right) \left[\overline{\phi}(c)\right]^2 . \tag{33}$$

Here $\overline{\phi}$ is written as $\overline{\phi}(c)$ in order to stress the dependence of the equilibrium wage premium on CB conservativeness through equation (23). Since $\Gamma(c)$ is a function of quadratic terms the lowest loss that can be obtained is zero. Examination of equation (33) reveals that a zero loss level is actually attained when $c = -\lambda$. The reason is that, from equation (23), the equilibrium wage premium is equal to zero in this case. This result is summarized in the following proposition .

Proposition 8 *: The no shocks social welfare is maximized when the central banker is "ultra-liberal" in the sense that she is concerned only with unemployment and is not concerned at all about inflation.*

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 they are moderately averse to inflation (in the sense that B is small but strictly positive) unions still strongly dislike such very high inflation rates. Since they know that even the slightest level of unemployment will induce the CB to inflate at an extremely high rate they all reduce their wage premiums to zero in order to avoid this calamity. And, indeed, when $\overline{\phi} = 0$ the CB has no reason to inflate as can be seen from equation (19). 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 unions an ultra-liberal CB has a comparative advantage in preventing them from using this power by effectively threatening them with unbearable inflation whenever any one of them sets the real wage above the competitive level. In a wider sense this result suggests that if the CB is known to be extremely liberal other institutions in society adjust their behavior so as to induce the CB to maintain inflation at a reasonable level.

How realistic is the ultra-liberal CB result? The answer to this question depends on the extent to which unions are aware of the link between their wage choices and monetary policy. If **all of them** are not aware of it, this result obviously does not have much descriptive realism. But this seems like an extreme presumption. For example, there is convincing evidence that prior to 1983 unions in Sweden systematically restrained their wage demands because of their concern for macroeconomic stability.

Another possible objection to the ultra-liberal CB as a realistic socially optimal institution is that governments and central banks inflate not only to achieve low unemployment but for other reasons like seignorage as well. There is thus a danger that an ultra liberal CB will be tempted to inflate even when unemployment is zero if it values seignorage revenues for example.[22] Such considerations modify the lesson from the benchmark ultra-liberal CB parable but do not make it meaningless. In the presence of additional motives for monetary expansion this benchmark suggests, by continuity, that if the **main** motive for monetary

[22]The stategic implications of the seignorage and other additional motives for monetary expansion are discussed in Part I of Cukierman (1992).

expansion is the reduction of unemployment a CB that is more liberal than society may still be socially desirable.

An additional critique of the ultra-liberal CB result is that the social loss function traditionally used in monetary policy games (equation(5)) is incomplete since it ignores the welfare of unions.[23] A possible way to account for this omission is to respecify social welfare as a weighted average of the conventional function and of the welfare of the unions. This is done in equation (34) that follows:

$$\Psi \equiv (1-\theta)\Gamma + \theta \frac{1}{n} \sum_{j=1}^{n} \Omega_j \ , \ 0 \leq \theta \leq 1. \tag{34}$$

Examination of the modified social loss function reveals that the optimal degree of CB conservativeness may be either positive or negative depending on whether the weight, θ, attributed to union's welfare is large or small.[24] Note, in particular, that when θ tends to one, so that the dominant argument of social welfare is the welfare of unions, the optimal level of conservativeness is infinite.

This can be seen by observing that unions welfare is maximized when inflation is zero **independently** of the level of real wages that they choose. The reason is that they can, in this case, indulge in their sectorial objectives and still get price stability. But, from equation (19), equilibrium inflation is zero at **any** level of the wage premium when c tends to infinity. Consequently unions can cater to their particularistic objectives without worrying

[23]This omission is of no consequence when monetary policy does not affect real variables. This is the case in conventional monetary policy games, in which the welfare of the union sector is unaffected by inflation (as in Chapter 3 of Cukierman (1992) for example). But when unions are inflation averse there is a conflict between their welfare and the conventional measure of social welfare.

[24]Conservativeness was originally defined as the "excess" weight attributed by the CB to inflation (c) as compared to the social weight (λ). When the modified welfare function Ψ is used, the weight λ is not an appropriate benchmark for comparison anymore; the social weight attributed to inflation is now given by: $(1-\theta)\lambda + \theta B$. Thus, a CB is conservative (liberal) if c is larger (smaller) than the modified inflation weight.

We are assuming for simplicity that the CB loss function remains equation (6) in spite of the fact that the social welfare function is now different. But the qualitative conclusions in the text remain the same for any benchmark weight on inflation as long as this weight is bounded away from both zero and infinity.

about price stability. This observation may provide an explanation for the fact that CBI is frequently granted by labor governments. Recent CB reforms in Argentina and the UK provide support for this conjecture. As the weight given to unions' welfare goes down, the socially optimal level of conservativeness goes down monotonically eventually reaching $-\lambda$ (ultra liberalism) when θ is zero.

7 Some Evidence

The theoretical insights offered by the model have several empirically testable implications. First, an important implication of the theory 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, the main empirical implication of the model concerns the relation between the degree of centralization of wage bargaining and unemployment performance. In the past decade, the hypothesis of a hump-shaped relation between unemployment and the CWB proposed by Calmfors and Driffill (1988) has received considerable attention. The evidence in favor of this hypothesis however appears to be mixed.[25] Our analysis qualifies the Calmfors and Driffill (1988) unconditional proposition by indicating that whether a hump-shape relation between unemployment and CWB will be **observed or not** depends 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.

Second, for a given level of CBI, both inflation and unemployment are expected to be related to the average wage premium (proposition 2). Therefore, if there is (there is not) a

[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 1). However, for a given range of variation of n, the downward segment of the hump may not be observable for "large enough" c.

significant hump in unemployment there should also (not) be a significant hump in inflation. Third, the theory implies the well known negative correlation between CBI and inflation (provided centralization is not too high; proposition 4), suggesting that the absolute value of this correlation is largest at intermediate levels of centralization (proposition 7). Fourth, proposition 5 asserts that the impact of CBI on unemployment may be positive and increasing (proposition 6) with the degree of centralization. The investigation of these relations requires the construction of empirical proxies for the degree of CWB and of CBI. Such proxies are discussed in the next subsection.

7.1 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, Chapter 3). 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-, sectorial- 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- 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), cen-

[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 differenciate between countries around the same 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.

tralized 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 are recorded in Australia, New Zealand and the UK, while an increase of centralization occurs in Norway.

To measure the degree of independence of the central bank we use the legal index of CBI (LVAU) developed by Cukierman, Webb and Neyapti (1992). A legal CBI index (rather than an actual CBI index) is chosen because that seems to be more appropriate for developed economies (Cukierman, 1992). The index ranges between zero (least independent) and one (most independent). This index covers all of the nineteen 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.

[28]For instance, the unemployment performance corresponding to the 1980's 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 it 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 the one for 1990. 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).

7.2 A preliminary look at the data

Before turning to regression analysis it is useful to examine whether any of the relations predicted by theory are broadly supported by the data. Tables 1 to 4 give simple representations of the relation between economic performance and both CEN and CBI. Observations are grouped in the Tables according to a countries' scores on CEN and CBI. For the latter variable, the cutoff point LVAU<0.4 has been chosen to identify a group of low-CBI countries. Table 1 (2) shows the results obtained by pooling together the observation on unemployment (inflation) using data from all three periods.[30] For example, the 5.9 figure in the upper left cell of Table 1 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 j ($j = 1, 2, ..., 19$) 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 1 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 evidence in Table 2 at low independence levels. However, the relation between unemployment (or inflation) and centralization at high levels of independence is not hump-shaped. Unemployment appears to be decreasing with the level of centralization, while inflation seems to be increasing (at least from intermediate to high centralization). These relationships are quite robust across time, as indicated by the fact that they continue to hold when "filtered averages" are used and when observations corresponding to the third period (1994) are dropped (Tables 3 and 4).

The tables suggest that the sign and magnitude of the relation between inflation and unemployment, on the one hand, and CBI, on the other, varies across different levels of centralization. In particular, comparison of the first and second rows in Table 2 and 4, points

[30] Data for the third period (1994) are not used in Tables 3 and 4.

to the existence of a relatively large negative impact of CBI on inflation at intermediate CEN, as suggested by proposition 7. Without controlling for centralization, the well documented negative correlation between inflation and CBI does appear.

7.3 Regression analysis

An assessment of the statistical significance of the relations displayed in Tables 1 to 4, which also makes it possible to control for other variables, is performed by means of regression analysis. The functional form chosen for the regression is one that captures the (potentially) non-linear effects of labor and of monetary institutions on unemployment and on inflation and also allows for potential interactions in the effects of those two institutions. The typical regression that is performed for both unemployment and inflation has the general specification:

$$\begin{aligned} y &= a \cdot CBI + b \cdot CEN + c \cdot CEN^2 + \\ &\quad + d \cdot (CBI \cdot CEN) + e \cdot (CBI \cdot CEN^2) + const + f \cdot control + \varepsilon \end{aligned} \tag{35}$$

where y is equal to either inflation or unemployment, CBI and CEN are the measures of central bank independence and of centralization described before, *const* is the regression intercept, *control* indicates a vector of control variables that includes period dummies and other variables described below and ε is the error term of the equation.[31] It can be easily seen that the functional form allows for an inverted U relation (parabola) between the dependent variable and CEN. Moreover, the interaction term between CBI and CEN makes this relation dependent on the degree of central bank independence, as suggested by the theoretic model.[32]

[31] Although this formulation appears as one which can account for many of the effects suggested by the theoretic model, we have also experimented with alternative specifications. For instance, we tried 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 Driffil (1988) and by Bleaney (1996). Overall, the results are qualitatively similar to the ones reported here.

[32] The interaction term CBI·CEN^2 accounts for the potentially non-linear relation between $\partial\pi/\partial c$ and centralization $(1/n)$ suggested by Proposition 7.

7.3.1 Estimation results

Tables 5 and 6 report the main results of the regression analysis for unemployment and inflation, respectively. Before testing the specification in equation (35), a benchmark regression that does not include an interaction term between CEN and CBI (i.e. $d = e = 0$) was estimated. The results are reported in the first column of each table. In both equations, the signs of the coefficients of CEN and CEN^2 suggest a hump-shaped relation; however, the coefficients are only marginally significant in the case of inflation and not significant in the unemployment equation. Moreover, in neither case is it possible to reject (at the ten per cent level) the joint F-test for the null hypothesis that $b = c = 0$. This confirms the results of the OECD (1997) which, using basically the same data, does not find evidence on hump-shaped effects between CEN and unemployment.

The second column of each table shows the full-sample estimates of equation (35) when the interaction terms are used. It appears that these terms significantly improve the explanatory power of the regression (particularly for the unemployment equation) and the significance of all coefficients. In both equations, the coefficients of CEN and CEN^2 are statistically significant (the F-test on the joint significance of the coefficients rejects the null hypothesis of zero coefficients at the one per cent level). This provides less ambiguous evidence on the existence of a Calmfors-Driffill type of relation than that reported in the equation of the first column, where interaction terms were not used. Moreover, the coefficients of the interaction terms between CBI and CEN are also significant. This is consistent with the theoretical implication that the relation between unemployment and CEN varies with the degree of CBI.

7.3.2 The impact of CBI and CWB on inflation and unemployment

It is interesting to examine whether the impacts of CEN and of CBI on inflation and unemployment implied by the estimated equations are consistent with the theoretical propositions derived above. The latter concern the following relations: the impact of CEN on unemployment and inflation (propositions 1 and 2; i.e. $\frac{\partial u}{\partial \frac{1}{n}}$; $\frac{\partial \pi}{\partial \frac{1}{n}}$); the impact of CBI on inflation and

unemployment (propositions 4 and 5; i.e. $\frac{\partial \pi}{\partial c}$; $\frac{\partial u}{\partial c}$); the effect of CEN on the impact of CBI on inflation and unemployment (propositions 6 and 7; i.e.$\frac{\partial^2 u}{\partial c \partial \frac{1}{n}}$; $\frac{\partial^2 \pi}{\partial c \partial \frac{1}{n}}$). Since these relations can be expressed in terms of partial derivatives, the estimated equations are used to examine whether the signs of these derivatives, as implied by the regressions, are consistent with the theoretical predictions.[33] The values of the partial derivatives implied by the equations in the second column of Tables 5 and 6 (equations 5.2 and 6.2) are presented in Tables 7 and 8.

Table 7 reports the estimated first order effects of CEN on inflation and on unemployment at various levels of CEN and CBI. The signs of these derivatives indicate the existence of a hump-shaped relation between centralization and both inflation and unemployment when CBI is smaller than 0.4. In this case (first two rows of Table 7) the inflation equation implies that at low-centralization, CEN has a positive (statistically significant) impact on inflation. The impact is not significantly different from zero at intermediate CEN, and it is negative (and statistically significant) at high-CEN. The unemployment equation shows a very similar hump-shaped pattern, although the negative impact of CEN on unemployment recorded at high CEN is not statistically significant at conventional levels (p-value 15%).[34] For CBI values larger than 0.4, however, no hump-shaped relation emerges for either the inflation or the unemployment equation. Over this range, inflation is not significantly correlated with centralization, while there is some evidence of a negative correlation between unemployment and centralization. The evidence in Table 7 is summarized by the following stylized facts:

[33]The partial derivatives implied by the data are obtained by differentiating equation (35) with respect to the relevant variable. For instance, $\frac{\partial u}{\partial \frac{1}{n}}$ is equal to:

$$\frac{\partial (Unemployment)}{\partial CEN} = b + 2 \cdot c \cdot CEN + d \cdot CBI + 2 \cdot e \cdot CBI \cdot CEN$$

Since the value of this derivative varies with the degree of CBI and CEN, the tables report this value for different levels of CBI and of CEN.

[34]The lack of evidence on the downward segment of the hump is not inconsistent with the prediction of the model. As noted before, this may simply be due to the fact the actual degree of centralization is upward bounded.

Fact 1 At low CBI (LVAU<0.4) there is a hump-shaped relation between inflation and centralization. A similar hump-shaped relation appears between unemployment and centralization.

Fact 2 At high CBI (LVAU>0.4) inflation is not correlated with centralization and unemployment is negatively correlated with centralization (at low and intermediate CEN).

Fact 3 Inflation and unemployment display a similar qualitative relation with centralization once CBI is controlled for (as indicated by the sign of the estimated impact).

Fact 1 is consistent with the relation between unemployment (inflation) and centralization predicted by proposition 1.ii. The same proposition implies that as CBI increases the hump-shaped relation (observed over a given CEN range) should gradually turn into a monotonically positive relation (assuming c is the only parameter that changes in the inequality that qualifies proposition 1). The fact that the slope of the downward segment of the hump (observed at high-CEN and low-CBI) decreases (in absolute value), for both inflation and unemployment as CBI increases is consistent with that prediction. However, the negative correlation between unemployment and centralization described by Fact 2 is not consistent with that prediction, while the zero correlation between inflation and centralization is inconclusive. It appears that the evidence concerning the shifts in the CDC caused by the increase in CBI is mixed. Fact 3 offers support for proposition 2, as inflation and unemployment display a similar qualitative relation with CEN over a large part of the CBI×CEN space.

The first row of Table 8 reports the estimated first order effects of CBI on inflation. The correlation between CBI and inflation is negative in two out of three cases (but it is statistically different from zero only at intermediate CEN). This is summarized by:

Fact 4 The impact of CBI on inflation is largest (in absolute value), and negative, at intermediate centralization.

This fact is consistent with the prediction of proposition 7 that the largest (negative) first order effect of CBI on inflation occurs at the intermediate level of centralization (Table

8). Given the negative impact of CBI on inflation at intermediate CEN, equation (28) (that is used in the proof of proposition 4) implies that the sign of this impact should also be negative at low CEN (i.e. at large values of n) and could be of either sign at high CEN. However, the estimated impact of CBI is not significantly different from zero at both low and high values of CEN. These findings are basically neutral in the sense that they do not provide support either for or against proposition 4.

Proposition 5 predicts that there should be, ceteris paribus, a positive relation between unemployment and CBI. Table 8 reveals that:

Fact 5 CBI has a positive impact on unemployment at low centralization and a negative impact at intermediate centralization.

Thus, the consistency between proposition 5 and the evidence is mixed. On one hand the proposition is contradicted by the negative (significant) correlation detected at intermediate CEN levels. On the other it is supported by the positive (significant) correlation at low levels of CEN.

In summary, the evidence broadly supports the implications of the theory regarding the effects of centralization and of independence on inflation. But the evidence is inconsistent with one implication of the theory regarding unemployment (Fact 2) and mixed on another implication (Fact 5). As already mentioned, these results are based on estimated equations 5.2 and 6.2. Similar conclusions are obtained when alternative equations that control for outliers, sample period and other labor market variables are used. This is discussed in the next subsection.

7.4 Sensitivity Analysis

The regression results reported in the previous section, and the derived implications reported in Tables 7 and 8, are robust to a number of alternative specifications. First, dummy variables were used to control for outlier observations. A dummy variable was added to the unemployment equation to control for the unusually high Spanish unemployment rate.

Similarly, for the inflation equation, a dummy for the high average inflation of Portugal was used.[35] The results are reported in the third column of Tables 5 and 6. It appears that neither the sign nor the statistical significance of the coefficients is affected by outlier observations. The latter actually improves substantially. Second, regressions were estimated excluding data from the third period (38 observations). The results of this experiment, which are reported in columns 4 and 5 of Tables 5 and 6, are basically identical to the ones obtained from the full sample.

Finally, we controlled both the inflation and the unemployment equation for the potential effects of other institutional determinants of unemployment performance. 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.[36] To account for those effects we added those variables as regressors in both equations. Data availability restricts observations to 14 countries and two time periods (1980; 1990).[37] In line with their findings, a positive correlation is detected between the unemployment rate and the replacement ratio. No significant correlation emerges between

[35]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 the time or as a group. When all three countries are dummied out, for instance, all coefficient are still significant at the 5 per cent level and most of them even at the 1 per cent level. In all cases, the results are essentially unchanged and the coefficients of CEN and of CBI maintain sign and significance.

[36]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.

[37]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 the data of Daveri and Tabellini are five-year averages ending in 1985, we used their last available observations (i.e. the average 1981-1985) to match our second period (1988-1992) observations; consequently, first period observations (1978-1982) were matched by the Daveri-Tabellini data measuring 1971-75 average effective labor taxation and replacement ratios. Despite the obvious improvements to which this approximation is subject, this compromise is imposed by lack of more appropriate (alternative) data.

unemployment and the effective tax-rates on labor income.[38] More importantly for the purpose of this paper, the statistical significance of the CEN and CBI coefficients is not affected by the addition of these variables and the signs of the coefficients of those variables remain as in the benchmark equation (column 2 in Tables 5 and 6).

8 A Possible Solution of the Inconsistency between Theory and Evidence

Although a non negligible number of the implications of our theory is supported by the (significant part of the) estimation results, two implications are contradicted by those results (details appear in subsubsection 7.3.2 above). We cannot rule out the possibility that this is due to data problems or to misspecification of the functional forms of the regressions. More experimentation with alternative measures of centralization or of coordination and with alternative functional forms is obviously desirable. But this is beyond the scope of this already lengthy paper.

In this section we take the empirical results seriously and try to assess more broadly whether the "contradictions" they contain mean that the theory constitutes a good description of reality or not. There are, in total, two significant facts that are inconsistent with some implications of the theory: 1. The impact of CBI on unemployment is negative at intermediate levels of centralization, 2. At high levels of CBI the impact of centralization on unemployment is negative at intermediate and (to a lesser extent) at low levels of centralization.

The first fact is particularly damaging since the theory **unambiguously** predicts that the impact of CBI on unemployment should be positive at **all** centralization levels. The second fact appears to be somewhat less disturbing since the theory generally allows a negative effect of centralization on unemployment for some parameter ranges. The problem with fact

[38]This, is consistent with the claim of Daveri and Tabellini that simple cross-country regressions do not manage to identify significant correlations between unemployment and the taxation of labor.

2 arises because it is hard to reconcile it with other facts that support the theory within the same **unified** framework. Do those contradictions imply that the theory should be abandoned? For reasons that are elaborated in what follows we argue that the answer is: "not necessarily".

A real life element that may be present in our sample of countries, but which is abstracted from in the conceptual framework, is that both the level of CBI and the inflation aversion of unions are positively related to the more basic inflation aversion of society. More precisely, suppose that countries with a higher relative aversion to inflation (as measured for example by the parameter λ in the social welfare function) have **both** more independent central banks ($I \equiv \lambda + c$ is higher) as well as unions with a larger inflation aversion parameter (higher B). Thus, countries like Germany or Austria that have experienced hyperinflations during this century are likely to have both more (effectively) conservative central banks and more inflation averse unions than the UK for example. Empirical work (de Haan and van 'T Hag (1995) and Hayo (forthcoming)) as well as theory (Cukierman (1994) and Lippi (1998)) yield support to this point of view.

This implies that our empirical proxy for independence captures cross country variations in **both** independence and in unions' inflation aversion. In what follows we briefly sketch how our theory can be extended to account for this additional element and demonstrate that this extension eliminates the two discrepancies between theory and evidence. Suppose, in particular, that when λ increases so do I and B. Let I_λ and B_λ be the, exogenously given and assumed positive, marginal impacts of a country's inflation aversion on CBI and on unions' inflation aversion. Evaluating the effect of an increase in the inflation aversion of society on equilibrium unemployment in equation (24), and taking into account that **both** CBI and unions' inflation aversion change with it, we obtain:[39]

$$\frac{\partial u}{\partial \lambda} = \frac{\alpha I_\lambda}{2}(2-\eta)\frac{\partial \overline{\phi}}{\partial I} \tag{36}$$

where η is the ratio between the relative change in B and the relative change in I that are

[39]Note that, given λ, $\frac{\partial \overline{\phi}}{\partial I} = \frac{\partial \overline{\phi}}{\partial c}$.

due to the underlying change in λ. In other words η is the implied elasticity of B with respect to I. Since I_λ and the effect of independence on the wage premium are both positive this expression is positive or negative depending on whether the elasticity, η, is smaller or larger than two. The intuitive reason for the ambiguity concerning the direction of the effect of society's inflation aversion, λ, on unemployment is simple. In addition to its effect on CBI an increase in λ **also** increases the inflation aversion of unions. This raises the **moderating** effect of their inflationary fears on real wages, thereby reducing unemployment for a given level of CBI. Since the increase in CBI raises unemployment, the net effect is ambiguous in general.

Provided η is smaller than 2 at low levels of centralization and larger than 2 at intermediate levels of centralization the theory predicts that the impact of λ on unemployment is positive at low levels of centralization and negative at intermediate levels of centralization. Recalling that the empirical proxy for CBI is capturing variations in both independence and in unions' inflation aversion this implies that the impact of independence on unemployment should be positive at low centralization and negative at intermediate centralization levels, as is the case in Table 8. The upshot is that if η is sufficiently larger at intermediate than at low centralization levels the major contradiction between the theory and the evidence vanishes.

What is the deeper meaning of the assumption that η rises with centralization? It states that the impact of an increase in the inflation aversion of society (and of unions) on CBI is relatively larger at lower levels of centralization. This appears as a reasonable conjecture since at higher levels of centralization a more inflation averse society can rely more on unions' inflation aversion to moderate inflationary temptations in the economy. In view of this consideration, and of its consistency with the empirical evidence, we shall continue the discussion of this section under the assumption that η rises with centralization. A related question is whether this assumption is consistent with the additional empirical finding that there is no significant impact of independence on unemployment at the high level of centralization (low n). The answer to this question is affirmative if $\frac{\partial u}{\partial \lambda}$ is increasing in centralization, which is not unlikely for the range of small n's.

Another important question is whether the model's extension above alters the predictions

that **are** supported by the empirical findings. Detailed comparative static analysis using the extended model (not presented here) suggests that the answer to this question is a clear no. The upshot is that the extended model makes it possible to resolve the major inconsistency between theory and evidence without creating new inconsistencies. Moreover it reinforces the prediction that CBI has a negative impact on inflation and, as shown below, provides additional insights into the nature of the observed change in the relation between unemployment and centralization when CBI increases.

We turn now to a possible resolution of the second inconsistency between theory and evidence: namely the fact that, for high CBI, unemployment is decreasing in centralization at low and intermediate levels of centralization. This finding is puzzling since, as can be seen from figure 2, theory predicts that as CBI goes up the peak of the CDC should shift towards higher levels of centralization. This, in conjunction with the finding that at low CBI unemployment is **increasing** with centralization over the **same** range of centralization (low and intermediate CEN; see Table 7) implies that it should, a fortiori, increase with it (or at least not decrease with it) over that range **also** at high levels of independence. But the evidence, to reiterate, shows the exact opposite.

It turns out that the extension of the model proposed above, in conjunction with an implication of the estimated unemployment equation, can accommodate this (seeming) anomaly as well. To see this it is useful to examine what the theory predicts, within the extended model, about the relative locations of the peak of the CDC at different levels of CBI. Totally differentiating equation (27) with respect to λ:

$$\frac{\partial n^*}{\partial \lambda} = \frac{BI_\lambda}{2}\sqrt{\frac{\alpha^3}{\gamma ABI^4}}\,(\eta - 2)\,. \tag{37}$$

Equation (37) implies that the peak of the CDC moves to higher or to lower levels of centralization depending on whether η is smaller than, or larger than 2.

At low CBI (CBI=0.2) the preferred empirical unemployment equation (equation 5.2) implies that the peak of unemployment is obtained at a relatively high centralization level (CEN=2.38). In this range η is larger than 2 by our assumption above. It follows, using

equation (37), that an increase in λ that is accompanied by an increase in independence (and in unions' inflation aversion) shifts the peak of the CDC for unemployment to **lower** levels of centralization.[40] In terms of figure 2 this means that the top panel corresponds now to low CBI and the bottom panel to high CBI. Looking at figure 2, and keeping in mind this reversed interpretation, it is easy to see that theory predicts that, there is a range of centralization levels such that, when CBI goes up the initially positive slope of the CDC in this range becomes negative as reported in the second panel of Table 7.

9 Implications for EMU

The formation of a EMU will increase the number, n, of unions playing against the monetary authority for **all** countries in the union. For most countries it will also increase the level of conservativeness, c, of the CB. But for a minority of countries, like Germany, it is likely to reduce it.

Since labor mobility across countries in Europe is unlikely to appreciably change (at least not initially) with the formation of the monetary union, the strategic effect of an increase in the number of unions is likely to dominate the enhanced competition effect, making both inflation and unemployment higher. For countries that will experience an increase in CB conservativeness unemployment will go up and inflation will go down because of this additional effect. The upshot is that for countries that will experience an increase in CB conservativeness, the theory presented here implies that unemployment will go up, but the direction of the combined effects on inflation is ambiguous. For Germany and some of its monetary satellites, like the Netherlands, conservativeness may go down. For such countries the changes in conservativeness and in the number of unions will combine to raise inflation. But the sign of the combined effects of a monetary union on unemployment in those countries is ambiguous.

This positive perspective on the effects of EMU is based on the presumption that the

[40] A fact that reinforces our confidence in this explanation is that the peaks of the unemployment CDC implied by the estimated unemployment equation indeed become smaller as CBI increases.

change in the degree of CB conservativeness due to the establishment of a EMU will not be accompanied by a parallel increase in trade unions' inflation aversion. As shown in the previous section, if trade unions' inflation aversion (B) and CB conservativeness (c) move together (for instance because they are both related to the social degree of inflation aversion λ), the unemployment consequences of an increase in CB conservativeness can be different from the ones predicted by propositions 5 and 6. The analysis in this section is based on the presumption that the formation of a EMU will change the degree of CB conservativeness but not the inflation aversion of unions or the structure of the economy. In this case, the establishment of the EMU shifts the CDC upward and gradually transforms it into a monotonic relation (as illustrated in panel a of figure 1). From this perspective, the normative implication of the model is that more decentralization of wage bargaining under a EMU is likely to reduce **both** unemployment and inflation.

An important issue related to the establishment of the EMU, and more generally to the design of monetary institutions, is whether the new regime will, or will not, credibly precommit monetary policy to some nominal target **prior** to the choice of nominal wages by unions. The results derived above are based on the presumption that, even if it is highly conservative, the European Central Bank will retain the discretion to choose monetary policy as it sees fit after wages are set. If, instead, monetary policy is precommitted before wages are set, the wage-moderating effect induced by unions' inflation aversion disappears leading to a higher wage premium, and therefore to higher unemployment. Thus, reduction of inflation by means of precommitment of monetary policy to low inflation carries a cost in terms of unemployment.[41] This suggests that an excessive precommitment of monetary policy instruments, i.e. one that eliminates the CB discretion to retaliate to excessive wage claims by creating inflation, may decrease welfare.[42]

[41] This point was probably first made by Cubitt (1992). He compares the equilibria that are produced by different "rules of the game" (simultaneous moves, government precommitment and union's precommitment) in a game between a single union (who also cares about inflation) and a monetary policy authority. Cubitt's main result is that precommitment of monetary policy is not necessarily welfare improving when the union cares about inflation.

[42] Other costs of policy precommitment include suboptimal stabilization of supply shocks by an independent

10 Concluding Remarks

This paper proposes a conceptual framework that makes it possible to investigate the effects of CBI, of the 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), CBI can only be beneficial since it reduces the inflationary bias without affecting employment. The theory developed here suggests that it also may have a cost in terms of employment. But the empirical evidence on this issue is mixed.[43]

The paper shows that a Calmfors-Driffill hump-shaped relation between real wages, unemployment and inflation, on the one hand, and CWB on the other 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 the 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 choice on the aggregate rate of inflation. Our model can therefore be viewed as a precise characterization of the free rider problem discussed in De Grauwe (1992) but with two differences.[44] First, we explicitly introduce the role of competition in the labor market. Second, we study a world without shocks, while De Grauwe emphasizes the response of wages to exogenous supply

central bank (Rogoff, 1985) and lack of flexibility to optimally adjust policy in the face of unpredicted shifts in policy targets (Lippi, 1998).

[43]Bleaney (1996), who does not control for the interactions between CBI and CWB, finds no effects of CBI on unemployment. Hall and Franzese (1996) as well as this paper detect evidence of a positive correlation between unemployment and CBI at low levels of coordination/centralization of wage bargaining. However we also find that this correlation is negative at intermediate levels of CWB and zero at high levels of CWB.

[44]"[..] 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." (De Grauwe, 1992, p.22).

shocks. As a matter of fact, this issue could be examined more precisely by introducing supply shocks into our framework.

While the model shows that a hump-shaped relation of the CD 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.

The model also qualifies previous literature. Cubitt (1992), for example, simply assumes 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 CWB, but in which their actions are more strongly affected by their inflation aversion the smaller their number. Differentiating between the economic impacts of CWB and those of unions' inflation aversion is important since each of those structural parameters generally may vary independently of the other.

The theoretic predictions of the model are tested empirically using data on nineteen OECD countries over three time periods. For low levels of CBI the evidence identifies a clear hump-shaped relation between unemployment and inflation, on one hand, and between centralization on the other. This relation vanishes at high levels of CBI. This evidence is broadly consistent with the theoretic predictions of our model.

This result may shed light on why the empirical findings of previous studies concerning the existence of a hump-shaped relation have been mixed. Previous studies, for instance OECD (1997) and others (see footnote(25)) did not control for CBI (and for its interactions with the CWB) when looking at the relation between CWB and economic performance. In terms of our theory, this led to the pooling of 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). When CBI is deliberately omitted from the set of explanatory variables, our data replicate the OECD result on the lack of evidence in favor of the hump-shaped relation. But the empirical work in this paper also shows that the hump shaped relation is clearly in evidence when CBI is controlled for. This supports the view that not controlling

for CBI may have prevented OECD from discovering a hump-shaped relation in spite of the fact that it exists at some levels of CBI.

The evidence also shows that the inflation-reducing impact of CBI on inflation is largest when centralization of wage bargaining is at intermediate levels. This is fully consistent with the prediction of our theory. But the evidence regarding the impact of CBI on unemployment yields mixed signals regarding the conformity between theory and evidence. There is a significant and positive effect of CBI on unemployment at low levels of centralization. This supports the theory. On the other hand the evidence also reveals that the same effect is significantly negative at intermediate centralization levels, which contradicts the theory. The paper offers a resolution for this puzzle that is based on the presumption that CBI and unions' inflation aversion are positively correlated across countries in our sample. This resolution also provides theoretical underpinnings for the finding of Hall and Franzese (1996) that unemployment and CBI are positively correlated at low levels of coordination of wage bargaining.

The proposed resolution introduces more flexibility into the interpretation of reality than what appears to be the case from the propositions derived under the assumption that CBI and unions' inflation aversion are unrelated across countries. When this correlation is zero an increase in CBI is expected to always increase unemployment provided unions' inflation aversion is unchanged (and is not zero).[45] But an increase in CBI **does not have to** be associated with an increase in unemployment if it is related to (or caused by) an increase in trade unions' inflation aversion.

Some of the theoretic results of the paper concern the socially optimal level of conservativeness of the central bank. The incorporation of unions' concern for inflation in the model alters the traditional welfare analysis leading to the desirability of a conservative central banker (Rogoff, 1985). It it shown that conventional social welfare is maximized when the CB is ultra-liberal in the sense that it does not care at all about price stability. This, initially

[45] Although the magnitude of this effect will vary across countries with different levels of CWB: it may be large in countries with high centralization and it is likely to be small, or even negligible, in countries with low levels of centralization.

astonishing, result is due to the fact that, when faced with such a bank, unions reduce their wage demands to competitive levels in order to avoid hyperinflation. This totally eliminates unemployment and, with it, the incentive to inflate. But when the welfare of unions is incorporated into the social welfare function, the optimal degree of conservativeness is positive or negative depending on the relative magnitude of the weight given to unions' objectives in the social welfare function.

From a positive perspective, the paper implies that the formation of a EMU may increase inflation in countries that currently have the highest levels of independence and may raise unemployment in the remaining countries. This is true under the assumption that the change in CB conservativeness due to creation of a EMU will not be accompanied by an increase in trade unions' inflation aversion. Given this assumption, an important policy recommendation implied by our model is that accompaniment of EMU by labor market reform towards more competition (decentralization) of wage bargaining is desirable since (for most countries in the union) it reduces undesirable repercussions of the EMU on the rate of unemployment.

We conclude with some qualifications and speculations on future work in this area. In the presence of a **fully** credible exchange rate commitment theoretical considerations suggests that the real effects of money via the moderating effect of inflation aversion on real wages vanish.[46] But, as demonstrated by occasional realignments, such commitments are rarely fully credible although the strength of commitment may vary across countries. This implies that viewing monetary policy as being discretionary is ultimately more realistic than viewing it as being committed. On the other hand it may be useful to examine empirically whether differing degrees of exchange rate commitments across different countries can alter existing empirical results.

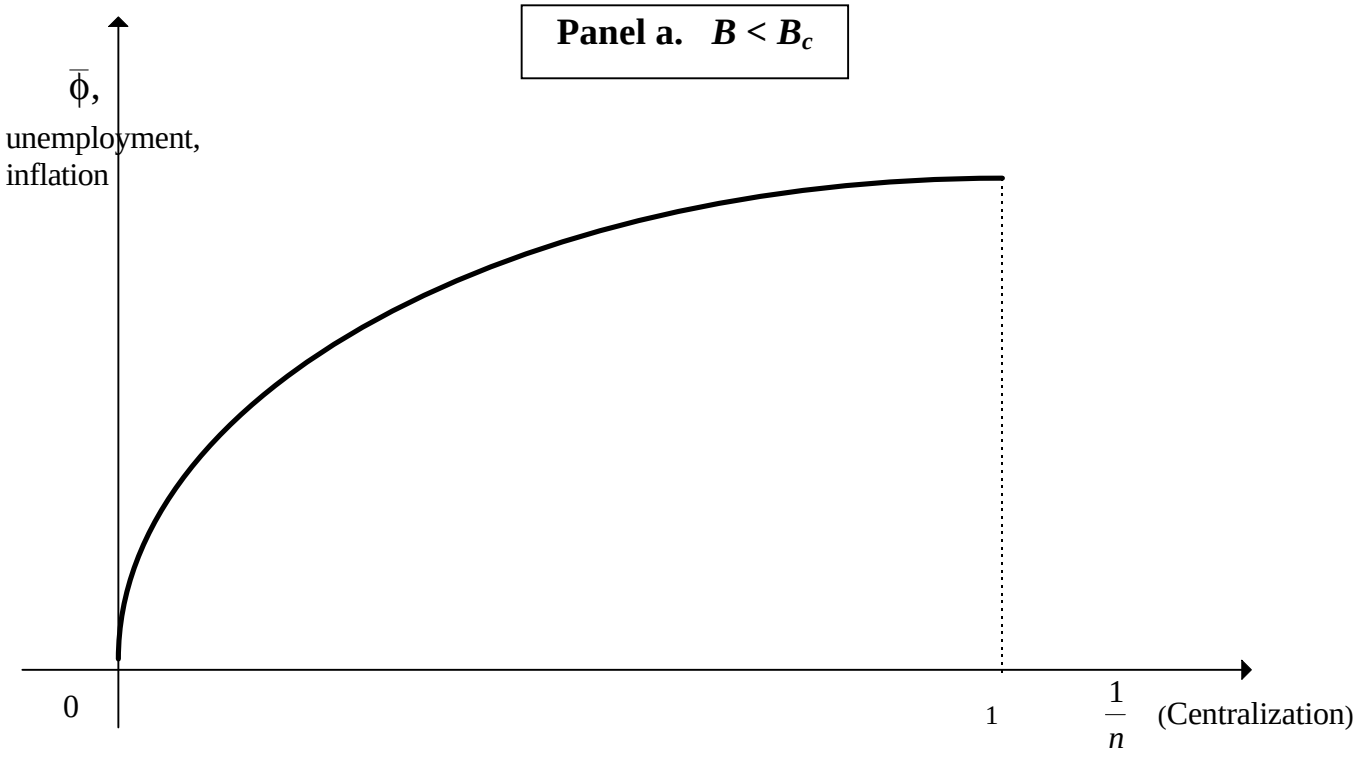
The theoretical part of the paper has assumed, for simplicity, that labor supplies are completely inelastic and that all unions have the same number of members. We also abstracted from the role of credible inflation targets as an alternative to the conservative central banker

[46]This may be one of the reasons that the highly independent Bundesbank retains discretion.

paradigm, from the structure of final goods markets and from open economy considerations.[47] Our hunch is that the main mechanisms illustrated by the analytical framework in this paper will also operate in more general environments or with a different device, like inflation targets, for implementing CBI.

[47]Some related work for open economies has been undertaken by Jensen (1993) and Zervoyianni (1997).

Figure 1:
The effects of centralization on real wages, unemployment and inflation



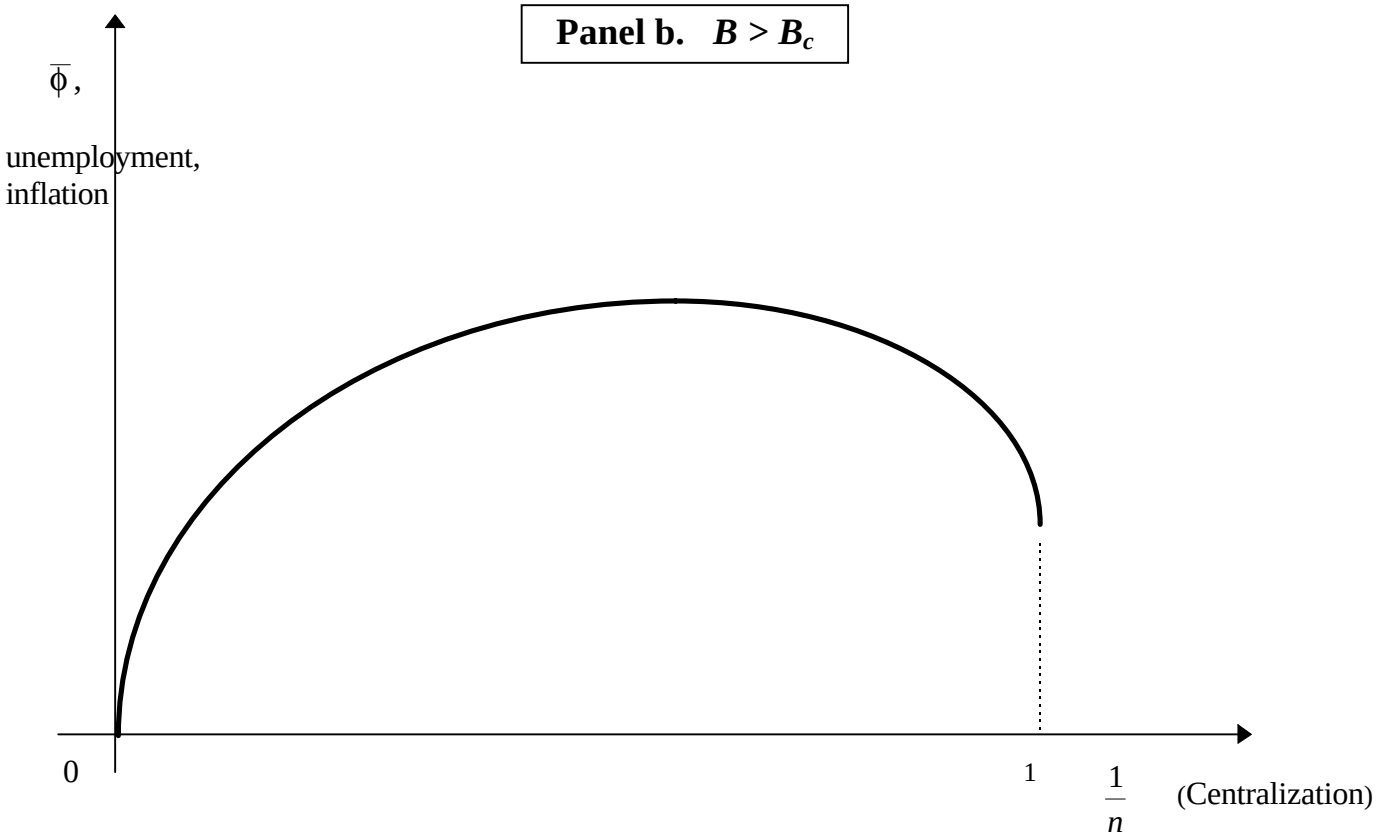
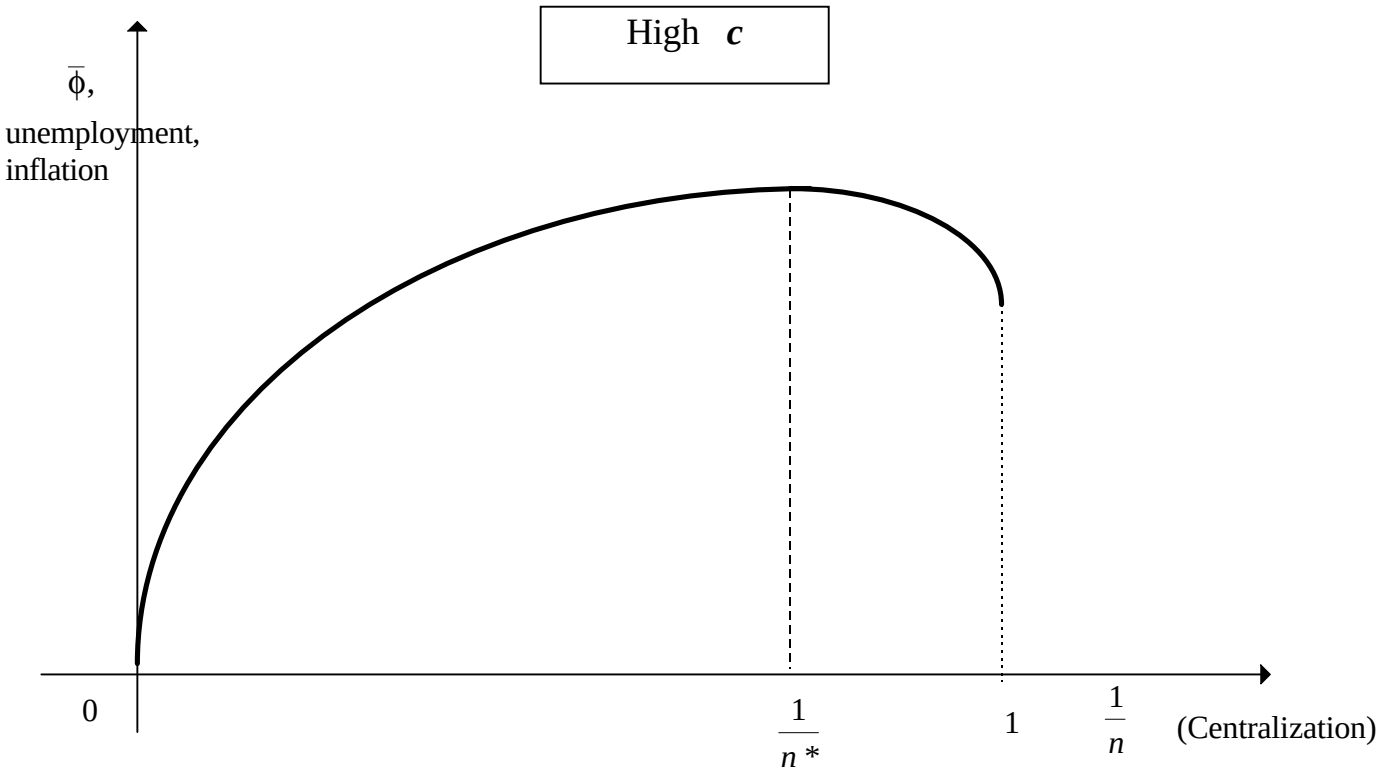


Figure 2:
The effects of central bank independence (c) on the Calmfors-Driffill curve



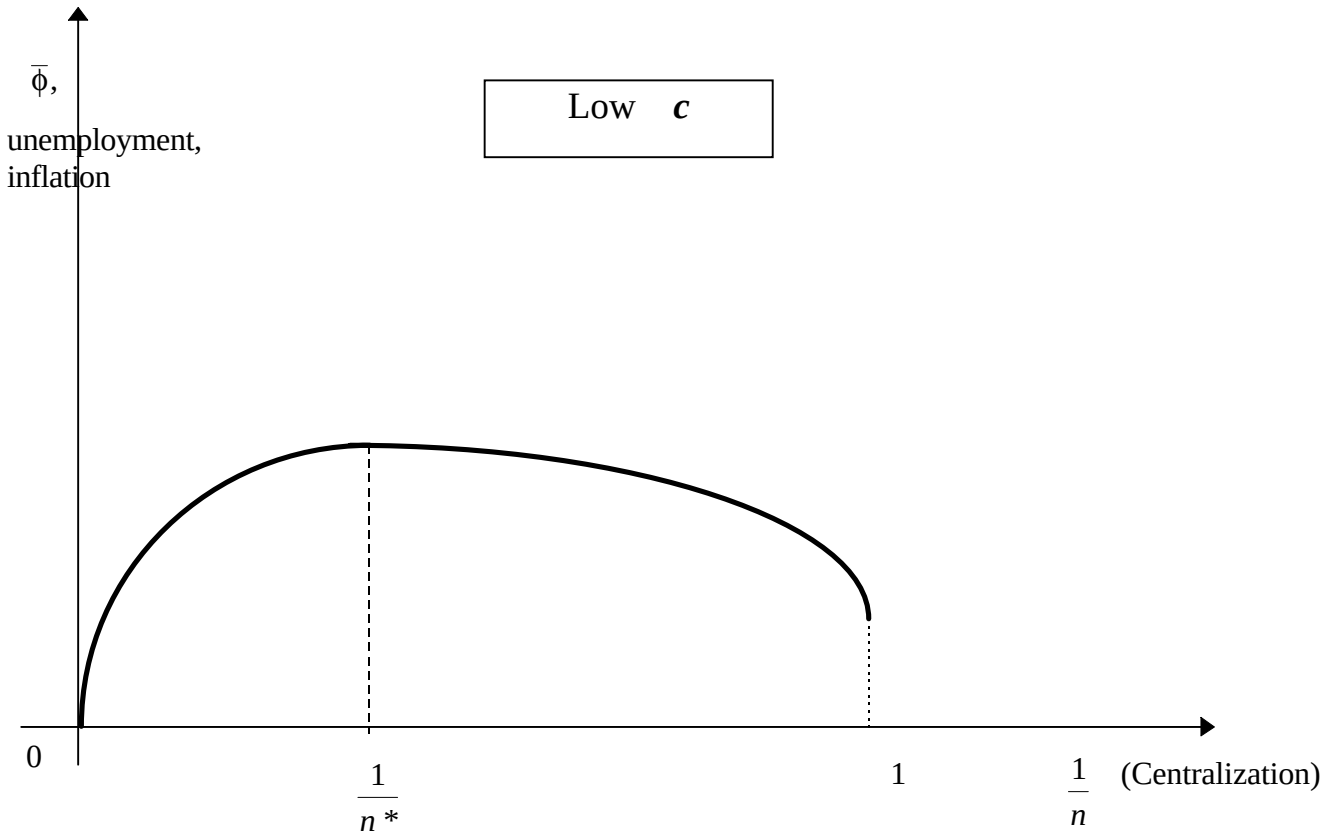


Table 1: **Unemployment Rate**; Pooled Observations from the first, second, and third period (51 observations).

		Centralization			
		Low	***Intermediate***	***High***	
Low-CBI	**Average Unemployment**	**5.9**	**7.5**	**7.4**	**7.1**
	("Filtered")	(-1.5)	(1.3)	(0.8)	(0.5)
	# observ. per cell	*6*	*9*	*12*	*27*
High-CBI	**Average Unemployment**	**8.1**	**6.1**	**5.1**	**6.4**
	("Filtered")	(1.2)	(-0.9)	(-1.6)	(-0.5)
	# observ. per cell	*6*	*13*	*5*	*24*
		7.0	**6.7**	**6.7**	**6.8**
		(-0.2)	(0.0)	(0.1)	(0.0)
		12	*22*	*17*	*51*

Table 2: **Inflation Rate**; Pooled Observations from the first, second, and third period (51 observations).

		Centralization			
		Low	***Intermediate***	***High***	
Low-CBI	**Average Inflation**	**2.6**	**10.1**	**6.4**	**6.8**
	("Filtered")	(-1.6)	(2.5)	(-0.1)	(0.4)
	# observ. per cell	*6*	*9*	*12*	*27*
High-CBI	**Average inflation**	**4.8**	**4.5**	**6.7**	**5.0**
	("Filtered")	(-0.8)	(-0.8)	(0.5)	(-0.5)
	# observ. per cell	*6*	*13*	*5*	*24*
		3.7	**6.8**	**6.5**	**5.9**
		(-1.2)	(0.6)	(0.1)	(0.0)
		12	*22*	*17*	*51*

Table 3: **Unemployment Rate**; Pooled Observations from the first and second period (38 observations).

		Centralization			
		Low	***Intermediate***	***High***	
Low-CBI	**Average Unemployment**	**4.2**	**7.5**	**6.7**	**6.7**
	("Filtered")	(-2.4)	(1.3)	(0.4)	(0.4)
	# observ. per cell	*3*	*9*	*10*	*22*
High-CBI	**Average Unemployment**	**7.7**	**5.2**	**4.9**	**5.8**
	("Filtered")	(1.4)	(-1.1)	(-1.4)	(-0.5)
	# observ. per cell	*4*	*8*	*4*	*16*
		6.2	**6.4**	**6.2**	**6.3**
		(-0.2)	(0.2)	(-0.1)	0.0
		7	*17*	*14*	*38*

Table 4: **Inflation Rate**; Pooled Observations from the first and second period (38 observations).

		Centralization			
		Low	***Intermediate***	***High***	
Low-CBI	**Average inflation**	**3.4**	**10.1**	**7.3**	**7.9**
	("Filtered")	(-3.0)	(2.5)	(0.0)	(0.6)
	# observ. per cell	3	9	10	22
High-CBI	**Average inflation**	**6.2**	**6.0**	**7.6**	**6.5**
	("Filtered")	(-1.1)	(-1.3)	(0.3)	(-0.8)
	# observ. per cell	4	8	4	16
		5.0	**8.1**	**7.4**	**7.3**
		(-1.9)	(0.7)	(0.1)	(0.0)
		7	17	14	38

TABLE 5: UNEMPLOYMENT

Eq Number:	5.1	5.2	5.3	5.4	5.5	5.6
Constant	8.4 (2.2)	-14.4 (-1.5)	-12.3 (-1.4)	-17.0 (-1.5)	-14.5 (-1.6)	-17.5 (-2.1)
dumPer1	-3.0 (-2.3)	-3.4 (-2.8)	-3.6 (-3.3)	-1.9 (-1.8)	-1.8 (-2.1)	-1.9 (-2.2)
dumPer2	-1.3 (-1.0)	-1.5 (-1.3)	-1.8 (-1.7)			
CBI	-4.1 (-1.3)	57.7 (2.4)	55 (2.5)	59.9 (2.1)	56.8 (2.4)	56.7 (2.5)
CEN	1.6 (0.4)	22.5 (2.2)	20 (2.2)	23.8 (2.1)	20.9 (2.2)	25.7 (2.9)
CEN^2	-0.4 (-0.4)	-4.6 (-1.9)	-4.2 (-1.9)	-4.9 (-1.8)	-4.5 (-2.0)	-5.7 (-2.5)
*CBI*CEN*		-54.8 (-2.2)	-51.9 (-2.3)	-57.2 (-2.0)	-54.0 (-2.3)	-52.9 (-2.0)
CBI CEN*^{2}		10.9 (1.8)	10.7 (2.0)	11.4 (1.7)	11.3 (2.0)	11.0 (1.5)
dumEsp			7.8 (3.5)		7.9 (3.9)	7.3 (3.9)
Repl.Ratio						0.1 (2.0)
Lab.Taxation						-0.1 (-1.8)
Adj. R2	0.03	0.16	0.33	0.14	0.41	0.60
# Obs.	51	51	51	38	38	28

Method of estimation: OLS
t-statistics in parentheses

TABLE 6: INFLATION

Eq Number:	6.1	6.2	6.3	6.4	6.5	6.6
Constant	-2.4 (-0.7)	-20.7 (-2.2)	-20.7 (-2.9)	-24.1 (-1.9)	-24.1 (-2.6)	-22.7 (-2.7)
dumPer1	7.4 (6.1)	7.1 (5.9)	6.5 (7.2)	5.0 (4.3)	5.0 (5.9)	4.4 (5.4)
dumPer2	2.2 (1.8)	2.0 (1.7)	1.4 (1.6)			
CBI	-4.3 (-1.5)	45.0 (1.9)	46.7 (2.6)	55.3 (1.7)	57.6 (2.4)	52.1 (2.4)
CEN	6.5 (1.6)	25.5 (2.5)	25.8 (3.4)	31.0 (2.4)	31.0 (3.3)	30.5 (3.5)
CEN^2	-1.5 (-1.5)	-5.8 (-2.4)	-5.9 (-3.3)	-7.0 (-2.2)	-6.9 (-3.1)	-6 (-2.8)
*CBI*CEN*		-49.9 (-2.0)	-51.8 (-2.8)	-60.8 (-1.8)	-63.3 (-2.7)	-47.2 (-1.9)
CBI CEN*^{2}		11.4 (2.0)	11.5 (2.6)	13.7 (1.8)	13.9 (2.5)	8.4 (1.2)
dumPor			10.3 (5.8)		10.5 (5.4)	
Repl.Ratio						-0.1 (-3.1)
Lab.Taxation						-0.1 (-1.3)
Adj. R2	0.50	0.53	0.73	0.39	0.68	0.74
# Obs.	51	51	51	38	38	28

Method of estimation: OLS
t-statistics in parentheses

Table 7: Estimated impact of CEN on Inflation and Unemployment (from equations 5.2 and 6.2)

	$\frac{\partial \pi}{\partial(1/n)}$			$\frac{\partial u}{\partial(1/n)}$		
	Centralization			***Centralization***		
CBI	***Low***	***Int***	***High***	***Low***	***Int***	***High***
0.2	**8.5*** **	**1.4**	**-5.6****	**6.7****	**1.9****	**-3.0**
0.3	**5.8*** **	**1.0**	**-3.8***	**3.4***	**0.7**	**-1.9**
0.4	**3.1**	**0.6**	**-1.9**	**0.1**	**-0.4**	**-0.9**
0.5	**0.4**	**0.2**	**0.0**	**-3.2**	**-1.5***	**0.2**
0.6	**-2.4**	**-0.3**	**1.8**	**-6.5***	**-2.6****	**1.3**

Note: The (bold) numbers in the cells are the values of the partial derivative of inflation (unemployment) with respect to *CEN* implied by equation (35) at different levels of CBI and CEN. From equation (35), the analytical expression for the derivative is equal to: $b+2\,c^{*}\,CEN+\,d^{*}CBI\,+\,2e^{*}CBI^{*}CEN$. One, two or three asterisks indicate that the null hypothesis of the estimated derivative being equal to zero is rejected at the 10%, 5% and 1% level using the Wald test for (linear) restrictions.

Table 8: Estimated impact of CBI on Inflation and Unemployment (from equations 5.2 and 6.2)

	Centralization		
	Low	***Int***	***High***
$\frac{\partial \pi}{\partial c}$	**6.4**	**-9.3****	**-2.2**
$\frac{\partial u}{\partial c}$	**13.8****	**-8.3****	**-8.6**

Note: The (bold) numbers in the cells are the values of the partial derivative of inflation (unemployment) with respect to *CBI* implied by equation (35) at different levels of CEN. From equation (35), the analytical expression for the derivative is equal to: $a+d^{*}CEN+e^{*}CEN^{2}$. One, two or three asterisks indicate that the null hypothesis of the estimated derivative being equal to zero is rejected at the 10%, 5% and 1% level using the Wald test for (linear) restrictions.

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