Monetary Institutions, Monopolistic Competition, Unionized Labor Markets and Economic Performance

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Abstract

Recent literature on the interactions between labor unions and monetary institutions features either a supply or a demand channel of monetary policy, but not both. This leads to two opposing views about the effects of central bank conservativeness. We evaluate the relative merits of those conflicting views by developing a unified framework. We find that: (i) the effect of conservativeness on employment depends on unions' relative aversion to unemployment versus inflation, and (ii) for plausible values of this relative aversion (and more than one union), social welfare is maximized under a highly conservative central bank. We also evaluate the effects of centralization of wage bargaining and product market competition on unemployment and inflation.

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I. Introduction

Does the structure of monetary institutions matter for real economic activity? Conventional wisdom maintains that, in the absence of shocks monetary institutions affect inflation but not the real economy. Recent literature challenges the conventional wisdom by considering the strategic interactions between monetary policymakers and trade unions in the presence of nominal wage contracts. The general conclusion is that, when the labor market is dominated by a small number of unions, the nature of monetary policymaking institutions affects real variables.[1] A central issue addressed by this burgeonning literature is whether a more conservative central bank encourages or discourages economic activity by deterring or by encouraging unions' real wage demands.

The recent literature contains two diametrically opposed views on this issue. The first view, based on a supply side transmission of monetary policy in conjunction with the notion that unions are averse to inflation, concludes that Central Bank (CB) conservatism will *increase* unemployment. The reason is that inflation averse unions are willing to shade their nominal wage demands down somewhat in order to reduce the inflationary response of the CB. The more conservative is the CB, the smaller the inflationary response of the bank and the lower the incentive of unions to shade wages down. As a consequence, unions will go for higher wage demands and unemployment will rise. According to this supply-side view, in the extreme case of a monopoly union, a "populist" central bank that cares only about unemployment is optimal for a society that dislikes both inflation and unemploment; see Skott (1997), Cukierman and Lippi (1999), Guzzo and Velasco (1999, 2002), Lawler (2000) and Lippi (2002).

The second view abstracts from unions' inflation aversion and postulates that monetary policy affects aggregate demand rather than aggregate supply. In this perspective, a conservative CB will *reduce* unemployment. The reason is that a conservative bank will respond to wage increases by reducing the money supply. Consequently, unions will restrain their wage demands to reduce the employment loss among their members; see Bratsiotis and Martin (1999) and Soskice and Iversen (1998, 2000).

[1] A non exaustive list includes Skott (1997), Jensen (1997), Gruner and Hefeker (1999), Cukierman and Lippi (1999, 2001), Guzzo and Velasco (1999), Bratsiotis and Martin (1999), Soskice and Iversen (2000), Lawler (2000), Holden (2003, 2005), Vartiainen (2002) and Lippi (2003). A broad survey of the issues appears in Calmfors (2001).

This paper develops an hybrid framework that nests both views. In particular, our model features a transmission process of monetary policy that operates via *both* aggregate supply and aggregate demand channels. The former is the traditional supply side channel in which, due to predetermined nominal wage contracts, expansionary monetary policy reduces real wages and stimulates employment by creating inflation. The other is the aggregate demand channel that operates by stimulating the demand for goods and therefore the derived demand for labor. An important advantage of this integrated formulation is that it makes it possible to identify the economic effects of the threefold interaction between CB conservativeness, centralization of wage-bargaining and product market imperfections.[2]

Two central result of the paper are; 1. the effect of conservativeness on employment is non monotonic and depends on unions'relative aversion to unemployment versus inflation, 2. when unions care sufficiently more about unemployment among their members than about inflation, an *ultra conservative* CB - which is concerned only with price stability - reduces both inflation and unemployment to their minimal possible levels. This supports the view that the social desirability of a "populist" CB is a rather extreme special case.[3] An important corollary is that the degrees of both real and nominal downward wage rigidity depend on the level of CB conservativeness. This is an instance of the Lucas critique.

The paper is organized as follows. The model and the characterization of equilibrium are presented in section 2. The effects of CB conservativeness, centralization of wage bargaining, and the degree of product competition on inflation and unemployment are discussed in section 3. Section 4 presents the results concerning the socially optimal level of CB conservativeness. Section 5 concludes.

II. The model

The economy is composed of a continuum of monopolistically competitive firms and of n, equally sized, labor unions that organize the entire labor force. The firms are evenly distributed over the unit interval and their mass is one. Thus, each union covers the labor force of a fraction

[2] On the nominal and real effects of labor frictions in Europe, see Galì, Gertler, and Lopez-Salido (2001).

[3] However, *if* workers are inflation-averse, the result that an ultra liberal CB is socially optimal still holds in the case of a *single monopoly* union. Such a possibility is excluded by assumption in Bratsiotis and Martins (1999) and Soskice and Iversen (1998, 2000) since their frameworks abstract from the possibility of inflation aversion on the part of unions.

$1/n$ of the firms. A quantity L_0 of workers, equal across firms, is attached to each firm but works only if the union in charge signs a labor contract with the firm. For convenience, and without loss of generality, the firms are indexed so that all firms whose labor force is represented by union i are located in the contiguous subinterval $(\frac{i}{n}, \frac{i+1}{n})$ of the unit interval, where $i = 0, 1..., n-1$. Each firm owns a production technology that exhibits decreasing returns to scale to labor input, and is given by

$$Y_{ij} = L_{ij}^{\alpha}, \quad \alpha < 1 \tag{1}$$

where Y_{ij} and L_{ij} are output supply and labor input of firm j. The index i means that the labor force of the firm belongs to union i. Each firm faces a demand for its output given by

$$Y_{ij}^{d} = \left(\frac{P_{ij}}{P}\right)^{-\eta} \frac{M}{P}, \quad \eta > 1 \tag{2}$$

where P_{ij} and P are respectively the price of the individual firm and the general price level, M is the aggregate nominal money supply, and η is the (absolute value of the) elasticity of demand facing the individual firm with respect to its relative price. Equation (2) states that the demand facing the individual firm is increasing in real money balances and decreasing in the relative price of its product.[4] The general price level is defined as the integral, over the unit interval, of the (logaritms of) the prices of individual firms. It is convenient, for reasons that will become clearer later, to write it as

$$p = \frac{1}{n} \sum_{i=0}^{n-1} \left(\frac{\int_{\frac{i}{n}}^{\frac{i+1}{n}} p_{ij} \, dj}{\int_{\frac{i}{n}}^{\frac{i+1}{n}} dj} \right) = \sum_{i=0}^{n-1} \int_{\frac{i}{n}}^{\frac{i+1}{n}} p_{ij} \, dj \; = \int_{0}^{1} p_{ij} \, dj. \tag{3}$$

where p_{ij} is the logarithm of P_{ij} and p is the logarithm of P. It suffices to note at this stage that this way of expressing the general price level facilitates the identification of the firms that are affected by an increase in the nominal wage rate set by union i.

Monetary institutions are represented by a CB that dislikes both inflation and unem-

[4]The demand function in equation (2) can be derived from the maximization of a Dixit-Stiglitz consumer's utility: see Blanchard and Kiyotaki (1987). Coricelli, Cukierman and Dalmazzo (2004b) provide a specification in which the CB affects real balances through the choice of the interest rate.

ployment. The CB loss function is given by

$$\Gamma = u^2 + I\pi^2 \tag{4}$$

where u and $\pi \equiv p - p_{-1}$ are respectively the aggregate rate of unemployment and of price inflation. As in Rogoff (1985), the parameter I denotes the degree of CB conservativeness to which we shall occasionally refer as central bank independence (CBI). It measures the relative importance that the CB assigns to the objective of low inflation versus low unemployment. The policy instrument of the CB is the nominal money supply, M.

Each union likes a higher real wage, dislikes unemployment among its members, and dislikes inflation. The individual union's loss function is given, as in Cukierman and Lippi (1999), by

$$\Omega_i = -2w_{ri} + Au_i^2 + B\pi^2 \tag{5}$$

where w_{ri} is the (logarithm) of the real wage of union's i members, u_i is the rate of unemployment among them, A is a positive parameter that measures the relative importance attributed to employment versus the real wage by the union's leadership, and B is a non negative parameter that characterizes the union's degree of inflation aversion. The first two arguments reflect the union's sectoral interest and are standard in the theory of trade unions' behavior: see Oswald (1982). The third reflects the union's aversion to inflation and appears rather often in the recent literature on the strategic interaction between unions and the CB.[5] Although the union cares about the real wage, it directly sets only the nominal wage.

To bring out the strategic interaction between unions and the monetary authority, as well as the effects of their behavior on the pricing strategies of firms, we postulate that monetary policy actions are more flexible than the decisions about the nominal wage made by the unions.[6]

[5] Inflation averse unions have appeared often since the early work of Cubitt (1992). Unions may be inflation averse for various reasons. One is that most pensions are, not indexed. Another is that, due to progressive taxation, inflation pushes labor income into higher tax brackets: see Agell and Ysander (1993). A third reason is that unemployment benefits are usually specified in nominal terms: see Berger, Hefeker, and Schoeb (2004).

[6] Jerger (2002) considers the case in which the CB and unions move simultaneously rather than sequentially. Since monetary policy is adjusted more frequently than nominal contracts, our assumption that unions move first appears to be more plausible.

To focus on the consequences of nominal wage stickiness we assume that product prices are flexible, in the sense that firms can immediately and costlessly adjust their prices to observed changes in monetary policy.[7] These assumptions lead to the following, three-stage, sequence of events.

In the first stage, each union chooses its nominal wage so as to minimize its loss function (5). In doing that, each union takes the *nominal wages* of other unions as given and anticipates the reactions of the monetary authority and of firms to its wage choice. The resulting nominal wages remain contractually fixed for the duration of the game. In the second stage the monetary authority chooses the nominal stock of money so as to minimize its loss function (4). In doing that, the CB takes the preset nominal wages as given and anticipates the reaction of firms both to wages and to its choice of money supply. In the third stage each firm takes the general price level as given and sets its own price so as to maximize its real profit. The resulting string of first order conditions, together with equation (3), simultaneously determine individual prices as well as the general price level. General equilibrium is characterized by backward induction: we start by solving the firms' pricing problem, then the CB problem, and finally we solve for the unions' wage decisions.

Price setting by monopolistically competitive firms

Real profits of an individual firm are given by

$$\Pi_{ij} = \frac{P_{ij}}{P} Y_{ij}^d - \frac{W_i}{P} L_{ij} = \left(\frac{P_{ij}}{P}\right)^{1-\eta} \frac{M}{P} - \frac{W_i}{P} \left[\left(\frac{P_{ij}}{P}\right)^{-\eta} \frac{M}{P}\right]^{\frac{1}{\alpha}} \tag{6}$$

where the second equality is obtained by using (2), the demand facing the individual firm, and (1), the production function. In the third stage of the game, the firm takes P, M and the nominal wage, W_i, as given and chooses its own price, P_{ij}, so as to maximize real profits. Maximizing with respect to P_{ij}, taking logarithms and rearranging yields:

[7] Wages are normally believed to be more sticky than most prices (see, e.g., Friedman (1999)). A recent detailed study of individual price adjustments in Belgium is consistent with this view: see Aucremanne and Dhyne (2004). The case for specifying monetary policy as preceding price setting is perhaps less compelling. Thus, models like those of Bratsiotis and Martin (1999) and Soskice and Iversen (2000), postulate that pricing decisions are taken before the money supply is set. Note however that the equilibrium derived in the paper will arise even when prices are set prior to monetary policy, provided this policy has been precommited prior to price setting, by means of inflation targets or some other transparent and credible commitment device.

$$p_{ij} - p = \theta + \frac{1}{\alpha + \eta(1-\alpha)} \left[\alpha(w_i - p) + (1-\alpha)(m-p)\right] \tag{7}$$

where $\theta \equiv \left[\frac{\alpha}{\alpha+\eta(1-\alpha)}\right] \log \left[\frac{\eta}{\alpha(\eta-1)}\right]$ and lower case letters stand for the logarithms of the corresponding upper case letters. Equation (7) states that the optimal relative price of a typical monopolistically competitive firm is higher the higher the real wage it pays and the higher real money balances. The first element reflects the firm's reaction to labor costs and the second its reaction to the demand for its product. The firm's derived demand for labor can be obtained by equating the product demand (equation (2)) with the firm's supply (equation (1)). Taking logarithms and rearranging yields:

$$l_{ij}^d = \frac{1}{\alpha} \left[-\eta(p_{ij} - p) + (m-p)\right]. \tag{8}$$

Equation (8) states that the individual firm's derived demand for labor is an increasing function of real money balances and a decreasing function of its relative price. Using equation (7) in equation (8), we obtain an alternative form of the firm's demand for labor

$$l_{ij}^d = \kappa + \frac{1}{\alpha + \eta(1-\alpha)} \left[-\eta(w_i - p) + (m-p)\right] \tag{9}$$

where $\kappa \equiv -\frac{\eta\theta}{\alpha}$. This form implies that when the union manages to raise its real wage, the firm's demand for labor goes down unless real money balances increase. This feature of labor demand plays a crucial role in what follows.

Choice of money supply by the CB

The CB picks the money supply in the second stage so as to minimize its loss function (4), after observing nominal wages and anticipating the pricing and employment reaction of the firms to its own choice (as given by equations (7) through (9)). Averaging equation (7) over firms and rearranging, we obtain

$$(m-p) = \rho - \frac{\alpha}{(1-\alpha)}(w-p) \tag{10}$$

where $\rho \equiv \frac{-\alpha}{(1-\alpha)} \log \left[\frac{\eta}{\alpha(\eta-1)}\right]$ and p and w are respectively the logarithms of the average price

and the average nominal wage. Equation (10) states that, in the aggregate, there is an inverse *equilibrium* relation between the average real wage and real money balances. The equilibrium general price level can now be obtained by rearranging equation (10)

$$p = -(1-\alpha)\rho + \alpha w + (1-\alpha)m. \tag{11}$$

Thus, up to a constant that depends on the basic parameters of the economy, the equilibrium price level is a weighted average of nominal wages and of the nominal money supply. Correspondingly, the rate of inflation is given by

$$\pi = p - p_{-1} = -(1-\alpha)\rho + \alpha w + (1-\alpha)m - p_{-1}. \tag{12}$$

We now turn to a characterization of unemployment. By averaging equation (8) over firms and exploiting (3), one obtains the average employment per firm:

$$l^d = \frac{1}{\alpha}(m-p). \tag{13}$$

Since the total mass of firms is one, l^d also coincides with aggregate demand for labor. In contrast with "supply-side" models where the CB picks inflation directly, equation (13) reflects the "flex-price-sticky-wage" Neo Keynesian feature of our model, where monetary policy affects employment not only via supply but also through aggregate demand. Let $l_0 \equiv \log[L_0]$ be the logarithm of labor supply per firm. The average rate of unemployment per firm, as well as the average economy-wide rate of unemployment, are given by

$$u = l_0 - \frac{1}{\alpha}(m-p). \tag{14}$$

Taking the average nominal wage w as given, the CB chooses the nominal stock of money m so as to minimize its loss function. Substituting the expressions for inflation and unemployment (equations (12) and (14)) into equation (4) and rearranging, the CB problem becomes

$$\min_{\{m\}} \left\{ \begin{array}{c} \left[l_0 - m + \frac{1}{\alpha}\left(-\rho(1-\alpha) + \alpha w\right)\right]^2 + \\ +I\ \left[(-\rho(1-\alpha) + \alpha w + (1-\alpha)m) - p_{-1}\right]^2 \end{array} \right\}. \tag{15}$$

This yields a reaction function for the CB in which the money supply is a linear function of the average nominal wage:

$$m = \mu + \frac{1 - \alpha(1-\alpha)I}{1 + (1-\alpha)^2 I}\, w, \tag{16}$$

where $\mu \equiv \frac{l_0 - \frac{\rho(1-\alpha)}{\alpha} + [\rho(1-\alpha) + p_{-1}](1-\alpha)I}{1+(1-\alpha)^2 I}$. Depending on the degree of CB conservativeness (or independence) I, the CB either counteracts or accommodates an increase in nominal wages. If the CB is sufficiently conservative, in the sense that $1 - \alpha(1-\alpha)\ I < 0$, a nominal wage increase will trigger a tightening of the money supply. Conversely, if the CB is relatively liberal, in the sense that $1 - \alpha(1-\alpha)\ I > 0$, it will partially accommodate wage increases.

The intuition underlying this result is as follows. Firms respond to an increase in nominal wages by increasing their prices. This raises the rate of inflation and, for a given nominal money supply, reduces real money balances. The second effect reduces the derived demand for labor and pushes unemployment up. Consequently, in the absence of any reaction by the CB, an increase in the average level of nominal wages raises both inflation and unemployment. The response of the CB is designed to optimally spread the costs of those two "bads" between the two components of its loss function. If it cares relatively more about price stability, the CB partially counteracts the effect of wage increases on inflation at the cost of even higher unemployment. If it cares relatively more about unemployment, the CB partially counteracts the adverse effect of higher wages on unemployment at the cost of even higher inflation.

Thus, in countries with a highly independent CB, the monetary authority leans against inflationary wage increases by contracting money growth in response to wage inflation. Casual evidence about the industrial organization of labor negotiations in Germany as well as recent empirical evidence concerning monetary policy reaction functions supports the theoretical discussion above. Studies on industrial relations in Germany like Berghan and Detlev (1987) and Streek (1994) report that the Bundesbank often threatened to tighten monetary policy in response to excessive wage settlements. Hall (1994, p.12) and Hall and Franzese Jr. (1998) note that, due to the high level of independence of the Bundesbank, labor unions usually took this threat seriously but that, from time to time, the German CB actually tightened monetary policy in response to high wage settlements in order to maintain its credibility. This view is

corroborated by empirical evidence in Cukierman, Rodriguez and Webb (1998).[8]

Choice of wages by unions

In the first stage of the game each union takes nominal wages set by other unions as given and chooses its own nominal wage so as to minimize its losses, given by equation (5). In doing so, each union takes into consideration the consequences of its wage policy for the prices that will be subsequently set by firms, as well as the response of the CB in equation (16).

Let w_i and w_{-i} be respectively the nominal wage of union i and the average nominal wage of all other unions. Taking w_{-i} as given, union i sets a common wage w_i for all its members, which are all the workers attached to firms in the interval $[\frac{i}{n}, \frac{i+1}{n}]$. The relevant average rate of unemployment per firm is given by the difference between the number of workers attached to each firm and the average labor demand for a firm represented by union i:

$$u_i = l_0 - \left\{ \frac{\int_{i/n}^{(i+1)/n} l_{ij}^d \, dj}{\int_{i/n}^{(i+1)/n} dj} \right\} = l_0 - l_{ij}^d. \tag{17}$$

From equation (8), labor demand l_{ij}^d of firm j in the interval $[\frac{i}{n}, \frac{i+1}{n}]$ is a function of aggregate real money balances and of its relative price. Since all firms in the interval $[\frac{i}{n}, \frac{i+1}{n}]$ face a common nominal wage w_i, equation (7) implies that $p_{ij} = p_i$ for all $j \in [\frac{i}{n}, \frac{i+1}{n}]$. Consequently, union i anticipates that all the firms employing its members will react to a common wage level by setting the *same* relative price for their products. Thus, equation (17) can be rewritten as:

$$u_i = l_0 + \frac{1}{\alpha} \left[\eta \left(p_i - p \right) - \left(m - p \right) \right]. \tag{18}$$

Note that u_i is also equal to the unemployment *rate* among union i's members. Minimizing the loss function in equation (5) with respect to the nominal wage w_i subject to equation (12) and (18) yields the following first order condition

[8] Cukierman, Rodriguez and Webb (1998) estimate of the degree of monetary accommodation (characterized by the reaction of high powered money growth to wage inflation) in a group of developed economies between the mid-seventies and the beginning of the nineties. They find that in countries with low CBI the coefficient of accommodation tends to be significantly positive; in countries with intermediate levels of CBI it is insignificantly different from zero; and in high CBI countries like Germany it is significantly negative. More generally Table 4.4 in that paper shows that the degree of accomodation, as measured by the reaction of high powered money to nominal wage increases (adjusted for significance) is a decreasing function of CBI.

$$-\left[1-\frac{dp}{dw_i}\right]+A\ u_i\ \frac{du_i}{dw_i}+B\,\pi\,\frac{dp}{dw_i}=0 \tag{19}$$

This condition holds for all unions ($i=1,..,n$). This system of n first order conditions implies that the equilibrium is *symmetric in both prices and wages*, that is, $w_i = w$ and $p_{ij} = p_i = p$ (see Appendix for a proof). To emphasize the impact of monopolistic unions on equilibrium outcomes, we express the (symmetric) solution to the unions' game in terms of the wage premium ϕ, defined as the difference between the common real wage of each union, w_r, and the competitive real wage, $w_r^c = -(1-\alpha)l_0 + \frac{1-\alpha}{\alpha}\rho$ (see the Appendix). The equilibrium premium is given by

$$\phi \equiv w_r - w_r^c = \frac{(1-\alpha)^2 I Z_w}{(1-\alpha)AIZ_u + B(1-Z_w)} \tag{20}$$

where

$$1-\frac{dp}{dw_i} \equiv Z_w = 1-\frac{1}{n\left[1+(1-\alpha)^2 I\right]} > 0 \tag{21}$$

and

$$-\frac{dl_{ij}^d}{dw_i} = \frac{du_i}{dw_i} \equiv Z_u = \frac{1}{\alpha}\left[\eta\frac{d(p_i-p)}{dw_i} - \frac{d(m-p)}{dw_i}\right] = \frac{1}{n}\left[\frac{\eta(n-1)}{\alpha+\eta(1-\alpha)} + \frac{(1-\alpha)I}{1+(1-\alpha)^2 I}\right] > 0. \tag{22}$$

Notice that the wage premium is always non negative and that it increases with Z_w and decreases with Z_u and B. Z_w is the overall elasticity of the union's *real* wage with respect to the nominal wage. Z_u is the (absolute value of) the overall elasticity of employment (and of unemployment) among union members with respect to the union's nominal wage. The overall elasticities, Z_w and Z_u, internalize the subsequent reactions of monetary policy and of prices to union i's wage decision.

The expression for Z_u contains the central parameters of the model (n, η, I). Note first that Z_u is larger the higher the centralization of wage bargaining (the lower n). Further, for any given n, the marginal impact of a nominal wage increase on the union's unemployment is composed of two effects: a *relative price* effect, and a *real balance* effect; see equation (8). The relative price effect works through goods substitution. When a union raises its nominal wage, it

anticipates that the firms employing its labor will increase their prices relative to competitors, and experience a reduction in product demand. Consequently, the union anticipates that the demand for its labor will fall. This effect is captured by the first term in brackets in each of the expressions in equation (22). Not surprisingly, the size of this effect depends on the parameter η, characterizing the degree of substitutability among consumption goods. The larger η, the larger the substitutability between products of different firms and, thus, the larger the substitutability between the labor of different unions.

The real balance effect is given by the second terms in brackets in equation (22), and captures the marginal impact on the union's labor demand of a higher nominal wage through lower real money balances. The decrease in money balances due to a higher wage-level is generated both by an increase in the price-level, and by the monetary policy response which, as shown above, may be either positive or negative depending on the level of CBI. But the combined impact of those two components on real balances turns out to always be negative. The reason is that, as we saw in the previous subsection, an increase in the union's nominal wage raises on impact both inflation and unemployment. Except for the extreme case of an ultra liberal CB, the bank's optimal response to those two "bads" is to equate at the margin the cost of inflation to the cost of unemployment. Consequently, the CB will not raise nominal balances by the full amount required to restore real balances to their pre nominal wage increase.[9] For, if it had done so the marginal cost of inflation would have exceeded the marginal cost of unemployment. Hence, the overall effect of an increase in the nominal wage on employment via the real balance effect is always negative too. Furthermore, the size of this effect is higher the higher is CBI, as denoted by I. This fact plays an important role in what follows.

The overall rate of unemployment, u, and the aggregate price level, p, can be expressed as simple functions of the wage premium. From equations (14) and (10), the equilibrium rate of unemployment is

$$u = \frac{1}{1-\alpha}\ \phi \tag{23}$$

[9] This can be demonstrated more formally by means of equations (12) and (16). Those equations imply that, when $I = 0$, the money supply is adjusted by the full amount of the wage increase so that real money balances remain unaltered. For any $I > 0$, the rate of increase in nominal balances is lower than the rate of increase in the nominal wage, implying that inflation rises by less than the nominal wage so that real balances go down.

Using the CB reaction function (equation (16)) in equation (12), and rearranging, the equilibrium rate of inflation can be expressed as

$$\pi = p - p_{-1} = \frac{1}{(1-\alpha)^2 I}\phi. \tag{24}$$

III. The effects of CBI, centralization of wage bargaining and the degree of product differentiation on economic performance

We now investigate how the wage premium, unemployment and inflation are affected by: *(i)* CBI, as characterized by I, *(ii)* the degree of decentralization of wage bargaining, as characterized by n, and *(iii)* the degree of product differentiation, as characterized by η.

CBI and economic performance

A quick look at equations (20) through (22) reveals that I affects the bargaining power of the union, and therefore the equilibrium wage premium. The direction of this effect depends on the aversion of the union to inflation in comparison to its aversion to unemployment among the union's members. The following proposition shows that when unions' inflation aversion, B, is small relative to its unemployment aversion, A, the wage premium, the rate of unemployment, and inflation are all lower the higher the degree of CB conservativeness (or CBI), I.

Proposition 1 *A necessary and sufficient condition for*

$$\frac{d\phi}{dI} < 0,\ \frac{du}{dI} < 0,\ \frac{d\pi}{dI} < 0$$

is

$$\frac{B}{A} < \left(\frac{B}{A}\right)_c \equiv \frac{\alpha(1-\alpha)^2(n-1)I^2}{[\alpha+\eta(1-\alpha)]\left[(n-1)+2n(1-\alpha)^2 I\right]}.$$

The proof of the Proposition involves straightforward, but tedious, calculations (details appear in the appendix of Coricelli, Cukierman and Dalmazzo (2004a)). In words, the proposition states that the real wage premium, unemployment and inflation are all lower the more conservative the CB, if and only if, the relative aversion of the union to inflation and to unemployment among its members is below some threshold. The intuition underlying this condition follows. An increase

in the degree of CB conservativeness triggers two opposing effects on the wage premium. These effects are generated by "inflation aversion" and by "unemployment aversion" on the part of unions. On one hand, a more conservative CB reduces the unions' concerns for price-inflation, inducing more wage aggressiveness.[10] On the other hand, a more conservative CB favors wage moderation on the part of unions, since a conservative CB provides little accomodation of wage increases and may even tighten the money supply in response to wage pressure, generating higher unemployment. In effect, as a by-product of its worry for price stability, a conservative CB is expected to punish higher wages by raising unemployment. Thus, the deterrence exerted on unions through their aversion to unemployment is stronger when the CB is more conservative.[11]

When the condition $\frac{B}{A} < \left(\frac{B}{A}\right)_c$ is satisfied, an increase in I raises unions' fear from unemployment by more than it alleviates their inflationary fears to an extent that induces them to set lower real, as well as nominal, wages. This implies that a higher level of CBI is conducive to less inflation, as well as to lower unemployment**.** It is possible to obtain a wider perspective on the mechanism underlying proposition 1 by using the dependence of the critical value, $\left(\frac{B}{A}\right)_c$, on conservativeness to reformulate the condition in the proposition also in terms of I. This leads to the following corollary to proposition 1.

Proposition 2 *: An increase in the degree of central bank conservativeness, I, induces a reduction or an increase in the wage premium, ϕ, depending on whether I is larger or smaller than a non negative critical value, I_c. This critical value is an increasing function of $\frac{B}{A}$.*

The proof and the explicit form of I_c appear in Coricelli, Cukierman and Dalmazzo (2004a). The proposition implies that the equilibrium wage premium is an inverted-U function of the level of CB conservativeness. When the CB is more liberal than I_c the deterring effect of monetary institutions on real wage demands is dominated by unions' aversion to inflation. In this range an increase in conservativeness induces an increase in the wage premium. When the CB

[10] As in Cukierman and Lippi (1999) this happens for two reasons. First a stronger anti-inflationary stance on the part of the CB means that a unit increase in the nominal wage translates into a larger increase in the real wage (Z_w is higher). Second, an increase in CB conservativeness reduces the inflationary cost of a given nominal wage increase for inflation-averse unions ($B > 0$).

[11] A similar conclusion appears in both Bratsiotis and Martin (1999) and Soskice and Iversen (2000). However, since they postulate an exogenously given monetary policy rule, these papers do not shed light on the relation between the rule and CB preferences. Additional discussion appears in Coricelli, Cukierman and Dalmazzo (2004a).

is more conservative than I_c the deterring effect is dominated by unions' fear of unemployment among their members. In this range, a further increase in conservativeness reduces the wage premium.

Intuitively, when I is sufficiently low in comparison to $\frac{B}{A}$ the central bank's relative aversion to inflation in comparison to unemployment is low in comparison to the union's relative aversion to those two "bads" implying that the dominant deterring effect is due to unions' inflation aversion. Consequently, an increase in I, by weakening the dominant deterring effect, raises the wage premium in this range. Conversely, when I is sufficiently large in comparison to $\frac{B}{A}$ the dominant deterring effect operates via unions' aversion to unemployment. As a consequence, a further increase in conservativeness, by strenghening the dominant deterring effect, reduces the wage premium.

The proposition also implies that, the lower the relative aversion of unions to inflation $(\frac{B}{A})$ the lower is the critical value, I_c, and the wider, therefore, the range of values of I for which an increase in CB conservativeness reduces the wage premium. In the extreme case in which unions are not averse to inflation at all $(B = 0)$, $I_c = 0$ and the real wage premium is decreasing in conservativeness for all positive values of I.

Centralization of wage bargaining and economic performance

The following proposition characterizes the relation between economic performance and decentralization in wage-setting.

Proposition 3 *The wage premium, the rate of unemployment and inflation are all increasing in the degree of decentralization of the labor market, as measured by the number of unions, n.*

The proof appears in the appendix of Coricelli, Cukierman and Dalmazzo (2004a).[12] The unambiguous result in proposition 3 is the total outcome of a number of effects some of which operate in opposite directions.[13] In order to understand the various channels through which

[12] In the extreme cases $n = 1$ and $n \to \infty$ the wage premium is given respectively by $\phi(n = 1) = \frac{(1-\alpha)^4 I^2}{(1-\alpha)^2 I^2 A + B}$ and by $\phi(n \to \infty) = \frac{1-\alpha}{A} \frac{\alpha+\eta(1-\alpha)}{\eta}$. Simple algebra verifies that $\phi(n \to \infty) > \phi(n = 1)$ as implied by the proposition.

[13] Bratsiotis and Martin (1999, p.253) also find conflicting effects of centralization, and conclude that centralization is more likely to lead to lower wages and unemployment when the CB is sufficiently conservative.

decentralization affects the wage premium, we examine the effect of n on Z_w and Z_u, defined in Section 2.3. An increase in n unambiguously raises Z_w, leading to a *higher* wage premium. When the labor market is highly decentralized (n large), the increase in the nominal wage of a typical union has a small impact on the aggregate price level p. Thus, the marginal gain to the union in terms of real wage is relatively large. However, the impact of an increase in n on Z_u is ambiguous in general, as the relative price effect and the generalized real balance effect react in opposite direction to changes in n. An increase in n raises Z_u through the *relative price effect*, and tends to *reduce* the wage premium. This reflects the fact that when the fraction $1/n$ of firms affected by an adverse price change is small, competition is stronger because consumers find it easier to shift their demand towards goods produced by firms whose unions did not raise wages. The second component of Z_u captures the impact of the generalized *real balance effect* on firms' labor demand. When n is large, each union perceives that an increase in its nominal wages has a negligible effect on the *aggregate* wage level w, which eventually determines the magnitude of the reaction by the CB. Therefore, an increase in n tends now to *increase* the wage premium, since unions internalize the adverse effects of a nominal wage increase to a lesser extent.

Proposition 3 states that, although the competition effect of more decentralization operates in the model, it is dominated by the strategic effects. Thus, the present model does not generate the "hump-shaped" relation between unemployment and labor market centralization stressed by Calmfors and Driffill (1988), and more recently by Cukierman and Lippi (1999). This feature obviously depends on the particular structure of the model. However, the result in proposition 3 is consistent with empirical evidence suggesting that countries with a high degree of coordination in wage setting have lower unemployment (Nickell (1997), OECD (1997) and Nickell (1999)).

The effects of the degree of product substitutability on economic performance

The degree of product substitutability is characterized by the relative price elasticity, η, of the demand for goods. The larger this elasticity, the larger competition in product markets.

Proposition 4 *The wage premium, the rate of unemployment and inflation are all decreasing in the relative price-elasticity of the demand for goods, η.*

The proof appears in the appendix to Coricelli, Cukierman and Dalmazzo (2004a). The intuition

for this result is simple. A larger η raises the size of the relative price effect generated by an increase in the nominal wage (this effect is contained in Z_u), and thus the employment loss.[14] More competitive product markets translate, via the derived demands for labor, into more competitive labor markets. Interestingly, interpreting the wage premium as a measure of real wage rigidity, it follows that higher market power in the goods market, as characterized by low values of η, induce downward real wage rigidities in the labor market. This implication is consistent with findings reported in Nickell (1999). After considering several studies on the relation between wages and the degree of imperfect competition on product markets, Nickell concludes that there is evidence supporting the view that the real wage of unionized firms is higher in sectors with more market power. For related evidence on European countries, see also Koedijk and Kremers (1996).

IV. The socially optimal level of conservativeness

Ever since Rogoff (1985), the idea that it is socially optimal to appoint a central banker that is more conservative than society constituted a basic benchmark in discussions of the optimal design of monetary institutions. In the absence of shocks, Rogoff's framework implies that the optimal level of conservativeness is infinite. Thus, the CB should care only about price stability. By contrast, Skott (1997), Cukierman and Lippi (1999), Guzzo and Velasco (1999), as corrected by Lippi (2002), and Lawler (2000) have recently shown that in the presence of an inflation averse monopoly union the socially optimal level of CB conservativeness is zero (the "populist CB" view in the sequel). Those frameworks abstract from the aggregate demand transmission channels of monetary policy. On the other hand, Bratsiotis and Martin (1999) and Soskice and Iversen (1998, 2000), while abstracting from the inflation fears of unions, incorporate the aggregate demand channel and conclude that a non accommodating CB brings about a better macroeconomic performance. Having established the relation between the relative aversion of unions to inflation/unemployment and the impact of conservativeness on one hand and the relation between conservativeness and accommodationon on the other, we are now in a position to shed some new light on those opposing views. Following Rogoff and others let the social loss

[14] Note that even when the goods' market is perfectly competitive ($\eta \to \infty$) the wage premium remains strictly positive. The reason is that, even in this case, monopolistic unions possess the power to set wages above the competitive level.

function be

$$\Lambda = u^2 + S\ \pi^2 \tag{25}$$

where $S \in (0, \infty)$ represents society's relative aversion to inflation, that may generally differ from the relative inflation aversion of the CB, I. The main issue then is the following: If society delegates the conduct of monetary policy to a central banker, what is the level of CB conservativeness (or inflation aversion) that is optimal for a society with relative inflation aversion S? Inserting the equilibrium expressions for u and π from equations (23) and (24) into equation (25) this problem is equivalent to minimization of the following expression with respect to I,

$$\Lambda(I) = \left(\frac{\phi(I)}{1-\alpha}\right)^2 + S\left(\frac{\phi(I)}{(1-\alpha)^2 I}\right)^2 \tag{26}$$

where $\phi(I)$ is given by equation (20). Thus, social losses depend on central bank conservativeness directly, as well as through the effect that conservativeness has on the wage premium, $\phi(I)$. Note first, that when unions do not care about inflation ($B = 0$) an ultra conservative central banker is socially optimal.[15] The intuition underlying this result is simple. When unions are averse only to unemployment, an extremely conservative CB has a maximal moderating effect on unions' real wage demands. This in turn implies that, under such a central banker, unemployment and inflation will be at their lowest levels. No matter how strong is the inflation aversion of society, it therefore pays to appoint an "ultra conservative" central banker.

We turn next to the more general case where the relative inflation aversion of unions is *strictly positive* but moderate; i.e., $\frac{B}{A}$ is strictly positive but not too large. The following proposition provides some overly strong conditions for an ultra conservative CB to be socially optimal when there is more than one union.[16]

Proposition 5 *: (i) If*

[15] This follows from proposition 1 which, for $B = 0$, implies that the wage premium is a decreasing function of I in the entire economically meaningful range of I. Hence social losses are minimized when the CB is ultra conservative ($I \to \infty$).

[16] With a single inflation-averse union (i.e., $n = 1$ and $B > 0$), the wage-premium is equal to $\frac{(1-\alpha)^4 I^2}{(1-\alpha)^2 I^2 A + B}$, and the social optimum is attained by an ultra liberal central banker ($I = 0$). This conclusion crucially depends on the presence of some inflation aversion ($B > 0$). See also next footnote.

$$\frac{B}{A} < Min\left\{S\left(1-\frac{\alpha}{2}\right), \frac{1}{2(1-\alpha)}\right\}$$

the social optimum problem does ***not*** *have an internal solution.*

(ii) If there is more than one union, the condition in part (i) is satisfied, and if

$$\frac{B}{A} < \frac{2-\alpha}{2(1-\alpha)}\sqrt{S}$$

an ultra conservative CB is socially optimal.

Proof. See Appendix. ■

Proposition 5 states that if the inflation aversion of unions is sufficiently small in comparison to their aversion to unemployment an ultra conservative central banker maximizes social welfare. For the standard case in which the parameter α is equal to 2/3, the conditions in the proposition reduce to $\frac{B}{A} < \min\left\{\frac{2}{3}S, \frac{3}{2}, 2\sqrt{S}\right\}$. Since unions are normally more concerned about unemployment than about inflation, this condition is likely to be satisfied in reality (see Calmfors (2001) for a discussion).

Thus, for the case of more than one union, an ultra conservative central banker is socially optimal unless $\frac{B}{A}$ is implausibly large. It follows that the optimality of the populist CB is very likely to be the exception rather than the rule.[17] One reason for those different conclusions is that the populist CB view is derived within frameworks that abstract from the aggregate demand channel of monetary policy. As a consequence the deterring effects of contractionary monetary policies designed to reduce wage driven inflations are neglected. Since such contractionary policies reduce the demand for labor, unions moderate their wage demands mainly because of fear of unemployment among their members, rather than because of their inflationary fears. Bratsiotis and Martin (1999) and Soskice and Iversen (1998, 2000) recognize this effect but, since they abstract from the inflation aversion of unions, their frameworks are not sufficient to settle the issue.

[17] Guzzo and Velasco (1999) have claimed that a populist central banker is socially optimal at **all** levels of centralization of wage bargaining. But this is due to their implicit assumption that wages are contracted in real terms. As shown by Lippi (2002), and recognized in Guzzo and Velasco (2002), when wages are contracted in nominal terms their model implies, as do the other models, that a populist CB is socially optimal provided there is a *single* monopoly union.

A somewhat more general lesson from this section is that deterrence of real wage claims by the CB is most effective when the relative aversion of the CB to unemployment versus inflation is biased in a direction opposite to that of labor unions.

V. Concluding remarks

This paper proposes a general equilibrium framework with endogenous monetary policy that characterizes the effects of CB conservativeness, product market differentiation, and the degree of centralization of wage bargaining on wages, employment and inflation. Unlike most of the literature on strategic monetary policy our framework features *both* aggregate supply and aggregate demand transmission channels of monetary policy.

Some of the main results follow. First, the degree of monetary accommodation in response to nominal wage inceases depends on CB conservativeness. The more conservative the CB the less accommodative it is. Second, a sufficiently conservative CB *reduces* money growth in response to nominal wage inflation. Third, the relation between unemployment and CB conservativeness is positive at low levels and negative at high levels of conservativeness. Fourth, when unions' aversion to unemployment is sufficiently larger than their inflation aversion, an ultra conservative CB is socially optimal.[18] This result supports the "conservative CB" paradigm, pioneered by Rogoff (1985), and sheds additional light on the recent debate on the optimal degree of CB conservativeness with non atomistic wage setters by showing that the "populist CB" result is a rather special extreme case.[19]

An interesting question concerns the robustness of our results to a modification in which some of the unions are leaders and others are followers with respect to wage setting. Although such an analysis is beyond the scope of this paper our gut feeling is that such a modification should lead to broad outcomes that are similar to those in this paper but with a smaller number of unions. This is based on the intuitive argument that, when some unions are followers, the number of fully independent wage setting unions is smaller.

A general lesson from the paper is that the extent of downward real wage rigidity depends

[18] This abstracts from the existence of shocks and stabilization policy.

[19] Recently, Berger et. al. (2002) provide additional support for this general position by showing that, when the government can choose the levels of both nominal unemployment benefits as well as the degree of CB conservativeness it always pays to make the CB more conservative than society. The option to index wages further weakens the case for a liberal CB: see Liviatan (2002).

on the nature of monetary institutions.[20] For plausible values of unions' relative aversion to unemployment and inflation, a high level of CB conservativeness reduces downward real and nominal wage rigidity, making wages closer to their market clearing level. This is an instance of the Lucas critique.

Appendix

Derivation of equilibrium wages

Differentiating equation (16) with respect to the nominal wage of union i

$$\frac{dm}{dw_i} = \frac{1-\alpha(1-\alpha)I}{n\left[1+(1-\alpha)^2 I\right]} \tag{A1}$$

where use has been made of the fact that $w = \frac{1}{n}w_i + \frac{n-1}{n}w_{-i}$. Differentiating (11) with respect to w_i and using the last relation yields:

$$\frac{dp}{dw_i} = (1-\alpha)\frac{dm}{dw_i} + \alpha\frac{dw}{dw_i} = \frac{1}{n\left[1+(1-\alpha)^2 I\right]}. \tag{A2}$$

>From equation (10) one obtains

$$\frac{d(m-p)}{dw_i} = -\frac{\alpha}{(1-\alpha)}\frac{d(w-p)}{dw_i}. \tag{A3}$$

Differentiating (7) with respect to w_i and using the previous expression yields:

$$\frac{d(p_{ij}-p_i)}{dw_i} = \frac{\alpha}{\alpha+\eta(1-\alpha)}\left[1-\frac{dp}{dw_i}-\frac{d(w-p)}{dw_i}\right]. \tag{A4}$$

Using $w = \frac{1}{n}w_i + \frac{n-1}{n}w_{-i}$ and equation (A2)

$$\frac{d(w-p)}{dw_i} = \frac{(1-\alpha)^2 I}{n\left[1+(1-\alpha)^2 I\right]}. \tag{A5}$$

Substituting (A2) and (A5) into (A4) and rearranging yields

[20] A disclaimer is in order here. Although the paper provides an explanation for downward rigidities in both real and nominal wages it does not attempt to provide an explanation for the existence of sticky, often contractually fixed, nominal wages.

$$\frac{d(p_{ij}-p)}{dw_i}=\left(\frac{n-1}{n}\right)\frac{\alpha}{\alpha+\eta(1-\alpha)} \tag{A6}$$

Differentiating equation (10) with respect to w_i, using (A5), and rearranging yields

$$\frac{d(m-p)}{dw_i}=\frac{-\alpha(1-\alpha)I}{n\left[1+(1-\alpha)^2I\right]}. \tag{A7}$$

Differentiating (18) with respect to w_i, using equations (A6) and (A7), and rearranging yields:

$$\frac{du_i}{dw_i}=\frac{1}{n}\left[\frac{\eta(n-1)}{\alpha+\eta(1-\alpha)}+\frac{(1-\alpha)I}{\left[1+(1-\alpha)^2I\right]}\right]. \tag{A8}$$

Using (A2) and (A8) in equation (19), the first order condition of union i can be rewritten as:

$$-Z_w+A\underbrace{\left\{l_0+\frac{1}{\alpha}\left[\eta(p_i-p)-(m-p)\right]\right\}}_{u_i}Z_u+B\,\pi\,(1-Z_w)=0 \tag{A9}$$

where $Z_w\equiv 1-\frac{1}{n[1+(1-\alpha)^2I]}$, $Z_u\equiv\left[\frac{\eta}{D}\frac{n-1}{n}+\frac{(1-\alpha)I}{n\,K}\right]$, $D\equiv[\alpha+\eta(1-\alpha)]$, and $K\equiv[1+(1-\alpha)^2I]$.

We now show that the existence of a Nash equilibrium in wages requires symmetry in prices, that is: $p_i=p$. Given symmetry in prices, we then show that the Nash equilibrium in wages is also *symmetric.* First, to show that price symmetry is necessary for the existence of a Nash equilibrium in wages, notice that a condition like (A9) must simultaneously hold for each union i, with $i=1,..,n$. These n conditions may differ, if at all, from one another *only* in the linear terms in (p_i-p). The first order conditions for any two unions, s and q, imply, therefore, that $(p_s-p)=(p_q-p)$: the two unions first order conditions can be *simultaneously* satisfied if and only if the monopolistically competitive firms set identical prices on their products. Since this is true for any two first order conditions it follows that $p_i=p$, for every $i=1,..,n$. Using this result in equation (A9) implies that the first order conditions of all unions are identical. Hence they all set the *same* nominal wage.

The reaction function of the CB in equation (16), the expression for the equilibrium price level in equation (11) and the typical union first order condition in equation (A9) provide a system of three linear equations from which w, p and m can be solved. The solution for the wage premium is obtained, after a substantial amount of algebra, by using the first two equations

in the last one and by using the expression for the competitive real wage.

Derivation of the competitive real wage w_r^c

The competitive real wage, w_r^c, is the wage level that equates labor supply and labor demand, or $\int_0^1 l_0 \, dj = \int_0^1 l_{ij}^d \, dj$. When the labor market is competitive all firms face the same wage and set, therefore, the same price. Hence the derived demand for labor (equation (8)) reduces to $l_{ij}^d = \frac{1}{\alpha}(m-p)$. Using the last expression in the previous one, the labor market clearing condition can be rewritten as $l_0 = \int_0^1 \left[\frac{1}{\alpha}(m-p)\right] dj = \frac{1}{\alpha}(m-p)$. Using equation (10), which relates real money balances to the average real wage level, and rearranging we obtain the solution for the competitive wage, $w_r^c = -(1-\alpha)l_0 + \frac{1-\alpha}{\alpha}\rho$.

Proof of Proposition 5

Part (i). We start by showing that, when $\frac{B}{A} < \frac{S}{2}\left(\frac{\alpha+\eta(1-\alpha)n}{\alpha+\eta(1-\alpha)}\right)$ and $\frac{B}{A} < \frac{\eta(n-1)^2}{n(1-\alpha)[\alpha+\eta(1-\alpha)]}$ hold simultaneously, the social optimum problem does not have an internal solution. We first differentiate equation (26) with respect to I:

$$\frac{d\Lambda(I)}{dI} = \frac{2\phi(I)}{(1-\alpha)^2}\left[\left(1+\frac{S}{(1-\alpha)^2 I^2}\right)\frac{d\phi(I)}{dI} - \frac{S}{(1-\alpha)^2 I^3}\phi(I)\right]. \tag{A10}$$

If there is an internal extremum this expression equals zero. Thus, for an internal solution to exist, the following must hold

$$\frac{d\phi(I)}{dI}\frac{I}{\phi(I)} = \frac{S}{(1-\alpha)^2 I^2 + S}. \tag{A11}$$

Condition (A11) in conjunction with the derivative of the wage premium with respect to I (obtained from equation (20)) generates, after some algebra, the following equation:

$$\Psi(I) \equiv K_3 I^3 + K_2 I^2 + K_1 I + K_0 = 0 \tag{A12}$$

where

$$K_3 \equiv \frac{-\alpha(1-\alpha)^3(n-1)}{D}, \tag{A13}$$

$$K_2 \equiv (1-\alpha)^3 n \left(2\frac{B}{A} - S\frac{\eta n(1-\alpha)+\alpha}{D}\right), \tag{A14}$$

$$K_1 \equiv (1-\alpha)(n-1)\left(\frac{B}{A} - 2S\frac{\eta n(1-\alpha)+\alpha}{D}\right), \tag{A15}$$

$$K_0 \equiv S\left(\frac{B}{A}(1-\alpha)n - \frac{\eta(n-1)^2}{D}\right). \tag{A16}$$

Since $I \geq 0$, the equation $\Psi(I) = 0$ cannot be satisfied whenever the coefficients K_0, K_1, K_2, K_3 are all negative. In this case, an internal solution ($0 < I^* < \infty$) to the social optimum problem does not exist. The proof of Part (i) is completed by noting that when the conditions

$$\frac{B}{A} < \frac{S}{2}\left(\frac{\alpha+\eta(1-\alpha)n}{\alpha+\eta(1-\alpha)}\right) \tag{A17}$$

and

$$\frac{B}{A} < \frac{\eta(n-1)^2}{n(1-\alpha)[\alpha+\eta(1-\alpha)]} \tag{A18}$$

hold simultaneously the constants K_0, K_1, K_2, K_3 are all negative. Since the bounds on the right hand side of these conditions are monotonically increasing in both η and n, they attain their smallest values when η and n are at their lowest permissible values which are 1 and 2 respectively. If $\frac{B}{A}$ is smaller than these minimal upper bounds, it is *a fortiori* lower than the upper bounds at higher values of η and n. Inserting the condition $\eta = 1$ and $n = 2$ into the upper bounds yields the conditions reported in Part (i) of the proposition.

Part (ii): Under the conditions stated in Part (i) of the proposition, the socially optimal level of conservativeness is either zero or infinity. To characterize the set of circumstances under which either of those two extreme types is socially optimal we evaluate the values of inflation, of unemployment and of social losses in equation (26) for each of them. Under an ultra liberal central banker the wage premium and unemployment are zero and inflation and social losses are given respectively by

$$\pi = \frac{n-1}{B} \tag{A19}$$

and

$$\Lambda(0) = S\left(\frac{n-1}{B}\right)^2. \tag{A20}$$

Thus, an ultra liberal CB totally eliminates unemployment by riding on the inflationary fears of unions. But it also totally eliminates inflation only in the extreme case in which there is a single monopoly union. Hence in the case of a monopoly union an ultra liberal CB is socially optimal.

Under an ultra conservative central banker inflation is zero and unemployment and social welfare are given respectively by

$$u = \frac{1-\alpha}{A}\ \frac{[\alpha+\eta(1-\alpha)]\,n}{\alpha+\eta(1-\alpha)n} \tag{A21}$$

and

$$\underset{I\to\infty}{Lim}\Lambda(I) = \left(\frac{1-\alpha}{A}\ \ \frac{[\alpha+\eta(1-\alpha)]\,n}{\alpha+\eta(1-\alpha)n}\right)^2. \tag{A22}$$

An ultra liberal or an ultra conservative CB is socially optimal depending on whether $\Lambda(0)$ is smaller or larger than $\underset{I\to\infty}{Lim}\Lambda(I)$. Not surprisingly the welfare ranking of those two cases depends on society's relative inflation aversion. The socially optimal level of conservativeness will be infinity if and only if $\underset{I\to\infty}{Lim}\Lambda(I) < \Lambda(0)$: equations (A20) and (A22) imply that this condition is equivalent to the condition $\frac{B}{A} < \left(\frac{\alpha+(1-\alpha)\eta n}{(1-\alpha)(\alpha+(1-\alpha)\eta)}\right)\left(\frac{n-1}{n}\right)\sqrt{S}$. Since the bound on the right hand side is increasing in both η and n, it will attain its smallest value when $\eta = 1$ and $n = 2$, yielding the condition $\frac{B}{A} < \frac{2-\alpha}{2(1-\alpha)}\sqrt{S}$ reported in Part (ii) of the proposition.

Thus, provided that the conditions in the proposition are satisfied, the social welfare function has no internal minimum, and an ultra conservative CB is optimal. QED

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