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Economic Performance and Stabilization Policy in a Monetary Union with Imperfect Labor and Goods' Markets

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1.1 Introduction

In this chapter we propose a framework for the analysis of the effects of institutions on economic performance in a monetary union in the presence of unionized labor markets and monopolistically competitive, price-setting firms. The development of such a framework is motivated by the creation of the European Monetary Union (EMU), by the observation that European labor markets are largely unionized with different degrees of centralization in wage bargaining (CWB) across member countries of the Monetary Union (MU), and by the belief that the paradigm of monopolistically competitive, price-setting firms provides a better description of reality than that of perfectly competitive firms.

The chapter has three main objectives. The first is to analyze the effects of country size and the degree of centralization of wage bargaining across countries on the MU-wide, as well as on country-specific, economic performance in the presence of a single unified monetary policy. The second is to analyze the effect of the level of conservativeness of the common central bank on union wide, as well as on country specific, average economic performance. The third is to examine how those factors (country size, centralization of wage bargaining and central bank conservativeness) are likely to affect stabilization policy by the common central bank (CB) in the face of common, as well as of differential, demand and productivity shocks.

By now it is well accepted that central bank conservativeness (CBC) is negatively related to inflation. Recent literature has additionally discovered that in the presence of large wage setters, the level of CBC also affects real economic activity even if unions are not averse to inflation, and that the magnitude of those real effects depends on the structure of

wage bargaining (Cukierman and Lippi 1999; Soskice and Iversen 2000; Lippi 1999; Coricelli, Cukierman, and Dalmazzo 2000).¹

The creation of EMU has raised the effective CBC for most countries that have joined the Monetary Union. As CBC has real effects, one may question whether or not a reform of monetary policy-making institutions is desirable. The framework we propose makes it possible to identify some factors that affect this issue. In particular, we show that a high level of CBC is associated with both lower inflation and lower unemployment in the aggregate. However, when in the presence of shocks a stabilization policy is desirable, we are faced with the familiar Rogoff (1985) type trade-off between average economic performance and stabilization. Product market competition and wage-bargaining institutions also play a fundamental role in the determination of inflation and of unemployment in the MU. We show that higher CWB and higher product market competition in the MU lowers the expected value of inflation and the MU wide rate of unemployment.

In addition to the aggregate performance of the MU, in the performances of the member countries we find that a higher level of CBC is associated with both lower inflation and lower unemployment at the country level. However, because the countries in the MU differ in size and in the degree of centralization in wage bargaining (CWB), a common monetary policy can have different effects on the economic performances of the different countries even in the absence of shocks (a recent survey appears in Franzese 2000). As we will show below, the framework we use makes it possible to analyze the different impacts of a common monetary policy.² Other things being the same, the countries in the MU that possess relatively more centralized wage-bargaining systems are more competitive in foreign trade within the union and enjoy lower rates of unemployment. Similar conclusions hold for relatively larger countries. Basically these results are a direct consequence of the fact that unions in larger countries with more centralized wage-bargaining systems internalize a larger fraction of the impact of their actions on employment, and this moderates their wage demands.

In the chapter we also show that independently of the level of conservatism, the CB of the MU fully offsets an appropriately weighted average of the demand shocks of the individual countries. Although optimal at the level of the entire MU, a policy that offsets all MU-wide demand shocks does not fully stabilize the effects of different demand shocks on individual countries' rates of unemployment. Unlike demand shocks, central bank conservatism affects the CB's reaction to

MU-wide productivity shocks. An interesting result of the chapter is that a more conservative CB reacts more strongly to supply shocks in order to stabilize inflation. This result is consistent with recent time series evidence on conservativeness and activism in Germany presented by Berger and Woitek (1999).

Section 1.2 presents the basic building blocks of the model and derives its equilibrium solution. The interactions among unions, the CB, and firms are presented as a three-stage game. The players are the (nominal) wage-setting unions, a CB that picks the money supply in the MU, and a large number of monopolistically competitive, price-setting firms in the countries of the MU. Section 1.3 considers the effects of country size and other institutional parameters, like product market competitiveness, CWB, and CBC, on the expected economic performance at both the MU and the individual country levels. Section 1.4 discusses the implications of optimal stabilization of shocks at the level of the MU for CB activism, realized inflation, MU-wide unemployment, country-specific rates of unemployment, and relative competitiveness. This is followed by concluding remarks.

1.2 The Model

The analytical framework extends the closed economy model in Coricelli, Cukierman, and Dalmazzo (2000; henceforth CCD 2000) by explicitly recognizing open economy interactions and the role of productivity and demand shocks. The monetary union is composed of two countries. In each country there is a continuum of monopolistically competitive firms each producing a single differentiated product. The labor force in each country is divided into a number of equal-sized labor unions that manage the country's entire labor force. Firms are evenly distributed over the unit interval, and their total mass is one. A fraction, s_1 , of firms is located in country 1 and the remainder ($s_2 = 1 - s_1$) is located in country 2.

Each union in each country organizes a labor pool of size $1/n_c$ where n_c is the number of unions in country c , with $c = 1, 2$. As a consequence s_c also represents the share of country c in the combined labor force of the monetary union. An equal quantity, L_0 , of workers is attached to each firm and works only if the union in charge signs a labor contract with the firm. For convenience, and without loss of generality, the firms in country c are indexed so that all firms whose labor force is represented by union i are located in the contiguous subinterval

$(\frac{i}{n_c}s_c, \frac{i+1}{n_c}s_c)$ of the interval of length s_c , where $i = 0, 1, \dots, n_c - 1$. In both countries the firms own a production technology that exhibits decreasing returns to scale to labor input and is subject to a country-specific productivity shock Z_c , whose logarithm has an expected value of zero:

$$Y_{ij}^c = L_{ij}^\alpha \cdot Z_c, \quad \alpha < 1, c = 1, 2. \quad (1.1)$$

Here Y_{ij}^c and L_{ij}^c are output supply and labor input of firm j in country c . The index i means that the labor force of the firm belongs to union i . The productivity shocks have a common component across countries as well as country-specific components. Each firm in country c faces a demand for its output given by

$$D_{ij}^c = \left(\frac{P_{ij}}{P} \right)^{-\eta} H(r) G_c, \quad \eta > 1, c = 1, 2, \quad (1.2)$$

where P_{ij} and P are the price charged by the individual firm and the general price level respectively, r is the real rate of interest, and η is the (absolute value of the) elasticity of demand facing the individual firm with respect to its relative price. The derivative of $H(r)$ with respect to r is negative, and G_c is a country-specific shock to the demands facing firms in country c . The logarithms of G_c have zero expected values. Equation (1.2) states that the demand facing the individual firm in country c is decreasing in the relative price of the product and in the real rate of interest. Demand shocks may have a common component across countries as well as country-specific components.

The general price level is defined as the integral, over the unit interval, of the (logarithms of) the prices of individual firms. It is convenient, for reasons that will become clearer later, to write this price level as

$$\begin{aligned} p &= \frac{s_1}{n_1} \sum_{i=0}^{n_1-1} \left(\frac{\int_{\frac{i}{n_1}s_1}^{\frac{i+1}{n_1}s_1} p_{ij}^1 dj}{\int_{\frac{i}{n_1}s_1}^{\frac{i+1}{n_1}s_1} dj} \right) + \frac{s_2}{n_2} \sum_{i=0}^{n_2-1} \left(\frac{\int_{\frac{i}{n_2}s_2}^{\frac{i+1}{n_2}s_2} p_{ij}^2 dj}{\int_{\frac{i}{n_2}s_2}^{\frac{i+1}{n_2}s_2} dj} \right) \\ &= \sum_{i=0}^{n_1-1} \int_{\frac{i}{n_1}s_1}^{\frac{i+1}{n_1}s_1} p_{ij}^1 dj + \sum_{i=0}^{n_2-1} \int_{\frac{i}{n_2}s_2}^{\frac{i+1}{n_2}s_2} p_{ij}^2 dj \equiv s_1 p_1 + s_2 p_2 \\ &= \int_0^1 p_{ij} dj, \end{aligned} \quad (1.3)$$

where p_{ij}^c is the logarithm of P_{ij}^c , p is the logarithm of P , and p_c , $c = 1, 2$, is an index of the average level of the (logarithms of) prices of the products of country c .³ 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 . The general price level is a weighted average of the prices of goods produced in both countries. It represents the average price of the consumption basket of a typical individual. Since individuals in both countries consume all the goods produced in the MU, the summation of individual prices is over the entire unit interval, and the relevant general price index is the same for both countries.

The CB of the MU dislikes both inflation and unemployment. Its loss function is given by

$$\Gamma = u^2 + I\pi^2, \quad (1.4)$$

where u and $\pi \equiv p - p_{-1}$ denote respectively the average rate of unemployment and price inflation in the MU. The parameter I is the (Rogoff 1985 type) degree of CB conservativeness, or weight-conservativeness.⁴

Nominal money demand in country c is given by

$$M_c^d = PK_c(i)Y_c^p, \quad c = 1, 2, \quad (1.5)$$

where i is the nominal interest rate, Y_c^p is the permanent level of output in country c , and $K_c(i)$ is a (positively valued function) with a negative derivative.⁵ Equilibrium in the union's money market implies that the sum of money demands over the two countries equals the total MU money supply M :

$$M = (K_1(i)Y_1^p + K_2(i)Y_2^p)P.$$

The monetary authority picks the total money supply in the union so as to achieve its desired value of the nominal rate, i . Solving for the nominal rate in terms of M , we have

$$i = F\left(\frac{M}{P}\right), \quad (1.5a)$$

and the derivative of $F(M/P)$ with respect to M/P is negative.⁶ Thus the choice of a given nominal rate is equivalent to the choice of a given level of real money balances. Hence the problem of the monetary authority can be viewed as a choice of the nominal money supply, taking into

account the effect of this choice on the price level. The real rate of interest is defined as the nominal rate minus the expected rate of inflation, $r \equiv i - \pi^e$. We assume, for simplicity, that the choice of nominal rate by the monetary authority does not affect expected inflation so that any change in the nominal rate translates, one to one, into a change in the real rate. It follows from (1.2) and (1.5a) that

$$D_{ij}^c = \left(\frac{P_{ij}}{P}\right)^{-\eta} H \left\{ F \left(\frac{M}{P}\right) - \pi^e \right\} G_c \equiv \left(\frac{P_{ij}}{P}\right)^{-\eta} h \left(\frac{M}{P}\right) G_c, \quad c = 1, 2,$$

where the constant value of π^e is subsumed into the functional form of $h(M/P)$. Since demand facing each firm is decreasing in the real rate, and since the real rate is decreasing in real money balances, $h(\cdot)$ is an increasing function of real money balances. We assume for simplicity that $h(\cdot)$ is the identity function so that demand facing an individual firm is⁷

$$D_{ij}^c = \left(\frac{P_{ij}}{P}\right)^{-\eta} \left(\frac{M}{P}\right) G_c, \quad c = 1, 2. \quad (1.2a)$$

Each union desires a higher real wage and low unemployment of its members. We abstract from inflation-averse unions. The loss function of a typical union is:⁸

$$\Omega_i = -2w_{ri} + Au_i^2, \quad (1.6)$$

where w_{ri} is the (logarithm) of the real wage of union i 's members, u_i is the rate of unemployment among them and A is a positive parameter that measures the relative importance attributed to employment versus the real wage by the union's leadership. This specification is in the spirit of labor union behavior theory as surveyed in Oswald (1982). Although the union cares about the real wage, it directly sets only the nominal wage. Prices and the money supply are more flexible than nominal wages, which are usually contractually fixed. Thus, in our model, wages are relatively sticky while product prices are fully flexible and—as in the classical tradition—respond to monetary policy shocks. This wage stickiness leaves some room for a stabilization policy by the CB.

We suppose that unions choose nominal wages prior to the realization of shocks, and that the Monetary Union's supply of money as well as individual prices in both countries are chosen after the realization of shocks. More precisely, we set up this model as a three-stage game. In the first stage every union in a country chooses its nominal wage so as to

minimize the expected value of its loss function. In doing so, the union takes the nominal wages of other unions as given, forms forecasts of future productivity and demand shocks, and anticipates the reactions of the monetary authority and of firms to its nominal wage choice. The resulting nominal wages are then contractually fixed for the duration of the game. Essentially the union plays Nash against all other unions and acts as a Stackelberg leader with respect to the CB and the firms that are attached to it.

In the second stage of the game shocks occur, the monetary authority observes them, and chooses the nominal rate of interest in the MU so as to minimize the loss function. In doing so, it takes the preset nominal wages in both countries as given and anticipates the pricing reaction of firms to those wages, to the realizations of the shocks, and to its choice of instrument.

In the third and final stage every firm in the MU observes a nominal wage cost and the demand for its good. Taking those variables and the general price level as given, each firm sets its own price so as to maximize its real profits. The resulting string of first-order conditions, along with equation (1.3), simultaneously determines individual prices as well as the general price level. General equilibrium is characterized by solving the game using backward induction.

1.2.1 Price Setting

In the final stage, each firm observes the level of demand for its own product and sets a price that will maximize profits. By equations (1.1) and (1.2a), real profits of an individual firm in country c are given by

$$\pi_{ij}^c = \frac{P_{ij}}{P} Y_{ij}^d - \frac{W_i}{P} L_{ij} = \left(\frac{P_{ij}}{P} \right)^{1-\eta} \frac{M}{P} G_c - \frac{W_i}{P} \left[\left(\frac{P_{ij}}{P} \right)^{-\eta} \frac{M}{P} \frac{G_c}{Z_c} \right]^{1/\alpha}. \quad (1.7)$$

As a firm chooses its own price, P_{ij} , it takes P , M , and the nominal wage, W_i , as given.⁹ Maximizing profits with respect to P_{ij} , taking logarithms of both sides of the resulting expression, and rearranging, yields the following relative price level of firm j in country c :

$$p_{ij}^c - p = \theta + \frac{1}{\alpha + \eta(1 - \alpha)} [\alpha(w_i^c - p) + (1 - \alpha)(m - p + g_c) - z_c], \quad c = 1, 2. \quad (1.8)$$

Here $\theta \equiv [\alpha/(\alpha + \eta(1 - \alpha))] \log[\eta/\alpha(\eta - 1)]$, and the lowercase letters stand for the logarithms of the corresponding uppercase letters. In particular, $\log(Z_c) \equiv z_c$, where z_c is a random shock with $E(z_c) = 0$ and $E(z_c^2) = \sigma_{z_c}^2$; similarly $\log(G_c) \equiv g_c$, where g_c is a random shock with $E(g_c) = 0$, $E(g_c^2) = \sigma_{g_c}^2$, $c = 1, 2$. Equation (1.8) states that the optimal relative price of a typical monopolistically competitive firm is higher, (1) the higher is the real wage relative to the productivity shock, and (2) the higher real money balances in the MU. 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 1.2a) with the firm's supply (equation 1.1). Taking logarithms of both sides of the resulting expression and rearranging results in

$$l_{ij}^{dc} = \frac{1}{\alpha} [-\eta(p_{ij} - p) + (m - p) + g_c - z_c], \quad c = 1, 2. \quad (1.9)$$

Equation (1.9) 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. Equation (1.8) implies, in turn, that the relative price of the firm depends on the real wage it faces. Combined, the two equations imply that an increase in the real wage by a union reduces the demand for labor facing it.¹⁰ This completes the analysis of firm j 's optimal decision in the last stage of the game.

1.2.2 Choice of Money Supply (or Interest Rate) by the CB

In the second stage of the game the CB of the MU chooses the money supply after the realization of all shocks in the union. The CB sets the money supply so as to minimize its loss function in equation (1.4) taking the nominal wages set by labor unions as given, and anticipating the pricing and employment reaction of firms to its choice (as given by equations 1.8 and 1.9). The general price level in equation (1.3) can be rewritten as

$$p = s_1 p_1 + s_2 p_2, \quad (1.10)$$

where

$$p_1 \equiv \frac{\int_0^{s_1} p_{ij}^1 dj}{s_1} \quad \text{and} \quad p_2 \equiv \frac{\int_{s_1}^1 p_{ij}^2 dj}{s_2}. \quad (1.11)$$

The indexes p_1 and p_2 represent the average price levels of the goods produced by the firms in country 1 and country 2 respectively. Averaging

equation (1.8) over firms within each country and rearranging, we obtain

$$\begin{aligned} s_2(p_1 - p_2) &= \theta + \frac{1}{\alpha + \eta(1 - \alpha)} [\alpha(w_1 - p) + (1 - \alpha)(m - p + g_1) - z_1], \\ -s_1(p_1 - p_2) &= \theta + \frac{1}{\alpha + \eta(1 - \alpha)} [\alpha(w_2 - p) + (1 - \alpha)(m - p + g_2) - z_2], \end{aligned} \quad (1.12)$$

where w_c is the average nominal wage in country c .¹¹ Equations (1.10) through (1.12) determine the general price level, p , and its national components, p_1 and p_2 as functions of the shocks, the average nominal wages in the two countries, and the money supply of the MU. The solution that emerges for the rate of inflation is

$$\pi \equiv p - p_{-1} = [\alpha + \eta(1 - \alpha)]\theta + \alpha\bar{w} + (1 - \alpha)(m + \bar{g}) - \bar{z} - p_{-1}, \quad (1.13)$$

where $\bar{w} \equiv s_1w_1 + s_2w_2$, $\bar{g} \equiv s_1g_1 + s_2g_2$, $\bar{z} \equiv s_1z_1 + s_2z_2$.

We now turn to a characterization of unemployment. Averaging equation (1.9) over firms within a given country yields the average level of demand for labor, and employment, per firm:

$$l_c^d = \frac{1}{\alpha} [-\eta(p_c - p) + (m - p) + g_c - z_c], \quad c = 1, 2. \quad (1.14)$$

Let $l_0 \equiv \log[L_0]$ be the logarithm of labor supply per firm. The average rate of unemployment per firm in country c coincides with the average country-specific rate of unemployment, which is given by

$$u_c = l_0 - l_c^d = l_0 + \frac{1}{\alpha} [\eta(p_c - p) - (m - p) + z_c - g_c], \quad c = 1, 2. \quad (1.15)$$

Thus the rate of unemployment in country c is higher the higher are the average relative price of the products of that country, and the higher the country's productivity shock. Unemployment is lower, the higher the level of real money balances in the MU and the higher the demand shock for the products of the country. The positive relationship between productivity and unemployment reflects the fact that given the average relative price of the products of a country, the demand for labor of this country is lower when labor is more productive.¹² Let L_c and L_c^d

be total labor supply and total labor demand in country c . Unemployment in the monetary union is therefore

$$\begin{aligned}
 u &= \frac{L_1 - L_1^d + L_2 - L_2^d}{L_1 + L_2} \\
 &= \frac{L_1}{L_1 + L_2} \frac{L_1 - L_1^d}{L_1} + \frac{L_2}{L_1 + L_2} \frac{L_2 - L_2^d}{L_2} \\
 &= s_1 u_1 + s_2 u_2.
 \end{aligned} \tag{1.16}$$

Substituting equation (1.15) into equation (1.16), using equation (1.13) to substitute p out, and rearranging, we have

$$u = l_0 + \frac{\alpha + \eta(1 - \alpha)}{\alpha} \theta + \bar{w} - m - \bar{g}. \tag{1.17}$$

The fact that \bar{z} does not affect aggregate unemployment might seem mysterious at first sight. The reason its impact is nil is that the direct (negative) effect of \bar{z} on employment is exactly offset by the indirect general equilibrium effect of \bar{z} on employment via real money balances. In particular, when \bar{z} increases less labor is needed to produce a given level of output, so the demand for labor goes down. On the other hand, the increase in output reduces prices and raises real money balances. This stimulates demand for goods and, through it, the derived demand for labor. In the present model those two effects exactly offset each other making union wide unemployment independent of \bar{z} . By contrast, from equation (1.13), productivity shocks do have a first-order impact on inflation. As a consequence the motivation underlying the central bank's reaction to productivity shocks is solely to prevent fluctuations in the rate of inflation.¹³

Taking the average nominal wage in the MU 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 1.13 and 1.17) into equation (1.4) and rearranging terms, the CB problem becomes

$$\begin{aligned}
 \min_{\{m\}} & \left\{ \left[l_0 + \frac{\alpha + \eta(1 - \alpha)}{\alpha} \theta + \bar{w} - m - \bar{g} \right]^2 \right. \\
 & \left. + I[(\alpha + \eta(1 - \alpha))\theta + \alpha\bar{w} + (1 - \alpha)(m + \bar{g}) - \bar{z} - p_{-1}]^2 \right\}.
 \end{aligned} \tag{1.18}$$

This yields a reaction function for the CB in which the money supply is a linear function of the average nominal wage, \bar{w} , in the MU and of the average realizations of the productivity and demand shocks, \bar{z} and \bar{g} :

$$m = \Psi + \frac{1 - \alpha(1 - \alpha)I}{1 + (1 - \alpha)^2 I} \bar{w} + \frac{(1 - \alpha)I}{1 + (1 - \alpha)^2 I} \bar{z} - \bar{g}, \quad (1.19)$$

where

$$\Psi \equiv \frac{l_0 + (1 - \alpha(1 - \alpha)I) \frac{\alpha + \eta(1 - \alpha)}{\alpha} \theta + (1 - \alpha)I p_{-1}}{1 + (1 - \alpha)^2 I}$$

is a constant. This reaction function has a number of notable features. First, the CB either counteracts or accommodates an increase in average, nationwide nominal wages depending on the degree of CB conservativeness (or independence), I . If the CB is sufficiently conservative, in the sense that $1 - \alpha(1 - \alpha)I < 0$, a wage increase triggers a tightening of the money supply. This extends the result found in the closed economy framework of CCD (2000) to the case of a MU composed of interdependent open economies. Evidence surveyed in CCD (2000) supports the view that, the highly conservative Bundesbank often tightened monetary policy in response to what it considered to be “excessive” wage settlements.¹⁴ The discussion of the intuition underlying the response of the CB to the productivity and demand shocks is left to section 1.4 on stabilization policy.

1.2.3 Choice of Wages by Unions

In the first stage of the game, prior to the realization of shocks, each labor union takes nominal wages set by other unions in the MU as given and chooses its own nominal wage so as to minimize its *expected* losses from unemployment and a low real wage. Thus the typical labor union i minimizes $E(\Omega_i)$, where Ω_i is given by equation (1.6), and the expectation is taken over the distribution of shocks in the MU. In doing that, the labor union takes into consideration the consequences of its wage policy for the prices that will subsequently be set by firms, as well as the expected response of the CB in equation (1.19).

Let w_i and w_{-i} be respectively the nominal wage of labor union i and the average nominal wage of all other labor unions in the MU. Taking w_{-i} as given, labor union i sets a common wage, w_i , for all of its members, which are the workers attached to firms in the interval $[\frac{i}{n_c} s_c, \frac{i+1}{n_c} s_c]$, $c = 1, 2$. In the firms represented by labor union i , 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 labor union i :

$$u_i^c = l_0 - \left\{ \frac{\int_{\frac{i}{n_c} s_c}^{\frac{i+1}{n_c} s_c} l_{ij}^d dj}{\int_{\frac{i}{n_c} s_c}^{\frac{i+1}{n_c} s_c} dj} \right\} = l_0 - l_{ij}^{dc}, \quad i \in c, c = 1, 2. \quad (1.20)$$

Since all firms in the interval $[\frac{i}{n_c} s_c, \frac{i+1}{n_c} s_c]$ face the same nominal wage w_i^c , equation (1.8) implies that $p_{ij}^c = p_i^c$ for all $j \in [\frac{i}{n_c} s_c, \frac{i+1}{n_c} s_c]$. Consequently labor union i anticipates that all the firms employing its members will react to the common wage level by setting the same relative price for their products. Thus equation (1.20) can be rewritten as

$$u_i^c = l_0 + \frac{1}{\alpha} [\eta(p_i^c - p) - (m - p) + z_c - g_c], \quad i \in c, c = 1, 2. \quad (1.21)$$

Note that since all firms are identical, the unemployment *rate* among the members of labor union i 's is also equal to u_i^c . By minimizing the union's expected loss function

$$E(\Omega_i) = E\{-2(w_i^c - p) + Au_i^2\}, \quad i \in c, c = 1, 2 \quad (1.5a)$$

with respect to the nominal wage, w_i^c , we obtain the following family of first-order conditions:

$$E\left\{-\left[1 - \frac{dp}{dw_i^c}\right] + Au_i^c \frac{du_i^c}{dw_i^c}\right\} = 0, \quad i \in c, c = 1, 2. \quad (1.22)$$

Equation (1.22) illustrates the trade-offs facing a single labor union. The first term in equation (1.22) shows that when the union raises its nominal wage by one unit, the increase in its real wage is going to be somewhat smaller because the CB does not, generally, fully offset the inflationary consequences of wage push. Hence the effectiveness of an increase in the nominal wage in raising the real wage is less than full. On the other hand, the increase in the nominal wage raises the labor costs, and thus the *price* set by firms that use labor union i . This triggers two effects. An adverse competition effect and an aggregate demand effect, both of which are captured by the second term in equation (1.22).

First, the increase in prices makes firms whose workforce is controlled by union i less competitive, and thus it reduces their derived demands for labor. Second, the increase in prices generated by union i 's wage

push raises the *aggregate* price level. Consequently, for any given level of nominal money supply, real money balances shrink and aggregate demand falls across the entire MU. If a sufficiently conservative CB reacts to wage inflation by contracting the money supply, the aggregate demand will be depressed even further. As a result unemployment among union i workers will rise. Hence the optimization problem of the individual labor union involves balancing the benefit of a higher real wage against the cost of a higher rate of unemployment among its members.

Equation (1.22) provides a string of $n = n_1 + n_2$ equations from which the nominal wages of the n labor unions in the MU can be solved. We look for a symmetric equilibrium for nominal wages *within each country*, while allowing differences in nominal and in real wages across countries. The equilibrium outcomes are expressed in terms of the wage premium, defined as the expected difference between the actual and the competitive market-clearing wages. The equilibrium wage premium, ϕ_c , in country c , is

$$\phi_c = \frac{1}{A} \left\{ (1 - \alpha)q^c + \frac{\alpha s_{\bar{c}}}{\eta} (q^c - q^{\bar{c}}) \right\}, \quad c = 1, 2, \quad (1.23)$$

where the superscript \bar{c} means “not c ,” and the explicit expression for q^c is

$$q^c = \frac{1 - \frac{s_c}{n_c} \left(\frac{1}{1 + \alpha(1 - \alpha)^2 I} \right)}{\frac{\eta}{\alpha + \eta(1 - \alpha)} \left(1 - \frac{s_c}{n_c} \right) + \frac{s_c}{n_c} \frac{(1 - \alpha)I}{1 + \alpha(1 - \alpha)^2 I}}, \quad c = 1, 2. \quad (1.24)$$

A full derivation of the results is provided in the appendix at the end of this chapter. Note that the wage premia of the two countries differ if and only if $s_1/n_1 \neq s_2/n_2$. In particular, if $s_1/n_1 = s_2/n_2$, the expected wage premia are the same in both countries. Thus the differences in wage premia across countries reflect differences in country size and in the degree of CWB.

1.3 Roles of Country Size and of Wage Bargaining Institutions

The expected average wage premium in the MU is a fundamental determinant of inflation and of unemployment in the member countries. The expected average wage premium in the MU is defined as

$$\phi \equiv s_1 \phi_1 + s_2 \phi_2. \quad (1.25)$$

After substituting equation (1.23) into equation (1.25) and rearranging, we can express this expected value as

$$\phi = \frac{1 - \alpha}{A} \{s_1 q^1 + s_2 q^2\}. \quad (1.26)$$

It is shown in the appendix that the expected value of average unemployment in the MU is

$$Eu \equiv E(s_1 u_1 + s_2 u_2) = \frac{1}{1 - \alpha} \phi. \quad (1.27)$$

Thus the expected value of unemployment in the MU is proportional to the expected value of the average wage premium. We turn next to the determination of expected inflation. The first-order condition for the minimization problem of the monetary authority in equation (1.18) implies that

$$-u + I(1 - \alpha)\pi = 0. \quad (1.28)$$

Applying the expected value operator to equation (1.28) and rearranging yields

$$E\pi = \frac{Eu}{I(1 - \alpha)} = \frac{1}{I(1 - \alpha)^2} \phi, \quad (1.29)$$

where the second equality follows from the extreme right-hand side of equation (1.27). Thus the rate of inflation in the MU is directly related to the wage premium.¹⁵

In what follows we analyze the effects of product market competitiveness, CB independence, and centralization in wage-setting on the equilibrium values of unemployment and inflation in the MU.

1.3.1 Effects of Competitiveness and of CB Conservativeness on MU-wide Variables

The larger the parameter η is in equation (1.2), the more substitutability there is among products and, therefore, the greater is the competition in the product markets within and among countries. The following proposition summarizes the effects of η on the MU-wide wage premium, unemployment, and inflation.¹⁶

Proposition 1.1 The more competitiveness there is in the product markets, as given by the parameter η , the lower are the expected

average wage premium, the rate of unemployment, and the rate of inflation in the MU.

The intuition behind the proposition is straightforward. As product markets become more competitive the demand for labor of a typical labor union in the MU becomes more elastic and so the monopoly power of the individual labor union diminishes. As a consequence the wage premia and real wages are kept low, and unemployment is low as well. When there is low unemployment the Kydland-Prescott (1977) and Barro-Gordon (1983) (henceforth KPBG) inflation bias is low too, since the CB of the MU is less tempted to engage in expansionary monetary policy.

We turn next to an investigation of the effects of CB conservativeness on expected macroeconomic performance in the MU. The following proposition summarizes the main results.¹⁷

Proposition 1.2 The more conservative is the CB, the lower are the expected average wage premium, the average rate of unemployment, and the rate of inflation in the MU.

The intuition is again straightforward. A conservative CB is correctly expected to contract the money supply (or to expand it less) in response to inflationary union wage increases. This acts to deter the real wage demands of unions. Since, on average, when real wages are low, employment is high, the KPBG inflation bias is small. It is small both because of the direct effect of the money supply being constrained to thwart the expected inflation and because of the moderating effect the constrained supply of money has on the MU-wide expected wage premium, ϕ (see equation 1.29).¹⁸

Finally, we look at the effects of centralization in wage-setting on the expected macroeconomic performance in the MU:¹⁹

Proposition 1.3 The larger is the number of unions in the MU, the higher are the expected average wage premium, the average rate of unemployment, and the rate of inflation.

We now turn to a discussion of the proposition results. Clearly, a basic factor that checks the tendency of unions to raise real wages, and thus the wage premium, is the fear of unemployment among union members. This deterrent works via different channels. First, there is the relative price effect. An increase in the wage of a particular union raises

the costs of firms that use its labor and so the affected firms will raise their prices. This depresses sales, and thus the demand for the union's workforce.

Two additional mechanisms will increase unemployment not only among the members of the union considered, but also among the members of other unions. One is related to the fact that an increase in the nominal wage of the single union raises the general price level. Then, in the absence of a policy response, the higher price level will depress real money balances and aggregate demand for goods and thus for labor as well. The other is related to the expected response of the CB. A relatively liberal CB (I is low) will counteract much of the contractionary economywide effects of the increase in the union's nominal wage by increasing the nominal money supply (equivalently, by reducing the interest rate). A conservative CB (I is high) will respond by reducing the nominal money supply, which further reduces real balances and the demands for goods and labor.²⁰ However, even when the CB is relatively liberal, the increase in a single union's wages will have a negative combined effect on the aggregate labor demand.

We turn now to a discussion of proposition 1.3. When the number of labor unions is small, the individual union is large. A large union can better internalize adverse aggregate consequences of its wage demands for employment. Unions' fear of unemployment becomes weaker the larger the number of unions in the MU.²¹ The macroeconomic effects described by proposition 1.3 can be calculated in terms of the expected value of real money balances in the MU. We can thus show that

$$E(m - p) = -\frac{[\alpha + \eta(1 - \alpha)]\theta}{1 - \alpha} - \frac{\alpha}{1 - \alpha}(\phi + Ew_{rc}), \quad (1.30)$$

where Ew_{rc} denotes the expected value of the competitive wage.²² Equation (1.30) implies that the average level of real money balances in the MU is inversely related to the real wage premium. The intuition underlying proposition 1.3 can now be stated as follows: as the number of unions increases, so do the real wage premium and the rate of unemployment, but real money balances and the aggregate demand for labor decrease. With high unemployment, the incentive of the CB would be to expand the money supply. As a result the KPBG inflation bias will rise.

1.3.2 Determinants of Country-Specific Average Performance

The following proposition summarizes the effects of country size and of country specific CWB for the expected values of country specific variables.²³

Proposition 1.4

- i. The country with a higher ratio, s_c/n_c , has a lower expected wage premium and a lower expected rate of unemployment.
- ii. Where two countries are of the same size, the country with the more decentralized wage-bargaining system (more unions) has a higher expected real wage premium and a higher expected rate of unemployment.
- iii. Where two countries have the same degrees of centralization in wage bargaining ($n_1 = n_2$), the smaller country has a higher expected real wage premium and a higher expected rate of unemployment.

Part ii of the proposition is supported by empirical evidence presented by Nickell (1997, 1999) and OECD (1997).

Before turning to a discussion of the intuition behind the country-specific results, it will be useful to derive an expression for the level of relative competitiveness between the two countries. It is shown in section 1.6.7 of the appendix that the relative price of the products produced in country c is

$$p_c - p = \frac{s_{\bar{c}}}{\alpha + \eta(1 - \alpha)} \{ \alpha(w_c - w_{\bar{c}}) + (1 - \alpha)(g_c - g_{\bar{c}}) - (z_c - z_{\bar{c}}) \},$$

$$c = 1, 2. \quad (1.31)$$

The expected value of this expression is

$$E(p_c - p) = \frac{s_{\bar{c}}}{\alpha + \eta(1 - \alpha)} \alpha E(w_c - w_{\bar{c}})$$

$$= \frac{s_{\bar{c}}}{\alpha + \eta(1 - \alpha)} \alpha (\phi_c - \phi_{\bar{c}}), \quad c = 1, 2, \quad (1.32)$$

where the second equality is a direct consequence of equation (A1.14) in the appendix. Equation (1.32) shows that the country with a higher wage premium charges a higher price for its products and is therefore less competitive than the country with the lower wage premium. This observation, in conjunction with the fact that q^c is decreasing in s_c and

increasing in n_c (see the proof of proposition 1.3 in the appendix) yields the following:

Proposition 1.5

- i. If the two countries are of equal size, the country with more decentralized bargaining in the labor market is, on average, less competitive.
- ii. Where two countries have similar CWBs, the smaller country is, on average, less competitive.
- iii. More generally, country 1 is more or less competitive than country 2 depending on whether s_1/n_1 is larger or smaller than s_2/n_2 .

Propositions 1.4 and 1.5 imply that despite the common monetary policy, real wages, unemployment, and competitiveness differ across the two countries in the MU even in the absence of shocks. The intuition underlying these results is related to the preceding discussion. In particular, the larger the number of unions in a country and the smaller the country's size, the smaller will be the extent to which a representative union in that country will internalize the adverse macroeconomic consequences of its wage decisions for employment. As a consequence the real wage premium will be higher. Finally, a country with higher real wages will be less competitive in its trade with the other country as noted in proposition 1.5 and illustrated by the extreme right-hand side of equation (1.32).

The following proposition summarizes the effect of CBC, I , on the expected rates of unemployment within each country.²⁴

Proposition 1.6 Other things the same, the more conservative the CB, the lower will be the expected unemployment rate in each country of the MU.

1.4 Stabilization Policy

The CB of the MU dislikes variability in both inflation and employment. But, since it has only one instrument, in general, the CB cannot fully offset the effect of shocks. It therefore compromises by choosing the money supply (or the interest rate) so as to equate the marginal cost of inflation variability to the marginal cost of MU-wide employment variability. But, as can be seen from equation (1.19), it is nonetheless optimal for the CB to fully offset the effect of the unionwide average demand shock on the demand for goods in the MU. The reason is that

aggregate demand shocks do not require the CB to compromise between reducing inflation variability and employment variability. By fully offsetting the velocity effects and other demand shocks on the economy, the CB can reduce fluctuations in both inflation and unemployment. This intuition is similar to that found in new Keynesian models of monetary policy of the type reviewed by Clarida, Gali, and Gertler (1999). But in the MU this implies that demand shocks facing producers in a country cannot be fully offset unless the demand shocks are perfectly correlated across countries.

Equation (1.19) implies that the CB accommodates the MU-wide average productivity shock, \bar{z} . The reason is that the unionwide average productivity shock does not directly affect unemployment but it does affect inflation. For this reason the CB's monetary policy is to offset the effects of fluctuations in productivity only on inflation.²⁵ This way in the face of a positive (negative) productivity shock the money supply is increased (reduced).

Interestingly a more independent CB (in terms of high I) would be more reactive. The reasoning is that a CB that is relatively more averse to inflation fluctuations would find it advantageous to be more reactive in order to offset a larger fraction of the effects of productivity shocks on the inflation.²⁶ Recent evidence for Germany provided by Berger and Woitek (1999) is consistent with this intuition. Berger and Woitek found that when the Bundesbank Council was controlled by a more conservative group, the monetary policy responded more strongly to exogenous shocks.

1.4.1 Effects of a Common Stabilization Policy on MU-wide Unemployment and Inflation

To evaluate the effects of shocks on inflation in the presence of a common stabilization policy, we substitute equation (1.19) into equation (1.13) and rearrange it to yield

$$\pi = \frac{1}{1 + (1 - \alpha)^2 I} \left\{ (1 - \alpha) l_0 + \frac{[\alpha + \eta(1 - \alpha)]\theta}{\alpha} + \bar{w} - p_{-1} - \bar{z} \right\}. \quad (1.33)$$

Note that the MU-wide aggregate demand shock does not appear in this expression. This confirms that independently of its level of conservativeness, the CB always fully offsets the effect of the aggregate demand shock on MU-wide inflation. But the CB allows some of the MU-wide aggregate supply shock, \bar{z} , to affect the rate of inflation. Thus

a negative, unionwide, supply shock is partially allowed to raise inflation and inflation variability. Only in the limit, where the CB is extremely conservative (I tends to ∞), inflation and its variability become independent of productivity shocks.

We turn next to the MU-wide rate of unemployment. The MU-wide rate of unemployment is²⁷

$$u = \frac{1}{1-\alpha} \left\{ \phi - \frac{(1-\alpha)^2 I}{1+(1-\alpha)^2 I} \bar{z} \right\}. \quad (1.34)$$

Again, this expression shows that the effect of the aggregate demand shock on unemployment is fully offset, although productivity shocks partially affect the MU-wide rate of unemployment. The more liberal the CB (the lower I) the smaller will be the fraction of the MU-wide average productivity shock that is allowed to affect the unemployment rate. In the limit where the CB becomes ultraliberal (I tends to 0), the effect of \bar{z} on MU unemployment is fully neutralized.²⁸ As can be seen from equation (1.33), in this case, supply shocks are fully passed on to inflation.

1.4.2 Country-Specific Effects of Shocks under a Common Stabilization Policy

Since the policy of the CB of the MU is geared to the stabilization of a weighted average of the shocks in the monetary union, the country-specific shocks are obviously not stabilized to the same extent that they would have been under national monetary policies. The remainder of this section focuses on the differential effects of the common stabilization policy in the face of heterogeneous cross country shocks.

Effects on Relative Competitiveness within the MU

Not surprisingly, equation (1.31) suggests that the level of competitiveness of a country in the MU, as measured by the average relative price of the products of that country, depends on the differences between the demand and productivity shocks of the two countries. Other things the same, the country with a relatively high productivity shock enjoys more competitiveness (a lower relative price) while the producers in that country set relatively high prices on experiencing a relatively high demand shock. Finally, the impact of the productivity and demand shocks is lower when the elasticity of substitution among products, η , is high.

Effects of Shocks on Country-Specific Rates of Unemployment

It is shown in section 1.6 of the appendix that

$$\begin{aligned}
 u_c = & \frac{\phi_c}{1-\alpha} + \frac{\alpha s_{\bar{c}}}{(1-\alpha)(\alpha + \eta(1-\alpha))} (\phi_{\bar{c}} - \phi_c) \\
 & - \frac{(1-\alpha)I(\alpha + \eta(1-\alpha) - s_{\bar{c}}) + s_{\bar{c}}(\eta - 1)}{[\alpha + \eta(1-\alpha)](1 + (1-\alpha)^2 I)} z_c \\
 & - \frac{s_{\bar{c}}((1-\alpha)I - (\eta - 1))}{[\alpha + \eta(1-\alpha)](1 + (1-\alpha)^2 I)} z_{\bar{c}} + \frac{s_{\bar{c}}}{\alpha + \eta(1-\alpha)} (g_{\bar{c}} - g_c), \quad (1.35)
 \end{aligned}$$

where $c = 1, 2$. A close look at this expression reveals some interesting interactions. First, despite the fact that the CB fully offsets the MU-wide average demand shock, \bar{g} , the difference between the demand shocks that hit the two countries **does** affect the country-specific rates of unemployment. In particular, when the two demand shocks are not perfectly correlated, the domestic rate of unemployment is higher when the demand shock in the other country is larger than the one in the domestic economy. The reason is that the monetary authority responds to a positive, MU-wide demand shock by reducing the money supply. When the demand shock in the other country is larger, the CB contracts more than what is needed to stabilize the domestic economy, creating a high rate of unemployment. This negative externality is more important when the country is relatively small, and less important when product markets are relatively competitive (η is high). Note that the magnitude of this cross effect is independent of central bank conservativeness. This is due to the fact that all central bankers tend to stabilize the MU-wide average demand shock in the same way.

The own productivity shock affects domestic unemployment via three channels that can be seen more explicitly by referring to equation (1.15). An increase in domestic productivity directly raises domestic unemployment since less labor is needed to satisfy the demand for the country's products. On the other hand, an increase in domestic productivity also raises the country's competitiveness and real money balances in the MU. These two effects raise the demand for domestic products and reduce domestic unemployment. Equation (1.35) shows that the last two (indirect) effects dominate the first (direct) effect. Note that the absolute value of the marginal impact of a domestic productivity shock on domestic unemployment is larger when the central bank is

more conservative (I is large). A more conservative CB accommodates productivity shocks through stronger adjustments of real money balances.

In raising real money balances, an increase in foreign productivity reduces domestic unemployment. On the other hand, an increase in foreign productivity also reduces the competitiveness of domestically produced products, thereby raising domestic unemployment. When the CB of the MU is sufficiently conservative, the first effect dominates and an increase in foreign productivity reduces domestic unemployment. More precisely, the coefficient attached to the foreign productivity shock in equation (1.35) implies the following:

Proposition 1.7 An increase in foreign productivity reduces domestic unemployment if and only if

$$I > \frac{\eta - 1}{1 - \alpha}. \quad (1.36)$$

Relative Variability of National Rates of Unemployment in a MU

Equation (1.35) provides the ingredients needed to identify some of the factors that affect the relative size of the variances of national rates of unemployment in a MU. It is instructive to look at two extreme cases. In the first case, the variability of unemployment is driven only by demand shocks. In the second case, the unemployment variability is driven only by supply shocks.

Role of Demand Shocks When the variance of productivity shocks is zero, equation (1.35) implies that

$$\text{var}(u_1) - \text{var}(u_2) = K_D \cdot [s_2 - s_1] = K_D \cdot [1 - 2s_1], \quad (1.37)$$

where $K_D \equiv E[g_2 - g_1]^2 / [\alpha + \eta(1 - \alpha)] > 0$. This implies that the smaller country experiences wider, demand-induced, fluctuations in unemployment. This is because the CB of the MU stabilizes mainly the demand shock of the large country. As a consequence the small country will experience large shifts in demand that are entirely induced by the CB stabilization policy.

Role of Productivity Shocks Assume that the variance of demand shocks is zero, and for simplicity, consider the case where $\text{var}(z_1) = \text{var}(z_2)$. Let $\rho \equiv \text{cov}(z_1, z_2) / \sqrt{\text{var}(z_1) \cdot \text{var}(z_2)} \in [-1, 1]$ be the correlation

coefficient between the productivity shocks in the two countries. It follows that

$$\text{var}(u_1) - \text{var}(u_2) = -K_s \cdot [(1 - \alpha)I - (\eta - 1)] \cdot (1 - \rho) \cdot [s_2 - s_1], \quad (1.38)$$

where K_s is a positive constant. This expression implies that the variability of unemployment is the same when the countries are of equal size (i.e., $s_1 = s_2$), or if their productivity shocks are perfectly and positively correlated (i.e., $\rho = 1$). The relation between country size and relative variability in unemployment crucially depends on the sign of $[(1 - \alpha)I - (\eta - 1)]$, which is positive if inequality (1.36) holds. In this case the variance of unemployment in the larger country is higher. The result depends on the fact that when it is sufficiently conservative, the CB does not care much about variability in employment. However, whichever its type, the CB responds more to the productivity shocks of the larger country (because those shocks have a stronger impact on inflation within the Monetary Union). A positive shock in the large country will reduce unemployment both by increasing its competitiveness and by triggering an accommodating money supply; see equation (1.19). For the smaller country, the worsening in competitiveness is compensated by the increase in money supply, thus reducing the effect of the foreign shock on unemployment.

1.5 Concluding Remarks

Rather than summarize the results of the chapter, we will briefly consider the implications of our framework for issues like the possible effects of the creation of the ECB on macroeconomic performance in the euro area, the incentives for labor market reform and the optimal level of central bank conservativeness in a MU.

As was shown by Cukierman and Lippi (2001), the creation of a MU tends to raise real wages by reducing the relative size of a typical union involved in strategic interactions with the CB. This adverse strategic effect raises both inflation and unemployment.²⁹ However, Gasiorek (2000) claimed that the creation of the euro, increases the transparency of relative prices across countries within the EMU and thus creates more competition in the product markets. The results of this chapter indicate that an increase in the level of competition in the product markets reduces real wages in the Monetary Union, and consequently inflation and unemployment. To the extent that the creation of the EMU

will raise competition in the goods markets the adverse strategic effect may be offset.

The creation of the EMU, however, did not leave the average level of central bank conservativeness in the euro area unaltered. For many countries in the euro domain, the creation of the ECB has raised the level of CB conservativeness. The results of this chapter show that such an institutional change would reduce the real wage demands of unions and along with that, unemployment and the inflation bias. Although a highly conservative ECB may result in insufficient stabilizations of fluctuations in employment, our results unambiguously establish that expected average performance with respect to both inflation and unemployment is better under the more conservative CB.³⁰ We have, indeed, the familiar Rogoff (1985) generalized trade-off between better average performance in inflation (and, here, in unemployment) and stabilization policy.³¹

Recent work has looked at the effects of monetary integration on the incentives for labor market reform (Calmfors 1998, 2001a, b; Sibert 2000). In particular, Sibert and Sutherland (2000) find that the incentive for labor market reforms that increase wage flexibility to shocks may or may not be stronger under a MU than under national monetary policies. This chapter does not provide an explicit answer to this question. But it suggests that by devoting less attention to employment stabilization, a relatively conservative ECB could stimulate labor market reform in a direction that would make real wages more responsive to the macroeconomic effects of supply shocks. One way to achieve lower real wage rigidity is by enhanced coordination of labor unions within the EMU. More precisely, in our model this requires an effective reduction in the number of unions. Coordination among unions may even arise spontaneously as in Holden (2001), or through some centralized initiative on the part of governments as was the case with income policies during the 1970s (Flanagan, Soskice, and Ulman 1983). In the context of the EMU such initiative would require the participation of individual governments or intervention from European community institutions.

We end with two more general remarks on the timing of events postulated in this chapter and on the transmission mechanism of monetary policy featured in it. Obviously, under a different timing some of the theoretical results may change. But we believe that the timing postulated here captures the most important dynamic, real life components of the interactions among firms, the central bank, and labor unions without the burden of a fully blown dynamic model. The timing of

events we selected reflects the fact that pricing in the economy is adjusted more frequently than monetary policy, and that monetary policy, in turn, is adjusted more frequently than contractually fixed nominal wages. Casual observation suggests that other possible timing assumptions, such as when firms commit to prices before the central bank sets the interest rate or the money supply, appear to be relatively counterfactual, at least under discretionary monetary policy.

Recently revived, the new Keynesian models anchor much of the real effects of monetary policy on sticky prices and aggregate demand management, rather than on a Friedman-Lucas expectations augmented Phillips relation in which the transmission of monetary policy operates via aggregate supply.³² Our framework postulates that nominal wages are contractually fixed for some time but allows for full price flexibility. An advantage of our framework is that it captures the effects of monetary policy on economic activity through both the aggregate demand and the aggregate supply channels. The first channel operates through the effect that monetary expansion has on the demand for goods, and through it on the derived demand for labor and employment. The supply channel of the transmission process also operates in the model since the CB can react to shocks that had not been anticipated at the time wage contracts were concluded. As a consequence the CB has some capacity to stabilize the level of employment also by lowering or raising the *ex post* real wage through the creation of inflation that had not been anticipated at the time nominal wage contracts were signed.

1.6 Appendix

1.6.1 Derivation of Equilibrium Wage Premia

A first step toward the solution of the n -equations system in (1.22) involves the characterization of the effects of an increase in the nominal wage w_i^c of the union on the general price level p and on the rate of unemployment u_i^c among the members of union i . Eliminating p_{-1} on both sides of equation (1.13) and differentiating the resulting expression with respect to w_i^c , we have

$$\frac{dp}{dw_i^c} = \alpha \frac{s_c}{n_c} + (1 - \alpha) \frac{dm}{dw_i^c}, \quad i \in c, c = 1, 2. \quad (\text{A1.1})$$

To find the impact of an increase in the union's nominal wage rate on the choice of money supply by the CB of the MU, we differentiate

equation (1.19) with respect to w_i^c . Substituting the resulting expression into equation (A1.1) and rearranging, we have

$$\frac{dp}{dw_i^c} = \frac{s_c}{n_c} \left(\frac{1}{1 + \alpha(1 - \alpha)^2 I} \right), \quad i \in c, c = 1, 2. \quad (\text{A1.2})$$

Note that this expression is smaller than 1 and is increasing in country size and decreasing in the number of unions in that country. The intuition is obvious. Since the CB of the MU responds to MU-wide aggregates, the effect of the nominal wage decisions of a particular union in a country on the reaction of the CB is smaller the smaller the country of that union, and the larger the number of unions in it. We turn next to a calculation of the impact of the union's wage choice on unemployment among its members. Differentiating equation (1.21) with respect to w_i^c yields

$$\frac{du_i^c}{dw_i^c} = \frac{1}{\alpha} \left[\eta \frac{d(p_i^c - p)}{dw_i^c} - \frac{d(m - p)}{dw_i^c} \right], \quad i \in c, c = 1, 2. \quad (\text{A1.3})$$

The expression for $(m - p)$ can be obtained as follows: Multiplying the first equation in (1.12) by s_1 , the second one by s_2 , and subtracting the second equation from the first one, we obtain

$$0 = \theta + \frac{1}{\alpha + \eta(1 - \alpha)} [\alpha(\bar{w} - p) + (1 - \alpha)(m - p + \bar{g}) - \bar{z}]. \quad (\text{A1.4})$$

Thus real money balances in the MU are given by

$$m - p = -\frac{[\alpha + \eta(1 - \alpha)]\theta}{1 - \alpha} - \frac{\alpha}{1 - \alpha} (\bar{w} - p) - \bar{g} + \frac{\bar{z}}{1 - \alpha}. \quad (\text{A1.5})$$

Differentiating equation (A1.5) with respect to w_i^c , using equation (A1.2), and rearranging, we obtain

$$\frac{d(m - p)}{dw_i^c} = -\frac{s_c}{n_c} \left(\frac{\alpha(1 - \alpha)I}{1 + \alpha(1 - \alpha)^2 I} \right), \quad i \in c, c = 1, 2. \quad (\text{A1.6})$$

Thus an increase in the nominal wage of union i induces a decrease in aggregate real money balances in the MU. This is due to the fact that although the CB of the MU allows some of the inflationary impact of the wage increase to be passed on in the form of higher prices, it does not fully compensate for the consequent reduction in real money balances. As a consequence aggregate real money balances go down. Not surprisingly, this effect is smaller, the smaller the country of the labor

union in question and the larger the number of unions in this country. Note also that the higher the level of CB conservativeness, I , the larger the consequent reduction in real money balances.

Differentiating equation (1.8) with respect to w_i^c , and recalling that all the firms using the labor of union i set the same price, we obtain

$$\frac{d(p_i^c - p)}{dw_i^c} = \frac{1}{\alpha + \eta(1 - \alpha)} \left[\alpha \left(1 - \frac{dp}{dw_i^c} \right) + (1 - \alpha) \frac{d(m - p)}{dw_i^c} \right],$$

$$i \in c, c = 1, 2. \quad (\text{A1.7})$$

Substituting equations (A1.6) and (A1.7) into equation (A1.3) and rearranging yields

$$\frac{du_i^c}{dw_i^c} = \frac{\eta}{\alpha + \eta(1 - \alpha)} \left(1 - \frac{s_c}{n_c} \right) + \frac{s_c}{n_c} \frac{(1 - \alpha)I}{1 + \alpha(1 - \alpha)^2 I} \equiv Q_w^c,$$

$$i \in c, c = 1, 2. \quad (\text{A1.8})$$

Equation (A1.8) shows that the marginal impact of an increase in the nominal wage of a union on the rate of unemployment among its members is positive and is the same for all unions within a given country. Furthermore it does not depend on the realizations of shocks in the MU, and it is uniformly larger the higher the degree of competitiveness on product markets (the higher η), and the higher the level of CB conservativeness. From equation (A1.2) the marginal impact of an increase in the nominal wage of the union on its real wage is

$$1 - \frac{dp}{dw_i^c} = 1 - \frac{s_c}{n_c} \left(\frac{1}{1 + \alpha(1 - \alpha)^2 I} \right) \equiv Q_w^c, \quad i \in c, c = 1, 2. \quad (\text{A1.9})$$

Equation (A1.9) is the elasticity of the real wage of a union with respect to the union's nominal wage. Expression (A1.9) implies that this elasticity is bounded between 0 and 1. Furthermore, it is larger the larger CB conservativeness, I , the smaller the relative size of the country of the union under consideration, and the larger the number of unions in that country. Since the marginal impacts of w_i^c on the real wage of a union and on its unemployment do not depend on the realizations of shocks in the MU,

$$E \left[1 - \frac{dp}{dw_i^c} \right] = 1 - \frac{dp}{dw_i^c}, \quad E \left[\frac{du_i^c}{dw_i^c} \right] = \frac{du_i^c}{dw_i^c}, \quad i \in c, c = 1, 2. \quad (\text{A1.10})$$

Combining equation (A1.10) and equation (1.22) results in

$$-Q_w^c + A Q_u^c E u_i^c \equiv - \left[1 - \frac{dp}{dw_i^c} \right] + A \frac{du_i^c}{dw_i^c} E u_i^c = 0, \quad i \in c, c = 1, 2. \quad (\text{A1.11})$$

We now determine the expressions for $E u_i^c$. In applying the expected value operator to equation (1.21) and exploiting expressions (1.8) and (A1.5), we see that in a symmetric equilibrium within each country,

$$\begin{aligned} E u^1 &= l_0 + \frac{((1-\alpha)\eta + \alpha)\theta}{\alpha(1-\alpha)} + \frac{((1-\alpha)\eta + \alpha s_1) E w_r^1 + \alpha s_2 E w_r^2}{(1-\alpha)(\alpha + (1-\alpha)\eta)}, \\ E u^2 &= l_0 + \frac{((1-\alpha)\eta + \alpha)\theta}{\alpha(1-\alpha)} + \frac{((1-\alpha)\eta + \alpha s_2) E w_r^2 + \alpha s_1 E w_r^1}{(1-\alpha)(\alpha + (1-\alpha)\eta)}, \end{aligned} \quad (\text{A1.12})$$

where $E w_r^c$ is the expected value, prior to the realization of shocks in the MU, of the real wage in country c .

It is convenient to find the (expected value of the) competitive real wage in each country. The system of equations in (A1.12) yields the competitive real wages in the two countries when the expected excess supply of labor in each country is zero. Setting $E u^1 = E u^2 = 0$ in (A1.12) and rearranging yields

$$\begin{aligned} \frac{((1-\alpha)\eta + \alpha s_1) E w_{rc}^1 + \alpha s_2 E w_{rc}^2}{(1-\alpha)(\alpha + (1-\alpha)\eta)} &= - \left\{ l_0 + \frac{((1-\alpha)\eta + \alpha)\theta}{\alpha(1-\alpha)} \right\}, \\ \frac{\alpha s_1 E w_{rc}^1 + ((1-\alpha)\eta + \alpha s_2) E w_{rc}^2}{(1-\alpha)(\alpha + (1-\alpha)\eta)} &= - \left\{ l_0 + \frac{((1-\alpha)\eta + \alpha)\theta}{\alpha(1-\alpha)} \right\}, \end{aligned} \quad (\text{A1.13})$$

where $E w_{rc}^1$ and $E w_{rc}^2$ are the expected values of the competitive real wages in the two countries. Due to the symmetry of the system in (A1.13) the competitive real wages in the two countries are identical. The common solution is given by

$$E w_{rc}^1 = E w_{rc}^2 = - \left\{ (1-\alpha)l_0 + ((1-\alpha)\eta + \alpha) \frac{\theta}{\alpha} \right\} \equiv E w_{rc}. \quad (\text{A1.14})$$

We now come to the final step of the solution. Substituting equation (A1.12) into the first-order condition in equation (A1.11) (for $c = 1$ and for $c = 2$) and using the solution for the competitive real wage in

(A1.14) yields, after some rearrangement,

$$\begin{aligned} ((1 - \alpha)\eta + \alpha s_1)\phi_1 + \alpha s_2\phi_2 &= \frac{(1 - \alpha)(\alpha + (1 - \alpha)\eta)}{A} \frac{Q_w^1}{Q_u^1}, \\ \alpha s_1\phi_1 + ((1 - \alpha)\eta + \alpha s_2)\phi_2 &= \frac{(1 - \alpha)(\alpha + (1 - \alpha)\eta)}{A} \frac{Q_w^2}{Q_u^2}, \end{aligned} \quad (\text{A1.15})$$

where

$$\phi_c \equiv E(w_r^c - w_{rc}) = Ew_r^c - Ew_{rc}, \quad c = 1, 2, \quad (\text{A1.16})$$

is the (expected value of the) difference between the equilibrium wage in country c and the competitive real wage rate. Following CCD (2000), we refer to ϕ_c as the “wage premium” in country c . Equations (A1.15) are the (implicit) reaction functions of the two countries to each other (expected values of) real wages. They imply that the real wages in the two countries are strategic substitutes. When the real wage in one country is higher, the real wage chosen by the other country is lower. The reason is that a higher real wage in, say, country 2 leads to a higher general price level and depresses real money balances in the MU (see equation A1.5). As a consequence the level of demand facing firms in country 1 is lower and so are their derived demands for labor. Labor unions in country 1 must content themselves with lower expected real wages. Equations (A1.15) provide a system of two simultaneous equations that determines the wage premia in the two countries. The solutions are given by

$$\phi_c = \frac{1}{A} \left\{ (1 - \alpha) \frac{Q_w^c}{Q_u^c} + \frac{\alpha s_{\bar{c}}}{\eta} \left(\frac{Q_w^c}{Q_u^c} - \frac{Q_w^{\bar{c}}}{Q_u^{\bar{c}}} \right) \right\}, \quad c = 1, 2, \quad (\text{A1.17})$$

where the superscript \bar{c} means “not c .” For example, if $c = 1$, $\bar{c} = 2$. We denote $q^c \equiv Q_w^c/Q_u^c$. The explicit expression for q^c is reported in expression (1.24) in the text.

1.6.2 Derivation of Equation (1.27)

From the expression for the competitive real wage (equation A1.14), it is possible to rewrite equations (A1.12) as

$$\begin{aligned} Eu^1 &= \frac{((1 - \alpha)\eta + \alpha s_1)\phi_1 + \alpha s_2\phi_2}{(1 - \alpha)(\alpha + (1 - \alpha)\eta)}, \\ Eu^2 &= + \frac{((1 - \alpha)\eta + \alpha s_2)\phi_2 + \alpha s_1\phi_1}{(1 - \alpha)(\alpha + (1 - \alpha)\eta)}. \end{aligned} \quad (\text{A1.18})$$

Since $s_1 + s_2 = 1$, these equations can be rewritten, after some algebra, as

$$\begin{aligned} Eu^1 &= \frac{\phi_1}{(1-\alpha)} + \frac{\alpha s_2(\phi_2 - \phi_1)}{(1-\alpha)(\alpha + (1-\alpha)\eta)}, \\ Eu^2 &= \frac{\phi_2}{(1-\alpha)} - \frac{\alpha s_1(\phi_2 - \phi_1)}{(1-\alpha)(\alpha + (1-\alpha)\eta)}. \end{aligned} \tag{A1.19}$$

The extreme right-hand side of equation (1.27) is obtained by substituting the last two equations into the middle part of (1.27) and by rearranging.

1.6.3 Proof of Proposition 1.1

Examination of equation (1.24) reveals that q^c is a decreasing function of η . It follows, from equations (1.26), (1.27), and (1.29) that the MU-wide expected values of the wage premium, the rate of unemployment, and inflation are all decreasing in η .

1.6.4 Proof of Proposition 1.2

Differentiating equation (1.24) with respect to I and rearranging gives

$$\frac{\partial q^c}{\partial I} = - \frac{(1-\alpha) \left\{ 2(1-\alpha)^2 I + 1 - \frac{s_c}{n_c} \right\} \frac{s_c}{n_c}}{\left[\frac{\eta(1+\alpha(1-\alpha)^2 I)}{\alpha + \eta(1-\alpha)} \left(1 - \frac{s_c}{n_c} \right) + (1-\alpha) I \frac{s_c}{n_c} \right]^2} < 0.$$

Application of this result to equation (1.26) implies that the expected, MU-wide, wage premium is lower, the higher is I . It then follows immediately from equations (1.27) and (1.29) that the expected values of unemployment and of inflation in the MU are lower the higher the I .

1.6.5 Proof of Proposition 1.3

We first show that q^c is a decreasing function of s_c and an increasing function of n_c . Let $\tau_c \equiv s_c/n_c$. Differentiating q^c with respect to τ_c yields

$$\frac{\partial q^c}{\partial \tau_c} = \frac{-\alpha(1-\alpha)I}{(Q_u^c)^2 (\alpha + \eta(1-\alpha))(1 + \alpha(1-\alpha)^2 I)} < 0, \quad c = 1, 2.$$

Proposition 1.3 follows from equations (1.26), (1.27), and (1.29), together with the fact that q^c is increasing in n_c .

1.6.6 Proof of Proposition 1.4

The proof of part i is obtained by substituting equation (1.23) into equations (A1.18). After some algebra this yields

$$Eu^c = \frac{q^c}{A}, \quad c = 1, 2.$$

The proof of part i is completed by using the fact that $\partial q^c / \partial \tau_c < 0$. Parts ii and iii are particular cases of part i.

1.6.7 Derivation of Equation (1.31)

Expressions (1.12) provide a system of two simultaneous equations from which the average price levels of the goods produced in the two countries (p_1 and p_2) can be solved in terms of the nominal wages, the money supply, and the realized shocks. The solutions are given by

$$p_c = \theta D + \frac{1}{D} \{ (s_{\bar{c}} + D s_c) [\alpha w_c + (1 - \alpha)(m + g_c) - z_c] + s_{\bar{c}}(D - 1) [\alpha w_{\bar{c}} + (1 - \alpha)(m + g_{\bar{c}}) - z_{\bar{c}}] \}, \quad c = 1, 2. \quad (\text{A1.20})$$

where $D \equiv \alpha + \eta(1 - \alpha)$. Equation (1.31) is obtained by subtracting p , obtained from equation (1.13), from equation (A1.20) and by rearranging.

1.6.8 Derivation of Equation (1.35)

Substituting equation (1.31) for the relative price in country c ($c = 1, 2$) into the expression for u_c (equation 1.15) and rearranging

$$\begin{aligned} u_c &= \frac{-E w_{rc}}{(1 - \alpha)} \\ &+ \frac{(1 - \alpha)\eta + \alpha s_c}{[(1 - \alpha)\eta + \alpha](1 - \alpha)} (w_c - p) + \frac{\alpha s_{\bar{c}}}{[(1 - \alpha)\eta + \alpha](1 - \alpha)} (w_{\bar{c}} - p) \\ &- \frac{(1 - \alpha)(\eta - 1) + s_c}{[(1 - \alpha)\eta + \alpha](1 - \alpha)} z_c - \frac{s_{\bar{c}}}{[(1 - \alpha)\eta + \alpha](1 - \alpha)} z_{\bar{c}} \\ &+ \frac{s_{\bar{c}}}{(1 - \alpha)\eta + \alpha} (g_{\bar{c}} - g_c), \end{aligned} \quad (\text{A1.21})$$

where $(w_c - p) \equiv w_r^c$, and

$$\frac{-E w_{rc}}{(1 - \alpha)} = \left[l_0 + \frac{(1 - \alpha)\eta + \alpha \theta}{(1 - \alpha)} \frac{1}{\alpha} \right]$$

(see equation A1.14).³³

The *aggregate* competitive wage, w_{rc} , is obtained by setting $u = 0$ in equation (1.17), and using equation (A1.5) to substitute away for m . Thus

$$w_{rc} = - \left[(1 - \alpha)l_0 + [(1 - \alpha)\eta + \alpha] \frac{\theta}{\alpha} \right] + \bar{z}. \quad (\text{A1.22})$$

Since (from equations A1.14 and A1.22) $E w_{rc} = w_{rc} - \bar{z}$, country c 's unemployment in (A1.21) can be rewritten as

$$\begin{aligned} u_c &= \frac{(1 - \alpha)\eta + \alpha s_c}{[(1 - \alpha)\eta + \alpha](1 - \alpha)} (w_r^c - w_{rc}) \\ &\quad + \frac{\alpha s_{\bar{c}}}{[(1 - \alpha)\eta + \alpha](1 - \alpha)} (w_r^{\bar{c}} - w_{rc}) \\ &\quad - \frac{(\eta - 1)s_{\bar{c}}}{(1 - \alpha)\eta + \alpha} (z_c - z_{\bar{c}}) + \frac{s_{\bar{c}}}{(1 - \alpha)\eta + \alpha} (g_{\bar{c}} - g_c). \end{aligned} \quad (\text{A1.23})$$

Thus u_c is a function of the differences between the *ex post* values of the actual real wage in each country and the *aggregate* competitive wage ($w_r^c - w_{rc}$ and $w_r^{\bar{c}} - w_{rc}$ respectively). Since, by definition, $w_r^c \equiv w^c - p$, the randomness associated with the real wage of each country depends entirely on the realization of the *aggregate* price level, p , in stage 3. From equation (1.13),

$$w_r^c \equiv w^c - p = w^c - [(1 - \alpha)\eta + \alpha]\theta + \alpha\bar{w} + (1 - \alpha)(m + \bar{g}) - \bar{z}. \quad (\text{A1.24})$$

Using equation (1.19) to substitute m away in (A1.24), we can rewrite the expression for w_r^c as

$$w_r^c = E(w_r^c) + \frac{1}{1 + (1 - \alpha)^2 I} \bar{z}, \quad c = 1, 2, \quad (\text{A1.25})$$

where $E(w_r^c)$ is the expected real wage in country c . Combining the expression for $E(w_{rc})$ from equation (A1.14) with equation (A1.25), we obtain

$$\begin{aligned} w_r^c - w_{rc} &= \left(E(w_r^c) + \frac{1}{1 + (1 - \alpha)^2 I} \bar{z} \right) - (E(w_{rc}) + \bar{z}) \\ &= \phi_c - \left(\frac{(1 - \alpha)^2 I}{1 + (1 - \alpha)^2 I} \right) \bar{z}, \quad c = 1, 2. \end{aligned} \quad (\text{A1.26})$$

After using equation (A1.26) to substitute away both $(w_r^c - w_{rc})$ and $(w_r^{\bar{c}} - w_{rc})$ in equation (A1.23) and rearranging, we obtain

$$\begin{aligned}
 u_c = & \left\{ \frac{(1-\alpha)\eta + \alpha s_c}{[(1-\alpha)\eta + \alpha](1-\alpha)} \phi_c + \frac{\alpha s_{\bar{c}}}{[(1-\alpha)\eta + \alpha](1-\alpha)} \phi_{\bar{c}} \right\} \\
 & - \left[\frac{(1-\alpha)I s_c}{1 + (1-\alpha)^2 I} + \frac{(\eta-1)s_{\bar{c}}}{[(1-\alpha)\eta + \alpha]} \right] \cdot z_c \\
 & - \left[\frac{(1-\alpha)I s_{\bar{c}}}{1 + (1-\alpha)^2 I} - \frac{(\eta-1)s_{\bar{c}}}{(1-\alpha)\eta + \alpha} \right] \cdot z_{\bar{c}} \\
 & + \frac{s_{\bar{c}}}{(1-\alpha)\eta + \alpha} (g_{\bar{c}} - g_c), \quad c = 1, 2.
 \end{aligned} \tag{A1.27}$$

Equation (1.35) in the text is obtained by rearranging equation (A1.27).

Note that although the aggregate shock $\bar{g} = s_1 g_1 + s_2 g_2$ is fully offset by the CB (see equation 1.19), the individual shocks g_1 and g_2 separately affect *each* country's rate of unemployment.

Notes

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1. An overview appears in Calmfors (2001). In some of the literature, the level of central bank conservativeness is found to have real effect only if unions are averse to inflation (Yashiv 1989; Gylfason and Lindbeck 1994; Jensen 1997; Skott 1997; Gruner and Hefeker 1999). The breakdown of monetary neutrality under inflation-aversion is not as surprising compared with the case where all individuals in the private sector care only about real variables.

2. In related work Gruner and Hefeker (1999) and Cukierman and Lippi (2001) analyze the real effects of the replacement of national monetary policies or an ERM by a monetary union. These effects are triggered by changes in the strategic interactions of unions with the CB. Lawler (2000) considers the effect of shocks in a closed unionized economy, and Lane (2000) considers the effect of shocks in an MU, but without explicit modeling of the behavior of unions and price-setting firms.

3. See also equations (1.10) and (1.11) below.

4. We will also occasionally refer to the parameter I as central bank conservativeness (CBC).

5. The permanent level of output in each country is defined as the equilibrium level of output in the absence of shocks. Those levels do not therefore depend on the realizations of shocks.

6. The constant values of (Y_1^p, Y_2^p) have been subsumed into the functional form of $F(\cdot)$.

7. Although this specification is reminiscent of the demand for good j in Blanchard and Kiyotaki (1987), it is based on somewhat different underpinnings. Blanchard and Kiyotaki derive it from a particular utility function in a model with no interest rate. In our model the primitive is the demand facing firm j rather than utility, but the role of the interest rate in affecting demand is incorporated explicitly. In a previous version of this paper (Coricelli, Cukierman, and Dalmazzo 2001) we had postulated a variant of such a demand function as the primitive.

8. In that we deviate from much of the recent literature on the strategic interaction between unions and the CB, built on unions' inflation-aversion. A nonexhaustive list includes Jensen (1997), Skott (1997), Cukierman and Lippi (1999), Guzzo and Velasco (1999), Lippi (2000), Lawler (2000), and our own work in Coricelli, Cukierman and Dalmazzo (2000). The reason for this abstraction is that unions' concern about unemployment among their members is likely to be far more important than their fear of inflation.

9. The index j identifies the firm and the index i identifies the union that organizes that firm's labor force.

10. Using (1.8) in (1.9), we obtain the following alternative form of a typical firm's demand for labor

$$l_{ij}^{dc} = \kappa + \frac{1}{\alpha + \eta(1 - \alpha)} [-\eta(w_i^c - p) + (m - p) + g_c + (\eta - 1)z_c],$$

where $\kappa \equiv -\eta\theta/\alpha$. This alternative form implies that, other things the same, when the union manages to raise its real wage, the demand for labor by the firm goes down unless real money balances also increase.

11. More precisely, it is an average of the logarithms of nominal wages in country c .

12. Note, however, that a higher productivity level also raises the competitiveness of a country's products ($p_c - p$ goes down), which reduces unemployment by raising demand for the products of the country. This general equilibrium effect is incorporated into the analysis later.

13. The result that \bar{z} has no net effect on employment is a specific feature of this model. In general, the effect of \bar{z} on unemployment is likely to be small in comparison to its effect on inflation. As a consequence the reaction of the CB to the productivity shocks will be motivated by the desire to iron out fluctuations in inflation, even when the two opposite effects of \bar{z} on employment do not exactly offset each other.

14. Econometric evidence appears in Cukierman, Rodriguez, and Webb (1998) and casual evidence in Hall (1994) and in Hall and Franzese (1998). Further details appear in subsection 2.2 of CCD (2000).

15. The expressions for the expected values of average unemployment and inflation in the MU are similar to those obtained in the closed economy model of CCD (2000) with country variables replaced by their MU aggregate counterparts. Compare equations (1.27) and (1.29) here with equations (24) and (25) in CCD (2000).

16. See section 1.6.3 of the appendix for a proof.
17. See section 1.6.4 of the appendix for a proof.
18. This mechanism is basically identical to that found in the closed economy framework in CCD (2000) for the case in which unions are not directly averse to inflation.
19. See section 1.6.5 of the appendix for a proof.
20. For further discussion of those channels the reader is referred to section 3.2 of CCD (2000).
21. Cukierman and Lippi (2001) rely on a similar mechanism, in the context of inflation averse labor unions, to argue that the formation of a MU will raise unions' wage aggressiveness by raising the number of unions playing against the single CB.
22. Equation (1.30) is obtained by applying the expected value operator to equation (A1.5) and using equations (A1.16) and (1.25).
23. The proof appears in section 1.6.6 of the appendix. Since the competitive real wages are the same in both countries all the statements made about expected wage premia in the preceding propositions also apply to expected real wages in both countries.
24. The proof is a direct consequence of the fact that $\partial q^c / \partial I < 0$ and $E u^c = q^c / A$. The first relation is established in the proof of proposition 1.2 and the second in the proof of proposition 1.4. Both proofs appear in the appendix.
25. See also note 13.
26. From the monetary rule in equation (1.19), the variance of the money supply turns out to be
- $$\text{var}(m) = E[m - E(m)]^2 = \frac{(1 - \alpha)^2 I^2}{[1 + (1 - \alpha)^2 I]^2} \sigma_{\bar{z}}^2 + \sigma_{\bar{s}}^2.$$
- Since $\partial \text{var}(m) / \partial I > 0$, the degree of activism in the management of money supply increases in CB conservativeness.
27. Equation (1.34) is obtained by substituting equation (A1.27) for $c = 1, 2$ into equation (1.16), and by rearranging.
28. The terms "populist" and "ultra liberal" to designate a CB with $I = 0$ are due, respectively, to Guzzo and Velasco (1999) and Cukierman and Lippi (1999).
29. Chprits (2001) utilizes the framework of this chapter to characterize economic performance in a pre-monetary union situation, in which one country (the follower) unilaterally pegs its exchange rate to the currency of the other country (the leader). She utilizes this framework to show that replacement of an EMS type system (in which the countries in the "follower" block unilaterally pegs their currencies to that of the leader country) by a monetary union affects real economic performance. In particular, other things the same, unemployment in the leading or core (follower or periphery) country is lower (higher) under EMU than under an EMS type system.
30. In related work for a single closed economy with many unions, Bratsiotis and Martin (1999) reach a similar conclusion using a framework in which the policy rule of the CB (rather than its objectives) is taken as the primitive. In a model with traded and non-traded goods Holden (1999) shows that the type of monetary regime (exchange rate rule vs. a price target) affects the composition of employment across sectors.

31. This trade-off is a generalized one since a more conservative CB is associated with better average performance not only with respect to inflation (as in Rogoff) but also with respect to unemployment.
32. A recent survey of New Keynesian models appears in Clarida, Gali, and Gertler (1999).
33. Note that w_c designates the nominal wage in country c , w_{rc} designates the MU-wide competitive real wage and w_r^c designates the competitive real wage in country c .

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