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1 Introduction

The creation of the European Monetary Union has significantly changed the institutional framework in which economic agents operate. In Coricelli *et al.* (2004), for instance, the formation of the monetary union (MU) is shown to have a twofold effect: on the one hand, it reduces the size of each firm and on the other hand it increases the degree of competition in product markets and consequently in the labor market. The first effect encourages wage aggressiveness and hence unemployment and inflation[1]. The second effect, on the contrary, dampens wage demands and stimulates employment. In this respect, a larger competition implies that for an increase in the wage demanded the unemployment consequences among union's members are greater. By the same token, a more conservative central bank (CB) reacts to wage claims by reducing its money supply and further boosting unemployment. It then follows that, with

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[1]In a siminal vein, a larger number of unions due to the formation of a MU entails that each union internalizes a smaller fraction of their inflationary wage settlement (Cukierman and Lippi, 2001).

non atomistic wage setters, the threat of unemployment provoked by a conservative CB curbs wage aggressiveness and consequently stimulates employment in the MU.

Most of the papers in the policy games literature assume a closed-economy framework[2] or a MU in which the member countries do not trade and are *only* linked through a common CB (e.g. Cukierman and Lippi, 2001; Soskice and Iversen, 1998; Grüner and Hefeker, 1999). Nevertheless the hypothesis that changes in the price level abroad do not have an impact on the home country via competitiveness or consumption wage effects but only indirectly via the reaction of the common CB is clearly an unrealistic scenario. When open economy aspects are taken into account the results derived in the recent literature on strategic institutional interactions are not generally robust.

Now when countries trade each other new issues arise from the strategic interactions among home and foreign CBs and home and foreign labor unions. This paper aims to investigate how strategic interactions between national monetary policies of two countries influence the wage setting behavior of labor unions and it contributes with a study on the long run economic consequences on the welfare.

We use a general-equilibrium model of two countries, different in size and labor market institutions, characterized by monopolistic competition in the product market and unionized labor markets. In a micro-founded framework in line with the new open economy macroeconomics, we show that under a floating regime the presence of an inflation averse *foreign* CB always increases employment in the home country. Moreover we challenge the main idea that a conservative *domestic* CB can always reduce unemployment at country level (Coricelli *et al.* 2004). We demonstrate that a more conservative CB and centralization of wage setting reduce unemployment only if labor market distortions are sizeable. However, a fully centralized wage bargaining system always maximizes welfare. When conversely labor distortions are sufficiently low, employment and welfare may be maximized by atomistic wage setters or a populist CB.

The structure of the paper is as follows. Section 2 develops the model under a flexible exchange rate regime. Section 3-6 compute the optimal strategy of each player. Section 7 analyzes the effects of the number of unions and CBC on employment and inflation in the two countries. Section 8 presents the conclusions.

2 Economic Setup

In this section we develop a general equilibrium model in a micro-founded framework. The economy comprises two countries, indexed H (home) and F (foreign), whose relative size is γ and $1-\gamma$, respectively. The domestic country is inhabited by a continuum of symmetric agents $j \in (0,\gamma)$, while $j^* \in (\gamma,1)$ agents settle in the foreign country[3].

The countries trade two types of goods but each country is specialized in the production of only one type. Each traded good can, in turn, be manufactured

[2] Among others Coricelli *et al.* (2000), Cubitt (1992; 1995), Guzzo and Velasco (1999), Lippi (1999), Skott (1997).

[3] Throughout the paper foreign variables are denoted by an asterisk.

by a continuum of monopolistic competitive firms in a variety of brands indexed by z.

Labor is the only factor of production and is differentiated in a variety of types defined in the continuous interval $(0,1)$. All workers are unionized and distributed equally among trade unions. Each agent supplies a differentiated labor type and, for a given wage, is willing to provide whatever quantity of labor is required to clear the market.

Each country has its own CB that is appointed to conduct the national monetary policy independently and non-cooperatively with the other CB.

A three-stage game is considered. In the first stage unions choose the growth rate of the nominal wages of their members simultaneously. In the second stage the CBs choose the growth of rate of money supply simultaneously in the two countries. In the third stage the firms set their own price. The game is then solved by backward induction.

2.1 Supply side

The world economy is inhabited by a continuum of monopolistic competitive firms, indexed by $z \in (0,1)$, each producing a differentiated brand. For convenience domestic firms are placed in the contiguous subinterval $[0,\gamma]$ of the unit interval, while foreign firms lie on the subinterval $[\gamma,1]$. Each firm uses a continuum of labor types according to the following decreasing-return-to-scale technology

$$Y_H(z) = \left(\int_0^1 L_i(z)^{\frac{\sigma-1}{\sigma}} di \right)^{\frac{\sigma\alpha}{\sigma-1}}, \qquad 0 < \alpha < 1,\ \sigma > 1$$

where $Y(z)$ is the output of the brand z produced in the home country, $L_i(z)$ is the labor type i supplied by the worker represented by union i, σ is the elasticity of substitution among labor types and α is representing the return to scale parameter. Firms are assumed to have market power in the product market but not in the labor market so that they take wages as given. Cost minimization implies the following domestic firms's demand for labor of type i

$$L_i(z) = \left(\frac{W_i}{W} \right)^{-\sigma} (Y(z))^{\frac{1}{\alpha}} \tag{1}$$

where

$$W = \left(\int_0^1 W_i^{1-\sigma} di \right)^{\frac{1}{1-\sigma}}$$

is the aggregate wage defined as the minimal nominal cost of producing a unit of output z in the home country.

2.2 Preferences

Each agent consumes a continuum of differentiated goods and supplies a differentiated labor type. The utilities of agents j and j^* are defined over consumption and hours worked as follows:

$$U_j = \log C_j - \frac{k}{2} (\log L_j)^2 \qquad k > \alpha$$

$$U_{j^*} = \log C_{j^*} - \frac{k}{2}(\log L_{j^*})^2 \qquad k > \alpha$$

where k is a preference parameter[4]. C_j and C_{j^*} are the consumption index of agent j and j^* defined respectively as follows:

$$C_j = \frac{C_{j,H}^{\gamma} C_{j,F}^{1-\gamma}}{\gamma^{\gamma}(1-\gamma)^{1-\gamma}} \quad ; \quad C_{j^*} = \frac{C_{j^*,H}^{\gamma} C_{j^*,F}^{1-\gamma}}{\gamma^{\gamma}(1-\gamma)^{1-\gamma}}.$$

The consumption index of home (foreign) agent j (j^*) consists of two baskets, one of the home-produced good, $C_{j,H}$ ($C_{j^*,H}$), and one of the foreign-produced good, $C_{j,F}$ ($C_{j^*,F}$). The basket of the home- and foreign-produced good are in turn a constant-elasticity-of-substitution function of brands:

$$C_{j,H} = \left[\left(\frac{1}{\gamma}\right)^{\frac{1}{\lambda}} \int_0^{\gamma} (C_{j,H}(z))^{\frac{\lambda-1}{\lambda}} dz \right]^{\frac{\lambda}{\lambda-1}}$$

$$C_{j,F} = \left[\left(\frac{1}{1-\gamma}\right)^{\frac{1}{\lambda}} \int_{\gamma}^{1} (C_{j,F}(z))^{\frac{\lambda-1}{\lambda}} dz \right]^{\frac{\lambda}{\lambda-1}}$$

where $C_{j,H}(z)$ ($C_{j,F}(z)$) is the jth individual's consumption of brand z produced in the home (foreign) country, and $\lambda > 1$.[5] Similar consumption indices of brand z hold for j^*th individual abroad.

The jth individual's optimal consumption allocation of the home and foreign good is respectively

$$C_{j,H} = \gamma \left(\frac{P_H}{P}\right)^{-1} C_j \quad ; \quad C_{j,F} = (1-\gamma)\left(\frac{P_F}{P}\right)^{-1} C_j$$

where

$$P = P_H^{\gamma} P_F^{1-\gamma} \tag{2}$$

is the consumer price index (CPI) in the home currency and

$$P_H = \left[\frac{1}{\gamma}\int_0^{\gamma} P_H(z)^{1-\lambda} dz\right]^{\frac{1}{1-\lambda}} \quad ; \quad P_F = \left[\frac{1}{1-\gamma}\int_{\gamma}^{1} P_F(z)^{1-\lambda} dz\right]^{\frac{1}{1-\lambda}}, \tag{3}$$

are the home and foreign producers index, respectively.

Likewise the j^*th individual's optimal consumption allocation is:

$$C_{j^*,H} = \gamma \left(\frac{P_H^*}{P^*}\right)^{-1} C_{j^*} \quad ; \quad C_{j^*,F} = (1-\gamma)\left(\frac{P_F^*}{P^*}\right)^{-1} C_{j^*}$$

where

$$P^* = P_H^{*\gamma} P_F^{*1-\gamma} \tag{4}$$

[4] Two conditions are to be satisfied by the utility function. The first is the disutility of work ($\frac{\delta U_j}{\delta L_j} < 0$, which implies $\log L_j > 0$). The second is the concavity of the utility function in leisure ($\frac{\delta^2 U_j}{\delta L_j^2} = -\frac{k}{L_j^2}(1 - \log L_j) < 0$, implying that $\log L_j < 1$). The assumption $k > \alpha$ garantees that in equilibrium $0 < \log L_j < 1$ holds (see equation (49)).

[5] The parameter λ is the price elasticity of demand faced by each monopolist. The inequality constraint ensure an interior equilibrium with a positive level of output. This relationship will become apparent later when we solve for the optimal price setting.

is the CPI in foreign currency and

$$P_H^* = \left[\frac{1}{\gamma}\int_0^{\gamma} P_H^*(z)^{1-\lambda}dz\right]^{\frac{1}{1-\lambda}} \quad ; \quad P_F^* = \left[\frac{1}{1-\gamma}\int_{\gamma}^{1} P_F^*(z)^{1-\lambda}dz\right]^{\frac{1}{1-\lambda}} \tag{5}$$

are the home and foreign producers index, respectively.

2.3 Demand side

We assume that the law of one price holds across all individual brands, i.e. $P_H(z) = EP_H^*(z)$ and $P_F(z) = EP_F^*(z)$ where E denotes the nominal exchange rate. Note that the indices (2), (3), (4) and (5) imply that purchasing power parity also holds across the overall consumption price indices, i.e.

$$P = EP^*. \tag{6}$$

The domestic allocation of consumption across the various brands is:

$$C_{j,H}(z) = \frac{1}{\gamma}\left(\frac{P_H(z)}{P_H}\right)^{-\lambda} C_{j,H} = \left(\frac{P_H(z)}{P_H}\right)^{-\lambda}\left(\frac{P_H}{P}\right)^{-1} C_j \tag{7}$$

$$C_{j,F}(z) = \frac{1}{1-\gamma}\left(\frac{P_F(z)}{P_F}\right)^{-\lambda} C_{j,F} = \left(\frac{P_F(z)}{P_F}\right)^{-\lambda}\left(\frac{P_F}{P}\right)^{-1} C_j \tag{8}$$

where $P_H(z)$ and $P_F(z)$ are the home-currency prices for a brand z charged by a domestic and foreign firm respectively. Recall that $\lambda > 1$ captures the elasticity of substitution among varieties, while the elasticity of substitution between the domestic and foreign good is equal to one.

The corresponding foreign allocation of consumption across brands is:

$$C_{j^*,H}(z) = \frac{1}{\gamma}\left(\frac{P_H^*(z)}{P_H^*}\right)^{-\lambda} C_{j^*,H} = \left(\frac{P_H^*(z)}{P_H^*}\right)^{-\lambda}\left(\frac{P_H^*}{P^*}\right)^{-1} C_{j^*} \tag{9}$$

$$C_{j^*,F}(z) = \frac{1}{1-\gamma}\left(\frac{P_F^*(z)}{P_F^*}\right)^{-\lambda} C_{j^*,F} = \left(\frac{P_F^*(z)}{P_F^*}\right)^{-\lambda}\left(\frac{P_F^*}{P^*}\right)^{-1} C_{j^*} \tag{10}$$

where $P_H^*(z)$ and $P_F^*(z)$ are the foreign-currency prices charged for a brand z by a domestic and foreign firm respectively.

Thus integrating the demand for a particular brand across the home (7) and foreign agents (9) yields the total demand faced by a domestic firm z:

$$Y_H(z) = \left(\frac{P_H(z)}{P_H}\right)^{-\lambda}\left(\frac{P_H}{P}\right)^{-1} C_W \tag{11}$$

where $C_W \equiv C + C^*$ is total consumption in the world economy, $C \equiv \int_0^{\gamma} C_j dj$ is the aggregate consumption in the home country and $C^* \equiv \int_{\gamma}^{1} C_{j^*} dj^*$ is the aggregate consumption in the foreign country.

Similarly, aggregating (8) and (10) across agents, we obtain the total demand for a foreign brand as follows:

$$Y_F(z) = \left(\frac{P_F^*(z)}{P_F^*}\right)^{-\lambda}\left(\frac{P_F^*}{P^*}\right)^{-1} C_W. \tag{12}$$

The current account equilibrium entails that the level of consumption in the two countries be constant and proportional to the economy dimension[6]:

$$C = \gamma C_W \quad ; \quad C^* = (1-\gamma)C_W. \tag{13}$$

Each agent in the economy needs cash in advance so as to pay for her nominal expenses

$$M_j = PC_j \quad ; \quad M_{j^*} = P^*C_{j^*}. \tag{14}$$

Under these assumptions the nominal exchange rate is proportional to nominal spending and corresponds to the relative money supply

$$E = \frac{PC}{P^*C^*} = \frac{M}{M^*} \tag{15}$$

where $M \equiv \int_0^\gamma M_j dj$ and $M^* \equiv \int_\gamma^1 M_{j^*} dj^*$ are total money supply in the home and foreign country, respectively. By normalizing the previous period nominal money supply and exchange rate, the current nominal money supplies and the exchange rate can be expressed as

$$M = 1 + m \quad ; \quad M^* = 1 + m^* \quad ; \quad E = 1 + e$$

where lower-case letters stand for percentage increases. In the text, the following approximation of equation (15) is exploited

$$m = e + m^* \tag{16}$$

where $m \approx \log M$, $m^* \approx \log M^*$ and $e \approx \log E$.

Finally, using (13) and (14), the aggregate-nominal demand (11) in the domestic country can be rewritten as

$$P_H Y_H \equiv \int_0^\gamma P_H(z) Y_H(z) dz = M. \tag{17}$$

Likewise in the foreign country the aggregate nominal demand is proportional to money supply

$$P_F^* Y_F \equiv \int_\gamma^1 P_F^*(z) Y_F(z) dz = M^*. \tag{18}$$

2.4 Individual budget constraints

To complete the qualification of the individual's problem, we consider the agent's budget constraint. Each jth individual draws a salary for the labor type supplied to firm z which, in turn, distributes dividends evenly among its owners (all of the workers). Markets are complete domestically and international equity trade is forbidden[7]. Moreover, in order to pay for nominal expenses, cash in advance is needed. Under these assumptions, the domestic agent's budget constraint is

$$M_j \geq PC_j = W_j L_j(z) + D_j(z) \tag{19}$$

where M_j are money balances, W_j is the nominal wage and $D_j(z)$ are dividends received by firm z. The j^*th agent is subject to a similar budget constraint.

[6] This result is due to the full international risk sharing as in Obstfeld and Rogoff (1998) and Corsetti and Pesenti (2001).

[7] Given the Cobb-Douglas preferences over home and foreign goods and the separability of agents' utility functions, international equity trade would not affect equilibrium outcomes.

2.5 Unions

As said above, labor is supplied in a variety of labor types defined in the interval $(0, 1)$ while each agent provides firm z only with a specific labor type. Although workers can be employed in all industries, they are not perfectly substitute to workers associated with other unions. In other words labor is differentiated and each type i is represented by union i. Thus a jth individual can be associated with a sole labor union i, i.e. $j \in i$.

The home country is populated by a finite number of unions, n_H. Since all workers are unionized and equally distributed among unions, each union has mass $\frac{1}{n_H}$ and $\frac{1}{n_F}$ in the home and foreign country respectively. In our setup the degree of centralization of wage setting (CWS) is proportional to union size and is higher the smaller the number of independent union bargainers in the economy.

Note that the smaller is the number of unions, the more relevant is the impact of their wage settlement on aggregate variables. In this respect the CWS is directly related to the unions' capacity to internalize the macroeconomic consequences of wage variations[8].

The representative union is benevolent, i.e. it maximizes the utility of its members under the workers' budget constraint (19):

$$V_i = n_H \int_{j \in i} U_j dj \tag{20}$$

$$V_{i^*} = n_F \int_{j^* \in i^*} U_{j^*} dj^*. \tag{21}$$

We assume that each worker (and the union that represents her) takes profits as given[9]. The home (foreign) union sets the same rate of growth of the nominal wage ω_i (ω_{i^*}) among its members so as to maximize its own objective function. It is convenient to express the nominal wage of worker i, W_i, and the CPI in the home country as

$$W_i = 1 + \omega_i \quad ; \quad P = 1 + \pi,$$

where π is domestic inflation rate[10]. By the same token the following relations hold abroad:

$$W_{i^*} = 1 + \omega_{i^*} \quad ; \quad P^* = 1 + \pi^*.$$

The benevolent union hypothesis is in line with the trade union behavior surveyed by Oswald (1982) whose objective function usually includes real wages and unemployment[11].

[8] Drawing on Guzzo and Velasco (1999) we refer to such capacity as *internalization effect*.

[9] Aside from monopoly power, this adds an other distortion introduced in the model. Conversely, when we present the CB problem below, the CB will allow for all economy-wide interactions so as to internalize the effect of D on the welfare of agents.

[10] The previous period of nominal wage and inflation are nomalized to unity without loss of generality since equilibrium outcome does not depend on it.

[11] Grüner and Hefeker (1999), Soskice and Inversen (2001), Cukierman and Lippi (2001) evaluate the macroeconomic effect of monetary unification when unions are averse to inflation. However we focus on microeconomic instead of macroeconomic foundations to analyse unions' behavior.

2.6 Central Banks

Drawing on the literature on time inconsistency in monetary policy, we assume that the monetary authority is inflation averse and cares about the real performance in the economy, which in our setup corresponds to agents' utility[12].

In particular under national monetary policies, the domestic and foreign central banks aim at country-specific targets:

$$\Omega = \int_0^{\gamma} U_j dj - \frac{\beta_H}{2}\pi^2 \qquad \beta_H \geq 0 \tag{22}$$

$$\Omega^* = \int_{\gamma}^{1} U_{j^*} dj^* - \frac{\beta_F}{2}\pi^{*2} \qquad \beta_F \geq 0. \tag{23}$$

The parameters β_H and β_F point out the CB's degree of conservatism (Rogoff, 1985a). If the level of conservatism is zero the CB becomes a benevolent planner who cares only about the agents' welfare.

2.7 Timing structure of the model

In the first stage (at time 1), each union chooses the rate of growth of the nominal wage of its members in a simultaneous game with foreign and the other domestic unions so as to maximize its objective function (20). Moreover, in the maximization problem each union anticipates the reaction of the CB and of firms to its wage choice. The timing sequence is built on the notion that nominal wages are substantially more sticky than prices and monetary policy. The rationale for such an assumption is that workers are normally under contract for at least a year; thus, wage setters are committed to the bargained wage over the whole period of the game.

In the second stage (at time 2) the sovereign CB sets the country-specific money supply in a simultaneous non-cooperative game with the other monetary authority, taking as given the preset nominal wages and internalizing the reaction of firms. Monetary policy is hence stickier than price setting[13].

In the last stage (at time 3) each monopolistic competitive firm sets the price of its own brand so as to maximize its profit, taking the general price level, nominal wages and money supply as given[14].

The three-stage game between firms, monetary authorities and labor unions is solved by backward induction so as to find the Nash sub-game perfect equilibrium.

[12] The paper investigates how the design of the monetary institution affects the country performance. The notion of an inflation averse CB may be interpreted also as a kind of general institutional constraint in the economy.

[13] Models with a New Keynesian orientation *à la* Clarida, Gali and Gertler (1999) suppose that price setters move first than the monetary authority. However, the assumption of prices stickiness is more debatable than wages stickiness (see Cukierman, 2004).

[14] Notice that the timing of the game implies no precommitment of the CB. Monetary policy is hence set in a "discretionary" way. Moreover since firms are the last to move, prices may be considered as fully flexible.

3 Price setting

Henceforth we will focus mainly on the domestic country. However, it is important to bear in mind that there is a parallel with the optimization problems in the foreign country.

In the last stage of game each domestic firm maximizes its own profits solving the following problem:

$$\begin{aligned} \max_{P_H(z)} D(z) &= P_H(z)Y_H(z) - \int_0^1 W_i L_i(z)di \qquad (24) \\ \text{s. to } \int_0^1 W_i L_i(z)di &= WY_H(z)^{\frac{1}{\alpha}} \text{ and } Y_H(z) = \left(\frac{P_H(z)}{P_H}\right)^{-\lambda}\left(\frac{P_H}{P}\right)^{-1} C_W. \end{aligned}$$

The first constraint stems from the cost minimization problem of firms (see equation (1)). The second one is the result of the consumer problem derived previously. Solving (24) for the optimal relative price of firm z, we obtains after some algebra[15]:

$$\frac{P_H(z)}{P_H} = \left[\frac{\lambda}{\alpha(\lambda-1)}\frac{W}{P}\left(\frac{P_H}{P}\right)^{-\frac{1}{\alpha}}\left(\gamma\frac{M}{P} + (1-\gamma)\frac{M^*}{P^*}\right)^{\frac{1-\alpha}{\alpha}}\right]^{\frac{\alpha}{\alpha+\lambda(1-\alpha)}}.$$

As in the closed economy literature, the price rule is an increasing function of the real wage and real money balances. However two further effects are at work in an open economy framework. First, the terms of trade captured by ratio between the home producers index and the CPI. An increase in the price of home-produced good improves the terms of trade but reduces the optimal relative price. This is due to the loss of competitiveness of the home-produced good and the following shift in the demand. Consumers in both countries switch, in fact, from the more expensive home good to the cheaper foreign one inducing firm to decrease their own brand price in order to keep out of reduction in sales. Second, the aggregate demand includes also the real balance effect emanating from the other country. An increase in foreign money supply, in fact, boosts consumption both for foreign and domestic products.

In a symmetric equilibrium the price of a brand, $P_c(z)$, coincides with the producer price index, P_c, for all z, where $c \in [H, F]$. Thus taking the logarithms of each first order condition of domestic and foreign firms and using (16) yields[16]

$$\pi_H - \pi = \alpha(\omega - \pi) + (1-\alpha)(m - \pi) \qquad (25)$$

$$\pi_F^* - \pi^* = \alpha(\omega^* - \pi^*) + (1-\alpha)(m^* - \pi^*). \qquad (26)$$

Although prices are fully flexible, they do not completely move when the money supply changes (equation (25) and (26)). As a matter of fact, it is not optimal for profit maximizing firms to respond exactly in kind to the money supply as long as nominal wages have not been changed. This implies that the

[15] Coricelli *et al.* (2000) introduced for the first time the optimal price setting in the literature on nominal wage bargaining systems.

[16] In deriving the following expression, we neglect the costant $\alpha \log \frac{\lambda}{(\lambda-1)\alpha}$.

monetary authority may affect real variables, even when prices are fully flexible, for nominal wages are contractually fixed (Cukierman, 2004).

Arranging equation (25) and (26), we obtain the following negative relation between real money balances and wages:

$$m - \pi_H = -\frac{\alpha}{1-\alpha}(\omega - \pi_H) \tag{27}$$

$$m^* - \pi_F^* = -\frac{\alpha}{1-\alpha}(\omega^* - \pi_F^*) \tag{28}$$

From the definition of the CPI (4) and (2) and the exchange rate (16), the previous equations imply that the general price level can be rewritten in terms of domestic and foreign wages and money supplies as follows:

$$\pi = \alpha\gamma\omega + m(1-\alpha\gamma) + (1-\gamma)\alpha(\omega^* - m^*) \tag{29}$$

$$\pi^* = \alpha\gamma(\omega - m) + (1-\gamma)\alpha\omega^* + m^*\left[1 - \alpha(1-\gamma)\right]. \tag{30}$$

An accommodating sovereign monetary policy operates in the country through two channels: on the one hand it expands the demand faced by each monopolistic firm and, on the other hand, it depreciates the exchange rate. Both effects stimulate price hikes.

The foreign monetary policy has instead two opposing effects: the rise of the domestic demand and the appreciation of the exchange rate. The latter effect always prevails so that an increase in foreign money supply reduces domestic inflation.

At this stage domestic and foreign wages affect inflation in the country only through their impact on input costs which in turn determine domestic and foreign good prices, respectively. In the following sections we will see that monetary policies are in turn influenced by domestic and foreign wage settlements through strategic interactions.

4 Inflation-employment trade-off

In each country the sovereign CB faces a trade-off between inflation and employment. Let L_i and L_{i^*} indicate the aggregate employment of labor type i and i^* in the home and foreign country, respectively. L_i is achieved by integrating (1) across all domestic firms and using equation (17) which yields the following demand for labor type i

$$L_i = \left(\frac{W_i}{W}\right)^{-\sigma}\left(\frac{M}{P_H}\right)^{\frac{1}{\alpha}}. \tag{31}$$

Then plugging equation (25) into equation (31) and integrating across all labor types, we attain (the logarithm of) domestic aggregate employment

$$l \equiv \log\int_0^1 L_i = -\sigma\int_0^1(\omega_i - \omega)di + m - \omega. \tag{32}$$

Now the home Phillips curve is obtained by solving for money supply equation (32) and substituting it into (29),

$$\pi = l(1-\alpha\gamma) + \alpha(1-\gamma)(\omega^* - m^*) + \sigma(1-\alpha\gamma)\int_0^1(\omega_i - \omega)di + \omega. \tag{33}$$

The slope of the Phillips curve in the home country is hence

$$\frac{d\pi}{dl} = 1 - \alpha\gamma > 0. \tag{34}$$

An analogous Phillips curve holds in the foreign country,

$$\pi^* = l^* \left[1 - \alpha(1-\gamma)\right] + \sigma \left[1 - \alpha(1-\gamma)\right] \int_0^1 (\omega_{i^*} - \omega^*) di^* + \omega^* + \alpha\gamma(\omega - m),$$

whose slope is

$$\frac{d\pi^*}{dl^*} = 1 - \alpha(1-\gamma) > 0. \tag{35}$$

It is apparent that the slope of the Phillips curve is a decreasing function of the country size. Thus, if the home country is smaller (larger) than the foreign country, the domestic CB will face a steeper (flatter) Phillips curve.

Intuitively, the impact of money supply on employment is always equal to one in both country (see equation (32)). Labor market is "isolated" from foreign variables[17]. The general level of price is instead affected by both domestic and foreign variables. An expansionary monetary policy affects both the producer price index and the exchange rate. Since the CPI is a weighted average of the domestic and foreign good where the weight coincides with the country size, the larger is the country size, the "more closed" is its economy. In this context an accommodating monetary policy plays a less important effect on the CPI level through the exchange rate channel.

How does a different trade-off between inflation and employment affect optimal monetary policy? A domestic CB payoff (22) may be rewritten as

$$\Omega = \alpha l - \frac{k}{2} l^2 - \frac{\beta_H}{2} \pi^2$$

which yields

$$\frac{d\Omega}{dl} = \alpha - kl - \beta_H \frac{d\pi}{dl} \pi = 0. \tag{36}$$

According to equation (36), marginal benefits (first two terms) from boosting employment has to be equal to the marginal cost (last term). Here we clearly see the role played by the Phillips curve in the CB balances of unemployment and inflation. The weight given to inflation depends on the degree of conservatism and the slope of the Phillips curve. As a matter of fact, both CBC and the slope of the Phillips curve have the same function: they determine the relative weight put on inflation by the CB.

It is easy to see that, ceteris paribus, the effect of a flatter Phillips curve is similar to the effect of smaller CBC. The CB will adopt a more accommodating monetary policy either with a smaller degree of conservatism or a flatter Phillips curve. In both cases the CB would realize a higher loss from reducing inflation than unemployment[18]. The following proposition summarizes the main results achieved so far.

[17] As a matter of fact we will see below that foreign variables affect domestic employment strategically through the domestic monetary policy.

[18] We will see below that, since the CB's reaction function is common knowledge for labor unions, workers anticipate the incentive of the CB to inflate. In the "time-consistent" equilibrium the marginal benefit to higher inflation exactly offsets the marginal cost. The monetary authority could inflate above and beyond the worker (rational) expectations, but it is not in her interest to do so.

Proposition 1 *The size of a country affects the trade-off between inflation and employment so that the domestic Phillips curve is flatter (steeper),* $\frac{d\pi^*}{dl^*} > \frac{d\pi}{dl}$ *(*$\frac{d\pi^*}{dl^*} < \frac{d\pi}{dl}$*), if the home-country size is large (small) over the foreign-country size. Ceteris paribus, the CB has a stronger (weaker) incentive to inflate so as to achieve higher employment in a big (small) country.*

5 Monetary policy

This section examines the optimization problem of the two central banks under a national monetary policy regime. Both policies take place simultaneously in the second stage of the game.

5.1 Central bank reaction functions

Each CB chooses its money supply taking as given nominal wages and the other central money supply so as to maximize (22) under the Phillips curve investigated in the previous section (33). The two central banks choose money supply simultaneously as Nash players and act as Stackelberg-follower player vis-à-vis trade unions (Stackelberg leaders).

Under a national monetary policy regime the first order condition of the CB in the home country is[19]

$$\begin{aligned} \frac{\partial \Omega}{\partial l}\frac{\partial l}{\partial m} &= \alpha\frac{\partial l}{\partial m} - kl\frac{\partial l}{\partial m} - \beta_{_H}\frac{\partial \pi}{\partial l}\frac{\partial l}{\partial m}\pi = 0 \Longleftrightarrow \quad (37)\\ \frac{\alpha}{k} - l - \frac{\beta_{_H}\pi(1-\alpha\gamma)}{k} &= 0. \end{aligned}$$

According to expression (37), as long as the employment level is below the optimal one[20], $\frac{\alpha}{k}$ (see equation (49)), it is optimal for the CB to fuel a positive inflation rate through its monetary policy. By contrast, when employment is above the competitive level, CB deflates the general price level.

Using (36) and (32), we explicitly solve (37) for the domestic money supply

$$m = \frac{k\omega + \alpha\left[1 - \beta_{_H}(\omega^* - m^* + (m^* - \omega^* + \omega)\gamma)(1-\alpha\gamma)\right] + \sigma k\int_0^1(\omega_i - \omega)di}{k + \beta_{_H}(1-\alpha\gamma)^2}. \quad (38)$$

Similarly the reaction function of the foreign CB is derived by selecting the foreign money supply that maximizes (23) and internalizing the firms' reaction functions. This yields the following optimal money supply in the foreign country

$$m^* = \frac{k\omega^* + \alpha + \alpha\beta_{_F}\left[1-\alpha(1-\gamma)\right]\left[(m-\omega)\gamma - (1-\gamma)\omega^*\right] + \sigma k\int_0^1(\omega_{i^*} - \omega^*)di^*}{k + \beta_{_F}(1-\alpha(1-\gamma))^2}. \quad (39)$$

Equations (38) and (39) reveal the novelty of the paper: monetary policy depends both on domestic and foreign labor market aspects and on the monetary policy in the other country. In the next section we focus on the interaction between the two CBs.

[19] Since the CB is a large agent, profits are not taken as given.

[20] i.e. the level of employment that maximizes the workers' welfare equating the consumption/leisure marginal rate of substitution ($k \log L$) to the (efficient) technical rate of transformation ($\frac{1}{\alpha}$).

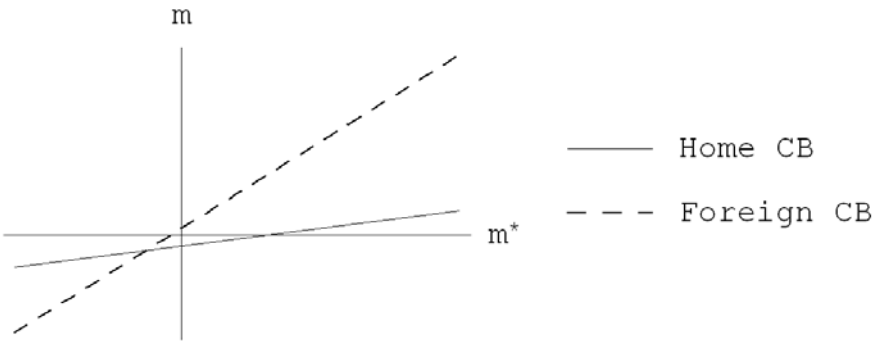

Figure 1: Positively sloped CB reaction functions. Note the values of the parameters are $\alpha = 3/4$, $\beta_F = 7$, $\beta_H = 5$, $\gamma = 1/2$, $\omega_F = 1$, $\omega_H = 1$, $n = 10$, $\sigma = 1.2$ and $k = 1$.

5.2 Home and foreign monetary policy interaction

Now, under a floating regime a strategic interaction arises between the domestic and foreign CB. The domestic monetary expansion raises home agents' nominal incomes but depreciates the exchange rate, increasing the home currency price of foreign goods. As the nominal exchange rate moves one-to-one with the money supply, the home CPI raises by $1 - \alpha\gamma$ (see equation (29)). It follows that home agents' income will increase in real terms by $\alpha\gamma$ expanding the demand for consumption goods.

The home currency depreciation improves the purchasing power of foreign agents in real terms by the same amount $\alpha\gamma$. Thus, consumption grows symmetrically in the two countries. Since the foreign CPI is reduced by the depreciation in the home currency, the foreign CB experiences a fall of its marginal cost which induces to inject money in the system[21]. It follows that the CBs react to each other by adapting the money supplies in the same direction. The two CBs' reaction functions display hence a positive slope (as for example in Figure 1) which implies the following lemma.

Lemma 2 *In an open economy the money balances supplied by two CBs are strategic complements.*

Proof. When foreign CB responds in kind to a more expansionary domestic monetary policy, m^* is a strategic complement of m. It is sufficient hence to evaluate how an increase in domestic (foreign) money balances affects the foreign (domestic) ones. From (38) and (39) the sign of $\frac{\partial m}{\partial m^*} = \frac{\alpha(1-\gamma)\beta_H(1-\alpha\gamma)}{k+\beta_H(1-\alpha\gamma)^2}$ and $\frac{\partial m^*}{\partial m} = \frac{\alpha\gamma\beta_F[1-\alpha(1-\gamma)]}{k+\beta_F[1-\alpha(1-\gamma)]^2}$ are both positive. ■

[21] Conversely, domestic contraction stimulates foreign tightening in the monetary policy. A similar mechanism holds mutatis mutandis if foreign CB shocks the economy with a monetary expansion or contraction.

5.3 Monetary policy and wages under floating exchange rate

In an open economy monetary strategic interactions depend also on home and foreign labor unions. The two CBs' reaction functions (39) and (38) can be rewritten in the following reduced form

$$\mathbf{m} = \mathbf{A}\boldsymbol{\omega}$$

so as to capture the direct and indirect effect of wages rise, where $\mathbf{m} = [m, m^*]^T$, $\boldsymbol{\omega} = [\omega, \omega^*]^T$ and

$$\mathbf{A} = \begin{bmatrix} \mu_{HH} & \mu_{HF} \\ \mu_{FH} & \mu_{FF} \end{bmatrix} = \frac{1}{1 - \frac{\partial m}{\partial m^*}\frac{\partial m^*}{\partial m}} \begin{bmatrix} \frac{\partial m}{\partial \omega} + \frac{\partial m}{\partial m^*}\frac{\partial m^*}{\partial \omega} & \frac{\partial m}{\partial \omega^*} + \frac{\partial m}{\partial m^*}\frac{\partial m^*}{\partial \omega^*} \\ \frac{\partial m^*}{\partial \omega} + \frac{\partial m^*}{\partial m}\frac{\partial m}{\partial \omega} & \frac{\partial m^*}{\partial \omega^*} + \frac{\partial m^*}{\partial m}\frac{\partial m}{\partial \omega^*} \end{bmatrix}. \tag{40}$$

It is apparent that the CB's reaction to wages is induced by a direct impact on inflation and employment and an indirect effect through the other country monetary policy response[22].

Reaction functions of the two CBs are *common knowledge* among labor unions. When setting their wages, unions may fear an adverse or favorable response by the domestic *and* foreign CB[23]. In order to facilitate the analysis of the role played by wages on the monetary policy, we present first the *direct effect* of wages on employment and inflation and secondly the *indirect effect* of wages through the other country monetary reaction function. In this respect each interaction is analyzed without giving way to clarity.

As in Coricelli *et al.* (2006) the national CB either thwarts or accommodates an increase in national nominal wages. This depends on its degree of conservatism.

Lemma 3 *In the absence of the foreign (domestic) CB's intervention, i.e.* $\frac{\partial m}{\partial m^*}\frac{\partial m^*}{\partial \omega} = 0$ *(*$\frac{\partial m^*}{\partial m}\frac{\partial m}{\partial \omega^*} = 0$*), and for values of domestic (foreign) CBC greater than* $\widetilde{\beta}_H = \frac{k}{\gamma\alpha(1-\gamma\alpha)}$ *(*$\widetilde{\beta}_F = \frac{k}{\alpha(1-\gamma)[1-\alpha(1-\gamma)]}$*), the CB contracts its money supply in response to domestic (foreign) wage hikes, while for values of conservatism below* $\widetilde{\beta}_H = \frac{k}{\gamma\alpha(1-\gamma\alpha)}$ *(*$\widetilde{\beta}_F = \frac{k}{\alpha(1-\gamma)[1-\alpha(1-\gamma)]}$*), the CB accommodates its money supply.*

Proof. It can be immediately demonstrated through (38) and (39) evaluating the sign of $\frac{\partial m}{\partial \omega} = \frac{k-\alpha\gamma\beta(1-\alpha\gamma)}{k+\beta_H(1-\alpha\gamma)^2}$ and $\frac{\partial m^*}{\partial \omega^*} = \frac{k-\alpha(1-\gamma)\beta_F[1-\alpha(1-\gamma)]}{k+\beta_F[1-\alpha(1-\gamma)]^2}$. ■

Intuitively, an increase in domestic wages fosters both inflation (29) and unemployment (32). The marginal impact on inflation is $\alpha\gamma$ while the marginal impact on employment is -1. The CB has to offset along the Phillips curve the increase in the marginal cost due to high inflation by the increase in marginal benefit due to less effort. A conservative domestic CB, i.e. $\beta_H > \frac{k}{\gamma\alpha(1-\gamma\alpha)}$, prefers to reduce inflation more than to increase employment by tightening its money supply. On the contrary, a populist CB, i.e. $\beta_H < \frac{k}{\gamma\alpha(1-\gamma\alpha)}$, desires to

[22] The impact of wages on money supply is henceforth evaluated at a symmetric equilibrium (where the terms $\int_0^1(\omega_i - \omega)di$ and $\int_0^1(\omega_{i^*} - \omega^*)di^*$ cancel out).

[23] Cavallari (2004) employs a similar framework but disregards the indirect influence of foreign monetary policy on the home wage setting.

boost employment more than dampen inflation. A similar reasoning holds for the foreign CB *mutatis mutandis*.

Differently from the closed economy literature, the monetary policy is affected by the wages prevailing in the other country as well. The wage hikes in a country in fact spill over into the other country through more expensive imports (imported inflation). Employment conversely is not affected directly by the variation of wages in the other country. Thus the direct effect on the CB's reaction function of a wage rise abroad is described as follows.

Lemma 4 *In the absence of the foreign (domestic) CB's intervention, i.e.* $\frac{\partial m}{\partial m^*}\frac{\partial m^*}{\partial \omega^*} = 0$ *(*$\frac{\partial m^*}{\partial m}\frac{\partial m}{\partial \omega} = 0$*), the domestic (foreign) CB always counteracts a foreign (domestic) wages increase.*

Proof. From (38) and (39) we note that the sign of $\frac{\partial m}{\partial \omega^*} = \frac{-\alpha(1-\gamma)\beta_H(1-\alpha\gamma)}{k+\beta_H(1-\alpha\gamma)^2}$ and $\frac{\partial m^*}{\partial \omega} = \frac{-\alpha\gamma\beta_F[1-\alpha(1-\gamma)]}{k+\beta_F[1-\alpha(1-\gamma)]^2}$ are always negative. ■

The effect of a ceteris paribus increase in foreign wages raises the marginal cost in the domestic CB's first order condition without having any impact on the marginal benefit. It results that domestic CB reduces its money supply so as to abate the higher inflation rate.

Drawing on Lemma 3, 4 and 2, we can now calculate the overall elasticity of the CB monetary response to wages displayed in the matrix (40) at a symmetric equilibrium. Note first that $\frac{\partial m}{\partial m^*}\frac{\partial m^*}{\partial m} \in (0,1)$. Thus, in order to assess the signs of the elements of matrix (40), it is sufficient to focus on the terms in square brackets.

The reactions of a CB to wages including direct and indirect effects are characterized by the following proposition.

Proposition 5 *(i) The CB's money response to wage hikes abroad is always negative. (ii) A conservative (populist) CB always tightens (accommodates) its monetary policy to national wage hikes.*

With an increase in wages in the other country, the direct effect on national monetary policy is always negative while the indirect effect depends on the degree of conservatism of the other CB. However the first part of Proposition 5 states that, in case of an increase in wages abroad, a domestic CB tightens its monetary policy despite the foreign CB accommodates[24]. It follows that the direct effect of wage through inflation always prevails on the indirect effect through the CB response abroad.

If the two CBs are conservative (populist) both the direct and indirect effect of national wages have negative (positive) sign, i.e. both effects go in the same direction. It follows that the elements on the main diagonal of matrix (40) have unambiguously positive sign if the CBs are populist and negative sign if the CBs are conservative.

When a CB is populist and the other is conservative, the direct and indirect effects of national wages on the national money supply are at odds. In such a case, the second part of Proposition 5 shows that the direct effect always prevails on the indirect one. Thus, a conservative (populist) CB always counteracts (accommodates) an increase in wages in its own country in spite of the other CB behavior.

[24] Remember that the two monetary policies are strategic complements.

The following tables summarize the sign of matrix (40) along with the results in proposition 5.

	Conserv	Conserv
Popul*	−	−
Popul*	−	+

;

	Popul	Popul
Conserv*	+	−
Conserv*	−	−

;

	Conserv	Conserv
Conserv*	−	−
Conserv*	−	−

;

	Popul	Popul
Popul*	+	−
Popul*	−	+

.

It is worth noting that $\frac{\partial \mu_{cc}}{\partial \beta_c} < 0$ and $\frac{\partial \mu_{c-c}}{\partial \beta_c} < 0$, where $-c$ stands for the other country[25]. The CB accommodates less or counteracts more home and foreign wage hikes if its degree of conservatism is higher. By the same token, $\frac{\partial \mu_{cc}}{\partial \beta_{-c}} < 0$ and $\frac{\partial \mu_{c-c}}{\partial \beta_{-c}} < 0$, i.e. the home (foreign) CB accommodates less or counteracts more home and foreign wage hikes if foreign (home) CB degree of conservatism is higher.

The explanation is that more foreign CBC prompts more restrictive foreign monetary policy which depreciates the home currency and reallocates production towards the home country. This, in turn, implies an increase in the domestic CPI and employment. The optimal domestic monetary policy is hence to tighten its money supply.

6 Wage setting

In the first stage of the game unions act as Stackelberg leaders vis-à-vis the monetary authorities, i.e. the labor unions anticipate the reaction functions of both CBs. In the home country union i chooses the rate of growth of the nominal wage, ω_i, so as to maximize (20) subject to (19) and (40). In doing that the union takes as given profits, D_i, and the nominal wages set by the other unions at home and abroad. The typical union i first order condition is hence[26]

$$\alpha(1 - s_H - \varepsilon_H) + \varepsilon_H k l_i = 0, \tag{41}$$

where s_H is the impact effect (elasticity) of ω_i on inflation when the nominal wages of other unions are taken as given:

$$s_H \equiv \frac{d\pi}{d\omega_i} = \frac{1}{n_H}\left[\alpha\gamma + (1 - \alpha\gamma)\mu_{HH} - (1 - \gamma)\alpha\mu_{FH}\right] \in (0, 1). \tag{42}$$

ε_H is the elasticity of labor demand to the nominal wage of union i:

$$\varepsilon_H \equiv -\frac{dl_i}{d\omega_i} = \sigma\left(1 - \frac{1}{n_H}\right) + (1 - \mu_{HH})\frac{1}{n_H}. \tag{43}$$

Note that equation (43) is a weighted average of the elasticity of substitution among labor types, σ, and the elasticity of aggregate labor demand, $1 - \mu_{HH}$.

[25] The elasticities of money supply to nominal wages are expressed in terms of the model parameters in the Appendix.

[26] See the Appendix for details.

Dividing (41) by $1-s_H$, we can express the first order condition in terms of the real wage elasticity of labor demand, η_H, as follows

$$\alpha(1-\eta_H)+k\eta_H l_i=0. \tag{44}$$

Equation (44) shows that an increase in the union i's wages has two opposing effects on the utility of workers: on one hand it reduces consumption (the first term in (44)); on the other hand, it increases utility through leisure (the second term in (44)). Thus, each union sets a nominal wage growth according to its consumption/leisure preferences, k.

The elasticity of domestic labor demand is given by

$$\eta_H \equiv \frac{\varepsilon_H}{1-s_H}=\frac{1-\mu_{HH}+(n_H-1)\sigma}{n_H-1+\theta_H(1-\mu_{HH})+(1-\theta_F)\mu_{FH}}\in(1,\infty) \tag{45}$$

where $\theta_H \equiv 1-\alpha\gamma$ and $\theta_F \equiv 1-(1-\gamma)\alpha$.

Similarly we may derive the labor demand elasticity in the foreign country as follows

$$\eta_F \equiv \frac{\varepsilon_F}{1-s_F}=\frac{1-\mu_{FF}+(n_F-1)\sigma}{n_F-1+\theta_F(1-\mu_{FF})+(1-\theta_H)\mu_{HF}}\in(1,\infty) \tag{46}$$

where

$$s_F=\frac{1}{n_F}\left[\alpha(1-\gamma)+(1-\alpha(1-\gamma))\mu_{FF}-\alpha\gamma\mu_{HF}\right] \tag{47}$$

and

$$\varepsilon_F=\sigma\left(1-\frac{1}{n_F}\right)+(1-\mu_{FF})\frac{1}{n_F}. \tag{48}$$

It is worth noticing that when unions internalize the impact of their wages on the CB reaction abroad, μ_{c-c}, such variable increases the elasticity of labor demand[27].

In the next section we will see how employment and inflation are determined by macroeconomic institutional variables that affect the labor demand elasticity.

7 Equilibrium employment and inflation

Since unions are identical, in a symmetric equilibrium $l_i=l$ for all $i=1,...,n_H$ we can derive employment from equation (44) as follows:

$$l=\frac{\alpha}{k}\left(1-\frac{1}{\eta_H}\right)\in(0,1). \tag{49}$$

Equation (49) points out that equilibrium employment is an increasing function of the elasticity of labor demand, η_c. When the elasticity of labor is finite ($\eta_c<\infty$) unions have some market power[28]. The smaller is the labor elasticity, the higher is the unions' incentive to raise its nominal wages. In fact, a nominal wage claim sends ripples through employment to a less extent in presence of

[27] Remember that the elasticities of money supply with respect to nominal wages abroad, μ_{c-c}, are always negative.

[28] As in Kydland and Prescott (1977) and Barro and Gordon (1983), equilibrium employment is at suboptimal level.

market power[29]. By contrast, when the elasticity of labor demand goes to infinity we achieve the competitive (optimal) level of employment $\frac{\alpha}{k}$.

The general price level in the home country is calculated by plugging equation (49) into the CB reaction function (37). Assuming a symmetric equilibrium, we obtain the inflation rate in the two countries as follows

$$\pi = \frac{\alpha}{\beta_H(1-\alpha\gamma)}\frac{1}{\eta_H} \tag{50}$$

$$\pi^* = \frac{\alpha}{\beta_F\left[1-\alpha(1-\gamma)\right]}\frac{1}{\eta_F}. \tag{51}$$

It is clear that labor market characteristics play a key role in determining equilibrium inflation as well. In particular, the inflation rate is negatively affected by the elasticity of labor demand. Moreover, equation (50) and (51) indicate an inflation bias. With no precommitment of any kind for the monetary authority, this is a standard result in the literature on the time inconsistency of monetary policies. We therefore can state that

Remark 6 *The conventional wisdom that discretionary policymaking by the CB yields an inflation bias, while leaving employment at suboptimal levels, still holds in an open economy when the elasticity of labor demand is finite.*

It is crucial at this point to compare the labor demand elasticity η_H and η_F so as to assess the impact of macroeconomic institutions on employment and inflation.

Assuming identical number of unions and money supply elasticity with respect to wages in both countries, from equation (42) and (47) it appears that a nominal wage hike in the home country has more repercussions on inflation the larger is the size of the home country. Clearly, the higher is the weight put on the domestic good, i.e. γ, the more is the impact of inflationary wage settlements in such a country. Notice that even in the case of a small-country hypothesis, when $\gamma = 0$, domestic unions perceive that they have an impact on inflation.

This result is in sharp contrast with the policy games literature, such as Coricelli *et al.* (2004) and Cukierman and Lippi (2001), where in the extreme case of $\gamma = 0$ unions do not perceive any impact on the inflation rate. This happens because in our model countries are linked through the exchange rate. Even though unions do not influence the domestic-produced good, their wage demands affect the exchange rate and, consequently, the inflation. As a matter of fact unions anticipate the (accommodating) response of the domestic CB through the depreciation of the exchange rate which, in turn, boosts inflation[30].

In general, the (negative) response of the foreign CB to domestic-wage hikes increases inflation at home as well. Intuitively, an increase in domestic wages causes a rise in the domestic-produced good. The foreign country undergoes an imported inflation by consuming the home good. The foreign CB then is induced to counteract the inflationary wage settlement by means of a restrictive monetary policy. The bigger is the foreign country size, i.e. the weight of the

[29] The monopolistic nature of the labor market and the effects on employment are in accord with Blanchard and Kiyotaki (1987) results.

[30] Note that when $\gamma = 0$, μ_{FH} does not affect s.

foreign-produced good in the home consumption, the stronger is the influence of the foreign CB reacting to domestic wage hikes.

However as shown in the Appendix, the elasticities of money supply to nominal wage differ among the two countries. Removing the assumption of equality renders the framework richer. The labor market structure (i.e. the labor demand elasticity) is in fact ultimately determined by the number of unions and the elasticity μ_{cc} and μ_{c-c} (see equation (45) and (46)). Thus, in the following section we assess how CBC, CWS and country size may modify the labor demand elasticity.

7.1 Role of central bank conservatism

How do employment and inflation depend on the CBC? Rewriting the labor demand elasticity with respect to the real wage as follows[31]

$$\eta_c = \frac{\beta_c \theta_c}{k} \frac{s_c}{1 - s_c} + \frac{n_c - 1}{n_c} \frac{\sigma}{1 - s_c}, \tag{52}$$

it is clear that a higher degree of conservatism has two opposing effects on labor unions. On the one hand, a non-atomistic wage setter becomes aware of the fact that an increase in its nominal wages causes higher inflation reducing employment through the CB reaction function (equation (37)). The higher is the degree of CBC, the more severe are the employment consequences of wage aggressiveness[32]. Drawing on Lippi (1999) terminology we refer to it as *adverse output effect*.

On the other hand, since a conservative CB leads unions to perceive less the inflationary impact of their wage, they also anticipate the real wage of other unions to decrease to a lesser extent and, hence, the shift of labor demand towards cheaper labor types is smaller[33]. This *adverse competition effect* encourages wage aggressiveness (Lippi, 1999).

Now it may be interesting analyzing the two limit cases of a CB ultra-populist and ultra-conservative. Letting the CBC go to zero, i.e. assuming that the CB does not care about inflation but only about agents' utility, we obtain the monopolistic competition level of employment[34]

$$[l_c]_{\beta_c=0} = \frac{\alpha}{k}\left(1 - \frac{1}{\sigma}\right). \tag{53}$$

[31] The elasticity of labor is obtained by substituting the CB reaction function in terms of aggregate labor into $l_{i,c} = -\sigma(\omega_{i,c} - \omega_c) + l_c$ and differentiating with respect to $\omega_{i,c}$.

[32] Formally this can be seen by differentiating the first term of equation (52) with respect to CBC: $\frac{d}{d\beta_c}\left(\frac{\beta_c\theta_c}{k}\frac{s_c}{1-s_c}\right) = \frac{\beta_c\theta_c}{k}\frac{s_c}{1-s_c}\left(\frac{1}{\beta_c} + \frac{\frac{ds_c}{d\beta_c}}{1-s_c}\right) = \frac{k(n_c-1)(k+\beta_{-c}\theta_{-c}^2)^2\theta_c}{\left[k^2(n_c-1)+n_c\beta_c\beta_{-c}\theta_c\theta_{-c}(1-\alpha)+k((n_c-1)\beta_{-c}\theta_{-c}^2+n_c\beta_c\theta_c^2\right]^2} > 0.$

[33] Formally this can be seen by differentiating the second term of equation (52) with respect to CBC: $\frac{d}{d\beta_c}\left(\frac{n_c-1}{n_c}\frac{\sigma}{1-s_c}\right) = \frac{n_c-1}{n_c}\frac{\sigma}{1-s_c}\frac{\frac{ds_c}{d\beta_c}}{1-s_c} = -\frac{k(n_c-1)(k+\beta_{-c}\theta_{-c}^2)^2\theta_c\left[k\theta_c+\beta_{-c}\theta_{-c}(1-\alpha)\right]\sigma}{\left[k^2(n_c-1)+n_c\beta_c\beta_{-c}\theta_c\theta_{-c}(1-\alpha)+k((n_c-1)\beta_{-c}\theta_{-c}^2+n_c\beta_c\theta_c^2\right]^2} < 0.$

[34] The values of η_c in the case of an ultra-populist and ultra-conservative CB are derived in the Appendix.

When the CB is ultra-populist the strategic interaction channel between trade unions and CB is halted[35]. In such a case, the employment level is below the Pareto efficient one, $\frac{\alpha}{k}$, and it depends on the degree of substitutability among labor types. As specified in section 5, an ultra-populist CB accommodates any domestic wage hike one-to-one which implies that wage setters can not affect employment.

The other extreme case of a CB that cares only about inflation, i.e. an ultra-conservative CB, yields the following equilibrium employment level

$$\lim_{\beta_c \to \infty} l_c = \frac{\alpha}{k}\left(1 - \frac{1}{\frac{1}{n_c}\frac{k+\beta_{-c}\theta_{-c}^2}{k\theta_c+\beta_{-c}\theta_{-c}(1-\alpha)} + \left(1-\frac{1}{n_c}\right)\sigma}\right). \tag{54}$$

Equation (54) shows that when a CB has inflation as overriding objective, the employment level may be larger or smaller than equation (53). Thus the idea that an ultra-conservative CB can always restore efficiency is rejected. In general labor demand elasticity and, hence, the macroeconomic consequences of a conservative CB depends on the monopolistic distortion in the factor market as summarized in the following proposition.

Proposition 7 *(i) For a number of unions $n \in (1, \infty)$, an increase in CBC raises employment only if $\sigma < \frac{k+\beta_{-c}\theta_{-c}^2}{k\theta_c+\beta_{-c}\theta_{-c}(1-\alpha)}$. (ii) If either $n_c = 1$ or $n_c \to \infty$, the impact of CBC on employment is nil.*

Proof. In the Appendix. ■

As β_c rises, the elasticity of money supply with respect to local wages switches from positive to negative values. Thus, an increase in CBC reduces the inflationary repercussions of wage settlement and enlarges the unemployment consequences (as apparent in equations (42), (43)). Since the CBC affects the first term (adverse output effect) of the elasticity of labor demand (52) positively and the second one (adverse competition effect) negatively, the effect of CBC on the adverse output effect prevails only if the condition in Proposition 7 holds. In other words, if labor distortions are sizeable, the i-th union understands that inflation (caused by its nominal wages) reduces employment by triggering a restrictive monetary policy[36]. On the contrary, if σ is large, unions anticipate that a more conservative CB reduces the real wages of their competitors to a lesser extent yielding wage aggressiveness.

The impact of CWS on employment will be tackled in the next section. However the second part of Proposition 7 states that monetary policy is neutral in the case of a single all-encompassing union ($n_c = 1$) and when unions are atomistic ($n_c \to \infty$). It is worth noticing that when $n_c \to \infty$ unions do not perceive wage demands to have any impact on inflation ($s_c = 0$), and when $n_c = 1$ wage differentials are ruled out. In both cases monetary neutrality arises since unions perceive they can not affect the real wages of the other unions[37]. The assumption of non-atomistic and uncoordinated wage setting is hence crucial when wages are negotiated in nominal terms.

[35] The CB is assumed to have only one target (employment) and hence the trade-off between inflation and employment in its optimal monetary policy is prevented.

[36] Similarly a wage increase is perceived by the i-th union to rise aggregate real wage (calculated by taking account of the producer price index) which dampens its wage demands.

[37] The source of non-neutrality in policy games is analysed in Acocella and Di Bartolomeo (2004).

What about the foreign monetary policy? The CB abroad always counteracts domestic wage demands by a restrictive monetary policy which triggers the depreciation of the domestic exchange rate. This, in turn, boosts inflation further dampening wage claims, since a nominal wage increase ends in a real wage improvement to a lesser extent. Thus, the higher is the foreign CBC, the stronger is domestic wage restraint.

Nevertheless, if the domestic CB is ultra-populist or wage setters are atomistic, the foreign CB impact on domestic wages fades away. This is because the strategic interaction between CB and unions is broken and the (negative) response of the CB abroad to a domestic wage hike is exactly offset by the (positive) response of the ultra-populist CB at home or is perceived nil by atomistic wage setters[38]. The following proposition summarizes the main results in terms of foreign monetary policy.

Proposition 8 *(i) An increase of foreign CBC rises labor demand elasticity and, consequently, employment. (ii) Foreign CBC does not have any impact on domestic employment in presence of an ultra-populist CB at home or atomistic wage setters.*

Proof. The sign of (60) is always positive. This proves *(i)*. When one of the conditions specified under *(ii)* holds, the labor demand elasticity η_c shrinks to σ. This proves *(ii)*. ■

It is worth noticing that in presence of coordinated wage setting at a country level, i.e. $n_c = 1$, domestic monetary policy is neutral but foreign CBC still affects employment through the CPI.

As to inflation, equation (50) and (51) reveal that ceteris paribus the larger is the country size, the larger is the inflation bias. The motive the relative country size raises inflation is the different trade-off between employment and inflation faced by the CB. Since the Phillips curve in a bigger country is flatter, the CB has stronger incentive to resort to surprise inflation (Rogoff, 1985b). Unions anticipate this inflationary inducement and strive to keep CB from modifying their real wages which culminates in a higher inflationary bias. In this respect, the country size and the proposition 9 explains why the Bundesbank had the most conservative statute among European countries.

Proposition 9 *A higher degree of the CBC, β_c, reduces the inflation bias ($\frac{d\pi_c}{d\beta_c} < 0$).*

Proof. See equation (61). ■

Contrary to Coricelli *et al.* (2004) where a higher degree of CBC is always associated with lower inflation and unemployment, a more conservative CB in this model does curb inflation while reduces unemployment only if the adverse output effect is stronger than the adverse competition effect. The different upshot in Coricelli *et al.* (2004) is mainly due to the absence of labor substitutability in the production function. Thus, the adverse output effect always dominates the adverse competition effect and a more inflation averse CB makes unions perceive higher labor demand elasticity, which results in lower real wages.

[38] When the domestic CB does not care about inflation and wage setters are atomistic, the labor demand elasticity is equal to σ.

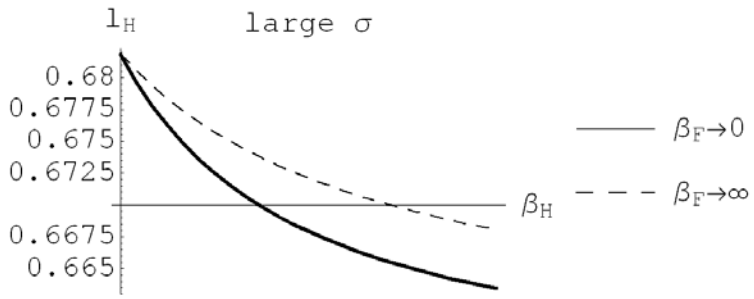

Figure 2: Employment and CBC when adverse competition effect prevails in the home country.

Now according to Proposition 7 and 8, the impact of national CBC on labor elasticity depends on the predominance of the adverse output or the competition effect. Hence, employment will be an increasing function of CBC if the labor market distortion are high. Since the foreign monetary policy may affect domestic employment as well, Figure 2 and 3 encapsulate the results of this section[39].

First, the adverse competition effect may prevail (Figure 2). Employment is therefore a decreasing function of CBC and an ultra-populist CB is the first best for the economy. Second, labor market distortions can be sizeable in the domestic country (Figure 3) and CBC boosts employment. Note that an increase in the foreign CB boosts employment in the domestic country since it raises the labor demand elasticity. This implies that for the home country is always beneficial (in terms of employment) to trade with a country where the CB is inflation-averse as long as the domestic CB is not ultra-populist. Unions understand that ceteris paribus their wage claims have more inflationary consequences with a foreign conservative CB[40], yielding wage restraint.

Figure 2 could represent, for instance, the situation of UK where labor market distortions are not particularly marked. In such a country it is attractive to trade with German where the CB has a strong reputation of conservatism.

7.2 Role of centralization of wage setting

What is the effect of the number of unions on employment and inflation? Here we tackle these questions holding constant the degree of CBC so as to focus only on the degree of CWS.

From equations (45), (49) and (50), union numerosity affects employment and inflation via the elasticity of labor demand, η_c. In particular, an increase in the labor market elasticity, i.e. in the competitiveness of labor market structure, diminishes both inflation and unemployment.

[39] Analytically proved in the Appendix. As for the following simulation, we let $n_c = 3$, $\gamma = 1/2$, $k = 1$ and $\alpha = 3/4$.

[40] This renders the real wages of other unions more competitive shifting demand towards cheaper labor.

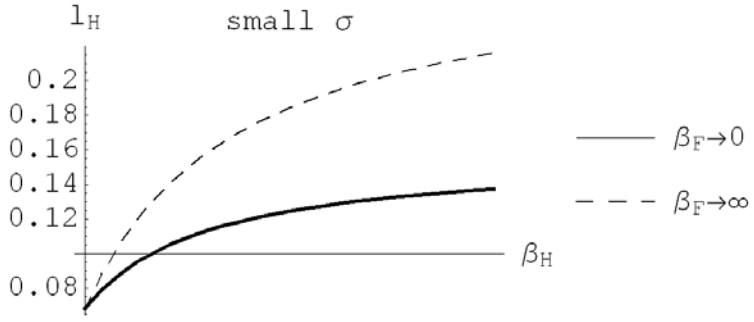

Figure 3: Employment and CBC when adverse output effect prevails in the home country.

Once again the adverse output and competition effect play a fundamental function in settling the impact of the CWS on macroeconomic outcomes as summarized in the following proposition:

Proposition 10 *For a given level of CBC, an increase (decrease) in the CWS, smaller (larger) n_c, reduces (raises) inflation and raises (reduces) employment if* $\sigma < \frac{k+\beta_{-c}\theta_{-c}^2}{k\theta_c+\beta_{-c}\theta_{-c}(1-\alpha)}$.

Proof. In the Appendix. ■

Intuitively, a non-atomistic labor union sets a higher nominal wage for its members as long as this does not reduce their employment, i.e. if its real aggregate wage does not exceed the real aggregate wage[41]. Thus, the smaller is the number of unions, the more each union internalizes the inflationary repercussions of their wage claims (internalization effect). On one side, the wage setter expects a higher inflation rate in the wake of an increase in nominal wage and, hence, less consequences on the aggregate real wage and the aggregate labor demand. This entails wage aggressiveness. On the other side, a higher level of centralization lets union anticipate that its own wage demand finishes in a higher aggregate nominal wage which, ceteris paribus, raises the real wage. This second effect discourages wage aggressiveness and is overwhelming if the conditions in Proposition 10 hold, i.e. when monopoly distortions are high enough so as to lead a large union to perceive an increase in its own nominal wage as a raise in its real relative wage (Cavallari, 2004).

Now we assess graphically the two conceivable combinations of the adverse output and competition effect in the home country. Since inflation and employment are monotonic functions of labor demand elasticity, η_c, we focus on the linkage between this key variable and CWS. In order to control for the domestic CBC, we assume that the CB is neither conservative nor populist[42].

When the adverse output effect is larger than the adverse competition one, monopoly distortions are relatively high and a more CWS lets unions internalize

[41] When employment is below the Pareto-efficient level, the welfare gain of a reduction in employment is lower than the welfare loss of a reduced consumption.

[42] Note that the value of CBC for which μ_{cc} is equal to zero is $\widehat{\beta}_c = \frac{k\left(k+\beta_{-c}\theta_{-c}^2\right)}{(1-\theta_c)\theta_{-c}\left(k+\beta_{-c}\theta_{-c}\right)}$.

the unemployment consequences of their wage demand through the CB reaction function (see equation (52))[43]. Under such circumstances, labor demand elasticity is decreasing in the number of unions and converging to σ in presence of atomistic wage setters (as illustrated in Figure 4).

By contrast, if the adverse competition effect is larger than the adverse output one, a more decentralized wage setting renders unions less aware of their inflationary wage settlement but increases the demand of firms for cheaper labor. In such a case, a competition effect would discourage wage aggressiveness to a larger extent since by assumption is higher than the adverse output (Figures 5).

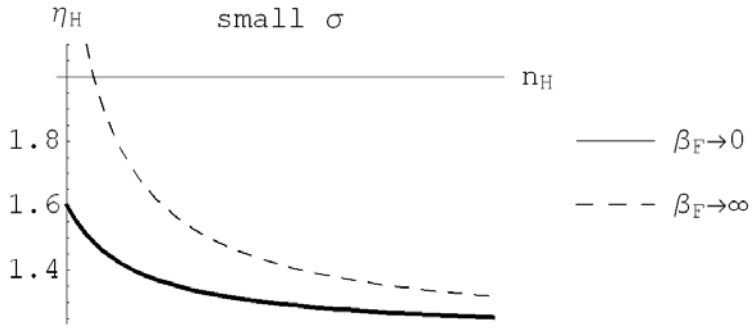

Figure 4: Labor demand elasticity and CWS when the adverse output effect prevails and $\mu_{HH} = 0$.

The results in this section are in sharp contrast with the U-shaped curve *à la* Calmfors and Driffill (1988). In order to have the U-shaped relationship between the CWS and economic performance three assumptions have to be satisfied[44]:

(a) There exists a monotonic relation between the CWS and the internalization effect.

(b) An increase in CWS always reduces competition in the labor market.

(c) In a decentralized wage setting the competition effect prevails on the internalization one, while under a centralized wage setting is the internalization effect to be dominant.

Condition (a) always holds in our model, while (b) is met only if the adverse output effect is smaller than the adverse competition one. The union i's labor demand elasticity with respect to its wage is an indicator of the degree of competitiveness in the labor market: an elastic labor demand shrinks monopoly power in the labor market. As said before, this elasticity can be increasing or decreasing in the CWS. However, the third assumption (c) is never satisfied since with atomistic wage setters (i.e. monopolistic competition, $n \to \infty$) the labor demand elasticity converges to σ.

[43] Multinational firms, for instance, may indirectly promote international wage coordination menacing to move the production where labor costs are lower (Calmfors, 2001).

[44] These conditions are pointed out in Guzzo and Velasco (1999).

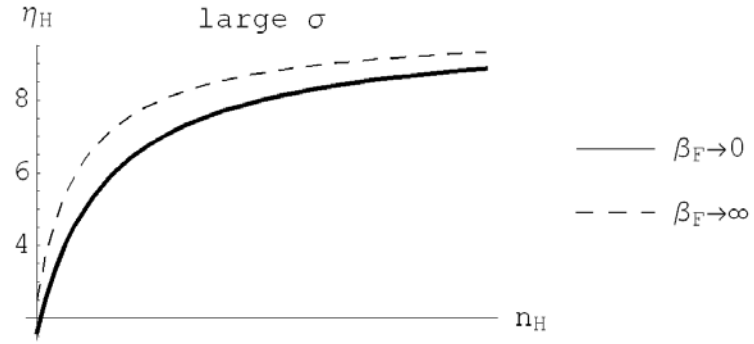

Figure 5: Labor demand elasticity and CWS when the adverse competition effect prevails and $\mu_{HH} = 0$.

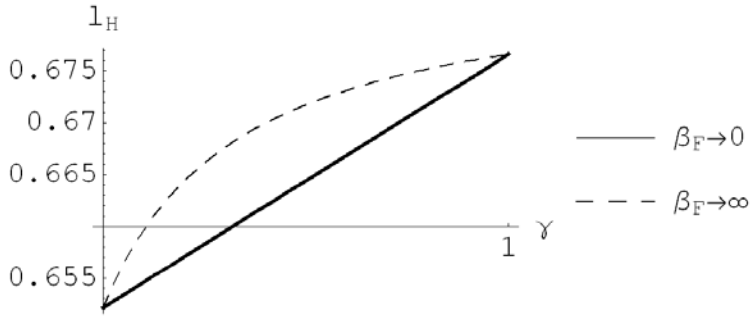

Figure 6: Home employment and γ when $\mu_{HH} = 0$.

7.3 Role of country size

In this section we deal with the impact of the relative country size on the macroeconomic performance. In doing that we assume that the national CB is neither conservative or populist, i.e. $\mu_{cc} = 0$, so as to control for the domestic monetary policy.

An increase in country size has two opposing effect. Since the weight of domestic good in the CPI is higher, the higher is the home size, unions perceive that a wage hike has a stronger impact on inflation while, on the other hand, the wage restraint exerted by the foreign CB diminishes. As Figure 6 shows the former effect dominates[45]. Thus, a rise in the nominal wage turns out to be a smaller increase in the real wage.

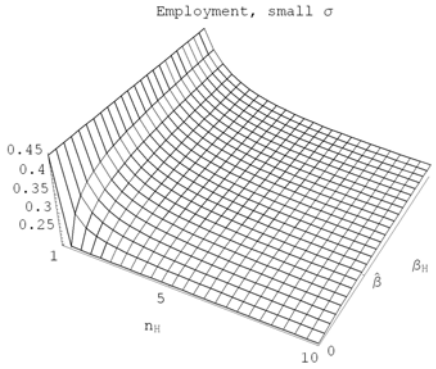

Figure 7: Home employment, CBC and n_H for σ small.

7.4 Interactions between central bank conservatism and centralization of wage setting

Here we combine the effect of CWS and CBC on employment and inflation relying on the results obtained in the previous sections. As for employment, the upshots for the home country are shown in Figure 7 and 8.

When σ is small, according to Proposition 7, employment is an increasing function of CBC as in Figure 7. An inflation averse CB is, actually, willing to contract its money supply so as to create more unemployment in the economy and reduce inflation. Labor unions are aware of the unemployment threat arising from a conservative CB and hold down their wage demands.

Moreover, for a given level of CBC, employment is always decreasing in the number of unions which is inversely related to their degree of internalization. With a single all-encompassing union, employment is maximized independently of the monetary conservatism. In such a context, it is not necessary to carry out a monetary contraction threat, for coordinated wage setters fully internalizes the aggregate labor demand. Note that in the case of monopolistic competition, i.e. when n_c goes to infinity, unions do not internalize at all the macroeconomic impact of their wage claims on inflation and the strategic interactions with the CB is ruled out[46].

Conversely, in Figure 8 labor market distortions are less relevant and a higher degree of CBC diminishes labor demand elasticity. Since unions are less concerned about the aggregate unemployment consequences of their wage hikes, they are tempted to set higher nominal wages which, in turn, increase their own relative real wages. In this case a more conservative CB is particularly costly in presence of very few unions. In fact, the less is the number of unions, the more they internalize the real wage gain. For a given level of CBC, we see a sharp monotonicity between employment and decentralization of the wage bargaining.

Only an ultra-populist CB may nullify the chance of achieving higher real wages; indeed, when $\beta_c = 0$ the level of employment is equal to the first best regardless of the number of unions, so that the monotonic relationship between employment and the number of unions disappears. Furthermore, the decrease

[45] Inflation has the same pattern of behaviour.

[46] The labor demand elasticity is in fact equal to σ.

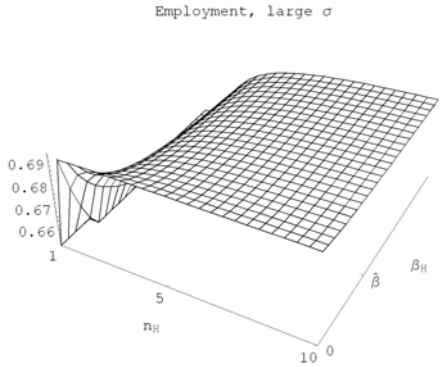

Figure 8: Home employment, CBC and n_H for σ large.

in employment stemming from a greater monetary conservatism is dampened by the number of unions (the grid becomes flat for large n_c). This conforms with the results in the earlier sections, where CBC does not affect labor elasticity as $n_c \to \infty$.

Next we account for the joint effect of the number of unions and CBC on the rate of inflation. The simulation is contained in Figure 9 and 10.

In both case inflation is a decreasing function of the degree of CBC as we expected. The main difference is the role played by the CWS with different degrees of σ. When labor market distortion are high, a lower number of unions may reduce inflation while it does not have any impact if substitutability among labor types is substantial (σ is high). This means that the effect of CBC on inflation seems to be largest (smallest) at very high level of CWS if σ is low (high).

The reason why inflation is not affected by a large number of trade unions is related to the internalization effect. Atomistic wage setters ($n_c \to \infty$) do not perceive to have any impact on inflation (see equation (42)). A non-atomistic union, instead, realizes that an increase in wage affects positively inflation triggering the response of the CB. What is key to large unions, however, is that monetary conservatism may influence their monopolistic power. In Figure 9 they have high monopoly power and conservatism reduce it by boosting the elasticity of labor demand. By contrast, in Figure 10 monopoly power is low and conservatism increase it by diminishing the elasticity of labor demand.

Finally, drawing on the employment analysis, we can consider the joint effect of the number of unions and CBC on individual welfare. The welfare analysis vis-à-vis labor market distortion is shown in Figure 11 and 12. The following proposition summarizes the main results in terms of individual welfare.

Proposition 11 *(i) A nationally centralized wage bargaining system maximizes individual welfare if labor market distortion are sizeable. (ii) In presence of keen competition in the labor market, an ultra-populist CB or atomistic wage setters are optimal for the society.*

Proof. In the Appendix.

■

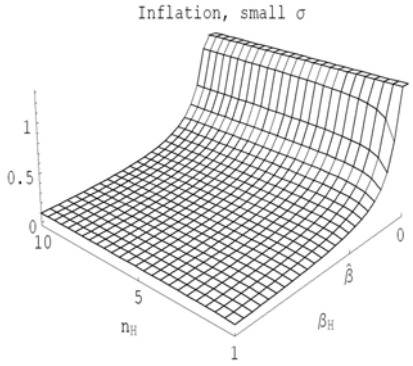

Figure 9: Home inflation, CBC and n_H for σ small.

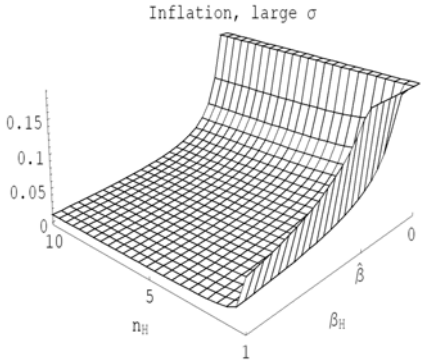

Figure 10: Home inflation, CBC and n for σ large.

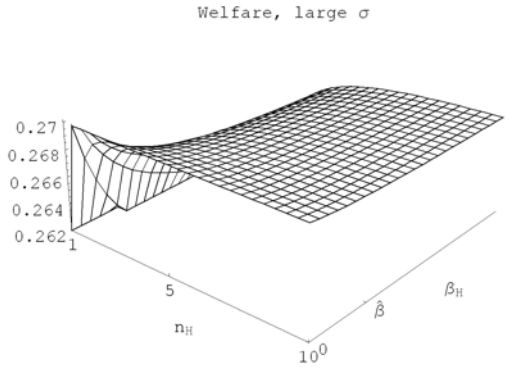

Figure 11: Home welfare, CBC and n_H for large σ.

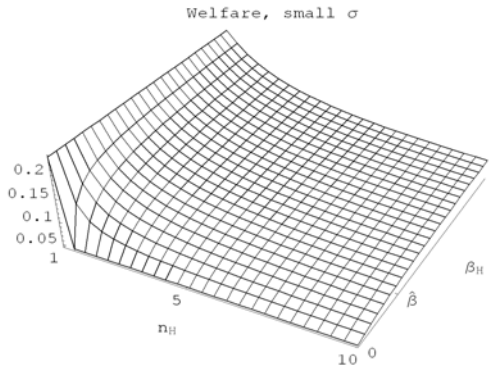

Figure 12: Home welfare, CBC and n_H for small σ.

The main difference between the cases depicted in Proposition 11 has to do with the behavior of welfare and employment. As long as the employment level is below the optimal one, a rise in employment is welfare augmenting. Hence, if labor market distortions are sizeable, we know that the smaller is the number of the unions, the better is employment performance, and, consequently welfare (see Proposition 10). Conversely, when σ is large, the monopolistic competitive outcome is optimal and both an ultra-populist CB and atomistic wage setters can replicate it.

Note that employment level and hence welfare are increasing functions of labor substitutability, σ. As a matter of fact, the higher is the labor substitution, the higher is the labor demand elasticity. Thus we know that labor markets characterized by sizeable distortions will perform worse, in terms of employment and welfare, than labor markets where such distortions are lower or nil.

8 Conclusions

This paper fills a gap in the literature on strategic interactions between a monetary authority and wage setters by extending the analysis in an open economy. Under a floating exchange rate regime, a new channel of interaction is investigated through two independent CBs. This issue is particularly relevant in Europe where labor markets are characterized by the presence of large trade unions and the monetary policy of the ECB is also affected by the Federal Reserve Bank.

Building on a micro-founded model, we find that the two optimal monetary policies are strategic complements: the CBs react to each other by adapting the money supplies in the same direction. Moreover foreign monetary policy is linked to domestic labor market by enlarging labor demand elasticity. An increase in domestic wages, in fact, spills over into the foreign country as imported inflation. This triggers a tightening monetary policy abroad which induces a similar policy at home creating further unemployment concern for domestic labor unions.

Investigating the strategic impact of centralization in wage setting (CWS) and central bank conservatism (CBC) on economic performance, we find that

the move towards higher level of CWS and CBC may increase employment and reduce inflation if monopoly distortions in the labor market are significant. In such a case, a conservative CB is willing to contract money supply so as to create more unemployment in the economy and control inflation. Labor unions are aware of the unemployment threat arising from a conservative CB and hold down their wage demands. Since the number of unions is inversely related to their degree of internalization of the monetary threat, more centralization will increase the economic performance.

Conversely, when labor market distortions are less relevant, a higher degree of CBC diminishes labor demand elasticity. Since unions are less concerned about the aggregate unemployment consequences of their wage hikes, they are tempted to set higher nominal wages which, in turn, increase their own relative real wages. In this case a more conservative CB is particularly costly in presence of very few unions. In fact, the less is the number of unions, the more they internalize the real wage gain.

However, the domestic monetary policy can affect the long-run equilibrium only when unions are large (non-atomistic). This happens because, when wages are negotiated in an uncoordinated manner, the CBC determines the CB response to inflationary wage demands. Each union anticipates that the less is the CB's aversion to inflation, the more an increase in its own nominal wage will reduce the other unions' real wages. The change in the other unions' real wage due to inflation has two effects. On the one hand a lower real wage renders the other unions' labor more competitive. On the other hand, an inflationary wage claim affects the economy's overall production.

A single all-encompassing union and atomistic wage setters may not affect the other unions' real wages and hence the strategic interaction with the domestic CB is ruled out. Nevertheless we show that in the case of a single union operating in the economy, the foreign monetary policy is not neutral. The foreign CB in fact can still affect the labor demand elasticity and, consequently, the employment level. This happens because of the existence of a wedge between the real wage relevant for firms (based on the producer price index) and the real wage relevant for unions (based on the consumer price index).

As for the welfare analysis, the paper shows that a nationally centralized wage bargaining system always maximizes welfare when labor market are characterized by sizeable distortions. On the contrary, in presence of keen competition in the labor market, an ultra-populist CB or atomistic wage setters are optimal for the society.

9 Appendix

Elasticities of money supply to nominal wages. Let θ_H and θ_F be the slope of the Phillips curve under a national monetary policy regime as expressed in equation (34) and (35) in the home and foreign country respectively. The elasticity of domestic money supply to local nominal wages is[47]

$$\mu_{cc} = 1 - \frac{\beta_c(k + \beta_{-c}\theta_{-c}^2)\theta_c}{k^2 + \beta_c\beta_{-c}\theta_c\theta_{-c}(1-\alpha) + k(\beta_{-c}\theta_{-c}^2 + \beta_c\theta_c^2)} \tag{55}$$

[47] Note that $\mu_{HH} = \mu_{FF}$ only if $\gamma = 1/2$ and $\beta_H = \beta_F$.

and the impact of domestic and foreign CBC is given by

$$\frac{\partial \mu_{cc}}{\partial \beta_c} = -\frac{k\left(k+\beta_{-c}\theta_{-c}^2\right)^2\theta_c}{\left[k^2+\beta_c\beta_{-c}\theta_c\theta_{-c}(1-\alpha)+k(\beta_{-c}\theta_{-c}^2+\beta_c\theta_c^2)\right]^2} < 0$$

$$\frac{\partial \mu_{cc}}{\partial \beta_{-c}} = -\frac{k\beta_c^2\theta_{-c}\theta_c^2\alpha^2\gamma(1-\gamma)}{\left[k^2+\beta_c\beta_{-c}\theta_c\theta_{-c}(1-\alpha)+k(\beta_{-c}\theta_{-c}^2+\beta_c\theta_c^2)\right]^2} < 0$$

$$\frac{\partial \mu_{cc}}{\partial \beta_c \partial \beta_{-c}} = -\frac{2k^2\beta_c(1-\theta_{-c})\theta_{-c}(k+\beta_{-c}\theta_{-c}^2)(1-\theta_c)\theta_c^2}{\left[k^2+\beta_c\beta_{-c}\theta_c\theta_{-c}(1-\alpha)+k(\beta_{-c}\theta_{-c}^2+\beta_c\theta_c^2)\right]^3} < 0.$$

Since both domestic and foreign CBC negatively affects μ_{HH}, it can range from 1 to $-\frac{\alpha\gamma}{1-\alpha}$ in the case of ultra-populist (when $\beta_H \to 0$) and ultra-conservative (when $\beta_H \to \infty \wedge \beta_F \to \infty$) CB, respectively. The elasticity of money supply to nominal wage abroad is instead given by[48]

$$\mu_{-cc} = -\frac{\beta_{-c}\beta_c\theta_{-c}(1-\theta_c)\theta_c}{k^2+\beta_c\beta_{-c}\theta_c\theta_{-c}(1-\alpha)+k(\beta_{-c}\theta_{-c}^2+\beta_c\theta_c^2)} \tag{56}$$

and affected by CBC as follows:

$$\frac{\partial \mu_{-cc}}{\partial \beta_c} = -\frac{k\beta_{-c}\theta_{-c}\left(k+\beta_{-c}\theta_{-c}^2\right)^2(1-\theta_c)\theta_c}{\left[k^2+\beta_c\beta_{-c}\theta_c\theta_{-c}(1-\alpha)+k(\beta_{-c}\theta_{-c}^2+\beta_c\theta_c^2)\right]^2} < 0$$

$$\frac{\partial \mu_{-cc}}{\partial \beta_{-c}} = -\frac{k\beta_{-c}\theta_{-c}\left(k+\beta_c\theta_c^2\right)^2(1-\theta_c)\theta_c}{\left[k^2+\beta_c\beta_{-c}\theta_c\theta_{-c}(1-\alpha)+k(\beta_{-c}\theta_{-c}^2+\beta_c\theta_c^2)\right]^2} < 0$$

$$\frac{\partial \mu_{-cc}}{\partial \beta_{-c} \partial \beta_c} = -\frac{k^2\theta_{-c}(1-\theta_c)\theta_c Z_1}{\left[k^2+\beta_c\beta_{-c}\theta_c\theta_{-c}(1-\alpha)+k(\beta_{-c}\theta_{-c}^2+\beta_c\theta_c^2)\right]^3} < 0$$

where $Z_1 \equiv \left[k^2+k(\beta_{-c}\theta_{-c}^2+\beta_c\theta_c^2)+\beta_{-c}\beta_c\theta_{-c}\theta_c((1-\theta_c)(1-\theta_{-c})+\theta_{-c}\theta_c)\right] > 0$. As for the case of domestic money elasticity, foreign money elasticity with respect to domestic wages is negatively affected by the domestic and foreign CBC. Thus μ_{FH} spans the range $-\frac{\alpha\gamma}{1-\alpha}$ to 0 in presence of an ultra-conservative ($\beta_H \to \infty \wedge \beta_F \to \infty$) and populist CB respectively. ■

A typical union first order condition. The typical union i maximizes (20) with respect to ω_i subject to (19) and (40), taking as given profits, D_i, and the nominal wages set by other unions at home and abroad. Note that individual union dividend flows are $D_i = P_H\frac{Y_H}{n}(1-\alpha)$. In a symmetric equilibrium in which all D_i are the same, profit per union is

$$D_i = P_H Y_H(1-\alpha) = (1-\alpha)PC_i.$$

From the budget constraint (19), we obtain for all domestic firms

$$PC_i = W_i L_i + (1-\alpha)PC_i$$

so that $\alpha PC_i = W_i L_i$. The first order condition with respect to ω_i yields

$$\alpha\left(\frac{d\log W_i}{d\omega_i} - \frac{d\log P}{d\omega_i} + \frac{d\log L_i}{d\omega_i}\right) + k\log L_i\frac{d\log L_i}{d\omega_i} = 0 \tag{57}$$

[48] Note that $\mu_{HF} = \mu_{FH}$ only if $\gamma = 1/2$.

where we used $\frac{1}{C_i}\frac{dC_i}{d\omega_i} = \frac{W_i L_i}{PC_i}\left[\frac{d\log W_i}{d\omega_i} - \frac{d\log P}{d\omega_i} + \frac{d\log L_i}{d\omega_i}\right]$ and $\frac{W_i L_i}{PC_i} = \alpha$. Dividing expression (57) by $1 - \frac{d\log P}{d\omega_i}$ and using the real wage elasticity definition $\eta \equiv -\frac{d\log L_i}{d\log \frac{W_i}{P}}$ yields equation (44). ■

Analysis of CBC and macroeconomic outcome. From equation (45) and (46), it appears that the value of labor demand elasticity is mainly determined by the elasticity of money supply to nominal wages. According to the degree of CBC, $1-\mu_{cc}$ spans the range 0 and $\frac{k+\beta_{-c}\theta_{-c}^2}{(1-\alpha)\beta_{-c}\theta_{-c}+k\theta_c}$ in the case of ultra-populist and ultra-conservative CB respectively. When $1-\mu_{cc}=0$, i.e. in presence of an ultra-liberal domestic CB, the elasticity of labor demand is σ. When the CB is ultra-conservative, instead, the labor demand elasticity is

$$\lim_{\beta_c\to\infty}\eta_c = \frac{1}{n_c}\frac{k+\beta_{-c}\theta_{-c}^2}{k\theta_c+\beta_{-c}\theta_{-c}(1-\alpha)} + \left(1-\frac{1}{n_c}\right)\sigma. \tag{58}$$

This proves equation (53) and (54). In general, the sign of $\frac{d\eta_c}{d\beta_c}$ not only depends on the adverse output and competition effect but also on the other CBC as follows:

$$\frac{d\eta_c}{d\beta_c} = \frac{k(n_c-1)(k+\beta_{-c}\theta_{-c}^2)\theta_c\left[k+\beta_{-c}\theta_{-c}^2-(k\theta_c+\beta_{-c}\theta_{-c}(1-\alpha))\sigma\right]}{\left[k(n_c-1)(k+\beta_{-c}\theta_{-c}^2)+n_c\beta_c(\beta_{-c}\theta_c\theta_{-c}(1-\alpha)+k\theta_c^2)\right]^2}. \tag{59}$$

The sign of $\frac{d\eta_c}{d\beta_c}$ is hence

$$sign\left(\frac{k+\beta_{-c}\theta_{-c}^2}{k\theta_c+\beta_{-c}\theta_{-c}(1-\alpha)}-\sigma\right).$$

The sign of $\frac{d\eta_c}{d\beta_{-c}}$ is instead always positive:

$$\frac{d\eta_c}{d\beta_{-c}} = \frac{k\beta_c(1-\theta_{-c})\theta_{-c}(1-\theta_c)\theta_c\left[k(n_c-1)\sigma+n_c\beta_c\theta_c\right]}{\left[k(n_c-1)(k+\beta_{-c}\theta_{-c}^2)+n_c\beta_c(\beta_{-c}\theta_c\theta_{-c}(1-\alpha)+k\theta_c^2)\right]^2} > 0. \tag{60}$$

The first part of Proposition 7 is proved by taking the partial derivative of (49), (50) and (51) with respect to CBC and using equation (59) as follows:

$$\frac{dl_c}{d\beta_c} = \frac{\alpha}{k}\frac{1}{\eta_c^2}\frac{d\eta_c}{d\beta_c}$$

$$\frac{d\pi_c}{d\beta_c} = -\frac{\alpha}{\theta_c\eta_c\beta_c^2}\left[1+\frac{\beta_c}{\eta_c}\frac{d\eta_c}{d\beta_c}\right] < 0. \tag{61}$$

Notice that the term in brackets in equation (61) is always positive since $\left|\frac{\beta_c}{\eta_c}\frac{d\eta_c}{d\beta_c}\right| < 1$ (see footnote (32) and (33)). The second part of Proposition 7 is achieved by evaluating equation (59) at $n_c = 1$ and $n_c \to \infty$. ■

Analysis of CSW and macroeconomic outcome. The marginal impact on labor elasticity of a more decentralized wage setting is

$$\frac{d\eta_c}{dn_c} = \frac{\left[(k\theta_c+\beta_{-c}\theta_{-c}(1-\alpha))\sigma-(k+\beta_{-c}\theta_{-c}^2)\right]Z_2}{\left[k(n_c-1)(k+\beta_{-c}\theta_{-c}^2)+n_c\beta_c(\beta_{-c}\theta_c\theta_{-c}(1-\alpha)+k\theta_c^2)\right]^2}$$

where $Z_2 \equiv \beta_c\theta_c\left[k^2+\beta_{-c}\beta_c\theta_c\theta_{-c}(1-\alpha)+k(\beta_{-c}\theta_{-c}^2+\beta_c\theta_c^2)\right] > 0$ and the sign of η_c depends on the

$$sign\left(\sigma-\frac{k+\beta_{-c}\theta_{-c}^2}{k\theta_c+\beta_{-c}\theta_{-c}(1-\alpha)}\right)$$

which proves Proposition 10. In order to assess the effect of CWS and get rid of the impact of domestic CBC, we assume in section 7.2 that the CB is neither conservative nor populist, i.e. we evaluate the labor demand elasticity when $\mu_{HH}=0$ which yields

$$[\eta_c]_{\beta_c=\widehat{\beta}_c}=\frac{\left(k+\beta_{-c}\theta_{-c}^2\right)\left[1+(n_c-1)\sigma\right]}{\beta_{-c}\theta_{-c}\left(n_c\theta_{-c}-1+\theta_c\right)+k(n_c-1+\theta_c)} \tag{62}$$

where $\widehat{\beta}_c=\frac{k\left(k+\beta_{-c}\theta_{-c}^2\right)}{(1-\theta_c)\theta_{-c}\left(k+\beta_{-c}\theta_{-c}\right)}$. ■

Welfare and macroeconomic institutions. It is straightforward to compute that welfare level as follows:

$$U_{i,c}=\frac{1}{2}\frac{\alpha^2}{k}\left[\left(1-\frac{1}{\eta_c}\right)\left(2-\left(1-\frac{1}{\eta_c}\right)\right)\right]. \tag{63}$$

Now consider the problem of maximizing the individual welfare on the constraint set as follows:

$$\begin{aligned} & \max_{n_c,\beta_c} U_{i,c} \\ s.to\ \ n_c \ \ & \geq \ \ 1\wedge\beta_c\geq 0. \end{aligned} \tag{64}$$

The solution of the Kuhn-Tucker conditions yields

$$\begin{aligned} \text{if } \sigma \ \ & > \ \ \frac{k+\beta_{-c}\theta_{-c}^2}{k\theta_c+\beta_{-c}\theta_{-c}(1-\alpha)},\ \beta=0\wedge n>1 \\ \text{if } \sigma \ \ & < \ \ \frac{k+\beta_{-c}\theta_{-c}^2}{k\theta_c+\beta_{-c}\theta_{-c}(1-\alpha)},\ \beta>0\wedge n=1. \end{aligned}$$

If we evaluate the (63) at the $n=1$ and $\beta=0$, we obtain

$$[U_{i,c}]_{n_c=1}=\frac{\alpha^2}{2k}\left[1-\frac{1}{\left(\frac{k+\beta_{-c}\theta_{-c}^2}{(1-\alpha)\beta_{-c}\theta_{-c}+k\theta_c}\right)^2}\right] \tag{65}$$

and

$$[U_{i,c}]_{\beta_c=0}=\frac{\alpha^2}{2k}\left[1-\frac{1}{\sigma^2}\right]. \tag{66}$$

It is apparent that expression (65) is greater (smaller) than expression (66) iff $\sigma<\frac{k+\beta_{-c}\theta_{-c}^2}{k\theta_c+\beta_{-c}\theta_{-c}(1-\alpha)}$ ($\sigma>\frac{k+\beta_{-c}\theta_{-c}^2}{k\theta_c+\beta_{-c}\theta_{-c}(1-\alpha)}$). Recall that both an ultra-populist CB and atomistic wage setters lead the labor demand elasticity to be equal to σ, i.e. the case of monopolistic competition. ■

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