The Welfare Effect of Foreign Monetary Conservatism with Non-Atomistic Wage Setters

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Abstract

This paper sheds light on the real effects of foreign central bank's degree of inflation aversion in presence of non-atomistic wage setters. It extends the Lippi's (2003) framework to an open economy and identifies the key strategic mechanisms between monetary policy and wage-setting decisions so as to assess the real effects of domestic and foreign policy makers' aversion to inflation. A main finding is that foreign central bank's aversion to inflation always increases employment. The impact of domestic central bank's aversion to inflation instead depends on the combination of three strategic effects.

Keywords: Foreign central bank conservatism, centralized wage setting, open-economy macro

JEL: E58, F41, J51

1 Introduction

Strategic monetary policy models with non-atomistic wage setters show that the central bank (CB) aversion to inflation ("conservatism" as defined by Rogoff (1985)) has a systematic effect on equilibrium employment (e.g. Lippi, 2003; Coricelli, Cukierman, and Dalmazzo, 2004; Soskice and Iversen, 2000; Bratsiotis and Martin, 1999).[1] The main reason for such a result is that an increase in wages leads to higher inflation; (large) wage setters internalize the monetary policy response to their actions which, in turn, depends on the degree of conservatism. Economic outcomes under this assumption may hence differ from the conventional wisdom, whereby equilibrium employment is unrelated to the policy maker's

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[1] Cukierman (2004) and Calmfors (2001) provide extensive surveys of this literature.

aversion to inflation, due to the strategic elements that characterize the players' strategy.[2] In this respect, these studies have highlighted three main strategic channels through which CB conservatism leads unions to modify their wage demands.

First, since nominal wages are negotiated in an uncoordinated manner, each union anticipates that its wage claim, raising inflation, reduces the other unions' real wages. This makes labor services provided by other unions more competitive. In this respect, CB conservatism encourages wage demands for it reduces the decline in the other unions' real wages and hence the fall in the labor demand perceived by each union. Such a mechanism is known as "substitution effect" (e.g. Cukierman and Lippi, 1999; Lippi, 2003).

Second, a strong CB's preference for price stability leads to less monetary accommodation to wage setting. In this case monetary conservatism raises the elasticity of aggregate labor demand, thereby involving an employment-increasing effect. This effect is labeled by Lippi (2003) as "output effect" and has been extensively studied in the recent decade (e.g. Bratsiotis and Martin, 1999; Soskice and Iversen, 1998, 2000; Coricelli, Cukierman, and Dalmazzo, 2004, 2006; Gnocchi, 2006).

The third mechanism instead operates only in open economies, where trade channels are explicitly modeled. An increase in domestic wages leads to a rise in domestic prices vis-à-vis foreign prices ("terms-of-trade effect"). Domestic wage hikes are therefore perceived as improving the terms of trade and hence real wages. More CB's inflation aversion entails each union realizing that the terms-of-trade improvement in the wake of a wage increase will be smaller. Thus, wage restraint arises (e.g. Jensen, 1993; Coricelli, Cukierman, and Dalmazzo, 2004).

However, previous contributions have neither investigated these three effects together nor disentangled the effect of foreign CB's inflation aversion. The novel element of this paper is in fact to propose a conceptual framework in which *all* the strategic mechanisms operate at the same time and assess the real effects of *foreign* CB conservatism. In particular, drawing on Corsetti and Pesenti (2001), I introduce an open-economy dimension in the Lippi's (2003) set-up so that benevolent[3] labor unions internalize the terms-of-trade effect associated with their wage choice.

This analytical framework qualifies previous results and encompasses existing models of strategic interaction between the central bank and unions as particular cases. The main result is that foreign conservatism always increases welfare. Intuitively, the asymmetric responses of domestic and foreign monetary policies to domestic wage hikes lead unions to anticipate an improvement in the terms of trade. However, the elasticity of domestic employment to the terms of trade only depends on foreign CB conservatism. As a result, a more conservative foreign CB diminishes the terms-of-trade improvement in the wake of a nominal wage increase and, therefore, induces wage restraint.

Domestic conservatism, instead, may increase or reduce employment. Specifically it will raise em-

[2]Wage determination in most OECD countries is structured in collective bargaining between employers and trade unions at the plant, firm, industry or aggregate level (see Nickell, Nunziata, and Ochel, 2005).

[3]The literature on the relationship between wage setting and monetary policy has followed two strands: (i) the one based on unions caring about inflation *per se*, which follows Cubitt (1992) and Skott (1997); (ii) the one spawned by Soskice and Iversen (1998, 2000) and Bratsiotis and Martin (1999) where unions only care about employment and real wages (i.e. standard preferences as here).

ployment when the output and terms-of-trade effects dominate the substitution effect. With a more conservative CB, a wage setter anticipates that its wage claims will trigger a less accommodating monetary response, thereby reducing aggregate employment and domestic prices. The reduction in prices, on the one hand reduces the substitution effect, but on the other hand worsens the terms of trade. It turns out that, differently from the model of Lippi (2003), the condition determining the sign of the impact on employment depends not only on the output effect but also on the term-of-trade effect.

The remainder of the paper is organized as follows. Section 2 presents the model. After presenting the equilibrium concept and the extensive form, the game is solved by backward induction. Sections 3 derives the consumers' and firms' strategies. The monetary authorities' and wage setters' strategies are respectively investigated in Section 4 and 5. Welfare analysis is performed in Section 6. Section 7 concludes.

2 Economic setup

The model combines monopolistic competition and nominal rigidities in the labor market. The economy consists of two equally-sized countries, Home (H) and Foreign (F). Each country is specialized in the production of a single traded good. There are no impediments or costs to trade across borders. Wages are contractually fixed for one period (contract period)[4] and are set by a finite number of unions.

The timing is as follows. At the beginning of the contract period, monopolistic unions simultaneously set nominal wages in their country of origin anticipating the monetary policy. Next, monetary policy is simultaneously conducted in each country by a conservative CB. Finally, households consume and firms hire labor.

2.1 Firms

In each country a representative competitive firm faces the following production function:

$$Y = L^{\alpha} \qquad ; \qquad Y^{*} = (L^{*})^{\alpha} \qquad 0 < \alpha < 1, \tag{1}$$

where Y and Y^{*} denote output per capita in the Home and Foreign country respectively.[5] Firms act competitively as in Corsetti and Pesenti (2001) and Lippi (2003).[6] Production of the Home (Foreign) good requires a continuum of differentiated labor inputs indexed by $j \in [0,1]$ ($j^{*} \in [0,1]$) and provided by Home (Foreign) agents:

$$L = \left[\int_0^1 L(j)^{\frac{\sigma-1}{\sigma}} \mathrm{d}j\right]^{\frac{\sigma}{\sigma-1}} \qquad ; \qquad L^{*} = \left[\int_0^1 L^{*}(j^{*})^{\frac{\sigma-1}{\sigma}} \mathrm{d}j^{*}\right]^{\frac{\sigma}{\sigma-1}} \qquad \sigma > 1. \tag{2}$$

[4] Multiperiod dynamics are not central to the strategic effects I will explore here.

[5] Henceforth, Foreign variables will be indicated by *.

[6] The assumption that goods market are competitive can be relaxed without affecting the paper's results.

For a given level of production, the demand for labor type j solves the dual problem of minimizing total cost, $\int_0^1 W(j)L(j)\mathrm{d}j$, subject to the employment index (2):

$$L(j) = \left[\frac{W(j)}{W}\right]^{-\sigma} L \qquad ; \qquad L(j^*) = \left[\frac{W^*(j^*)}{W^*}\right]^{-\sigma} L^*, \tag{3}$$

where $W(j)$ denotes the nominal wage of labor type j and W is the nominal wage index defined as

$$W = \left[\int_0^1 W(j)^{1-\sigma}\mathrm{d}j\right]^{\frac{1}{1-\sigma}} \qquad ; \qquad W^* = \left[\int_0^1 W^*(j^*)^{1-\sigma}\mathrm{d}j^*\right]^{\frac{1}{1-\sigma}}. \tag{4}$$

These wage indexes have the property that the minimum cost of employing an array of labor types $L(j)$ is given by WL. Therefore, from profit maximization, aggregate labor demands are given by

$$L = \left[\frac{1}{\alpha}\frac{W}{P_H}\right]^{-\frac{1}{1-\alpha}} \qquad ; \qquad L^* = \left[\frac{1}{\alpha}\frac{W^*}{P_F^*}\right]^{-\frac{1}{1-\alpha}}, \tag{5}$$

where P_H and P_F^* are the prices of Home and Foreign goods, respectively expressed in Home and Foreign currency. In the absence of of market segmentation across countries, the law of one price holds:

$$P_F = \mathscr{E} P_F^* \qquad ; \qquad P_H^* = P_H/\mathscr{E}, \tag{6}$$

where $\mathscr{E}$ is the nominal exchange rate (domestic currency per unit of foreign currency), and P_H^* and P_F^* are the prices of Home and Foreign goods in Foreign currency.

2.2 Agents' payoff

Consumers

Each country contains a unit interval of households. Home and Foreign individuals have identical preferences:

$$U(j) = \log C(j) - \frac{k}{2}\left[\log L(j)\right]^2 + \chi \log\left(\frac{M(j)}{P}\right) \qquad k > \alpha, \quad \chi > 0, \tag{7}$$

where M/P are real money balances.[7] For any household j the overall consumption index, C, is a Cobb-Douglas aggregator over the two available types of goods:

$$C = C_H^{\gamma} C_F^{1-\gamma} \qquad 0 < \gamma < 1, \tag{8}$$

where C_H and C_F are consumption of the Home-produced traded good and of the Foreign-produced traded good respectively.

[7] In order to have a utility function decreasing and concave in equilibrium leisure, the assumption $k > \alpha$ must hold (see eqs. (16) and (34)).

The consumption-based price index expressed in domestic currency is defined as

$$P = \frac{1}{\gamma^{\gamma}(1-\gamma)^{1-\gamma}} P_H^{\gamma} P_F^{1-\gamma}. \tag{9}$$

Foreign households are modeled in an analogous way.

Central banks

Monetary policy is conducted by an independent CB. I draw on Lippi (2003) and assume that the objective function of the Home monetary authority is

$$\Omega = \int_0^1 \left[\log C(j) - \frac{k}{2} [\log L(j)]^2 \right] \mathrm{d}j - \frac{\beta}{2} p^2 \qquad \beta > 0 \tag{10}$$

where the parameter β captures the degree of CB conservatism (Rogoff, 1985) and $p \equiv \log P$.[8] If the level of conservatism is zero, the CB is a benevolent planner that cares only about agents' welfare.[9]

The Foreign CB's objective is given by

$$\Omega^* = \int_0^1 \left[\log C^*(j^*) - \frac{k}{2} [\log L^*(j^*)]^2 \right] \mathrm{d}j^* - \frac{\beta^*}{2} p^{*2} \quad \beta^* > 0. \tag{11}$$

Notice that Home and Foreign CBs have dissimilar preferences toward inflation, respectively β and β^*.

Unions

Workers are organized in $n > 1$ labor unions. I assume that all labor types are unionized and equally distributed among unions. Therefore, each union u has mass $1/n (= \int_{j \in u} dj)$. In such a setup, both the degree of wage centralization and the unions' ability to internalize the consequences of their actions are proportional to the union's size: the smaller the number of unions, the more they internalize the impact of their wage settlement on aggregate wage.

I assume that the representative Home union u acts benevolently by maximizing the utility of its members (of mass $1/n$) and disregarding liquidity effects:

$$V_u = n \int_{j \in u} \left[\log C(j) - \frac{k}{2} [\log L(j)]^2 \right] \mathrm{d}j. \tag{12}$$

Notice that unions' objective differs from the CB's objective in that the unions consider only a fraction

[8] In what follows, I will denote natural logarithm of any variable X by the corresponding lower-case letter; thus $x \equiv \log X$. Without loss of generality, I normalize the previous period nominal wage, money supply, and general price level to unity, so that the log of these variables can be considered as an approximation of their percentage increase.

[9] Following Obstfeld and Rogoff (1998) and Corsetti and Pesenti (2001), the monetary authority ignores the utility of real balances; therefore, I abstract from the traditional considerations that lie behind the Friedman rule of zero nominal interest rate.

of agents in the country and does not care about inflation.[10]

2.3 A benchmark: the efficient allocation

As a benchmark, it is useful to compute the efficient allocation. That is obtained by appointing a central institution (social planner) that maximizes an objective function represented by a weighted average of the welfare of the single countries. The world's optimal allocation in any given period implies the solution of the following social planner's problem:

$$\max_{C_z, C_z^*, L, L^*, \frac{M}{P}, \frac{M^*}{P^*}} \frac{1}{2}\int_0^1 U(j)\mathrm{d}j + \frac{1}{2}\int_0^1 U^*(j^*)\mathrm{d}j^* \qquad z \in [H, F],$$

subject to the feasibility constraint

$$Y = C_H + C_F \qquad ; \qquad Y^* = C_H^* + C_F^*$$

and the technological constraint

$$Y = L^\alpha \qquad ; \qquad Y^* = (L^*)^\alpha.$$

The optimal conditions for the social planner's problem are:

$$\frac{\gamma}{C_H} = \frac{1-\gamma}{C_F} = \frac{k \log L}{\alpha Y}$$

$$\frac{\gamma}{C_H^*} = \frac{1-\gamma}{C_F^*} = \frac{k \log L^*}{\alpha Y^*}$$

$$\chi\left(\frac{M}{P}\right)^{-1} = \chi\left(\frac{M^*}{P^*}\right)^{-1} = 0,$$

i.e. the planner would like to equate the marginal utility of consumption of each tradeable good to the marginal loss of utility of producing an additional unit of the tradeable good. The last condition, instead, requires to equate the (social) marginal utility of real balances to the social marginal cost of producing real money balances, which is zero.

From the resource and technological constraint, it is easy to obtain the following solutions to the

[10] The benevolent union hypothesis is in line with the trade union behavior surveyed by Oswald (1985), whose objective function usually includes real wages and unemployment.

social planner's problem:

$$C_H = \gamma Y \quad ; \quad C_H^* = \gamma Y^* \tag{13}$$

$$C_F = (1-\gamma)Y \quad ; \quad C_F^* = (1-\gamma)Y^* \tag{14}$$

$$Y = L^\alpha = C \quad ; \quad Y^* = (L^*)^\alpha = C^* \tag{15}$$

$$\log L = \alpha/k \quad ; \quad \log L^* = \alpha/k. \tag{16}$$

2.4 Timing protocol

I assume a one-shot two-stage game. Nominal wages are set by unions in the first stage of the game in an uncoordinated way. They have full information about the reaction functions of the central banks and take them into account in the wage setting process. In other words, each union acts strategically as Stackelberg leaders against the central banks, while playing Nash relative to other unions. The equilibrium of this wage-setting game determines the growth of nominal wages in the two countries. In the second stage the two CBs choose their money supply simultaneously taking the other CB's money supply as well as previously set nominal wages as given. Thus each CB plays Nash with the other CB and acts as a Stackelberg follower with respect to the unions. Finally production and trade take place through the firms and consumers' decisions after observing the money balances and the negotiated nominal wages.

The choice of modeling the game between unions and CBs as a Stackelberg game is in line with the literature on the strategic interaction between the CB and unions (e.g. Soskice and Iversen, 1998, 2000; Bratsiotis and Martin, 1999). Moreover it reflects the fact that wage contract are usually fixed for at least one year while prices and the money supply can be adjusted more frequently than annually. The game is solve by backward induction.

3 Production and Trade

Each j-th consumer owns equal shares of all domestic firms and of an initial stock of the domestic currency. Markets are complete domestically and international equity trade is forbidden.[11]

A typical Home agent j maximizes (7) with respect to $C(j)$ and $M(j)$ subject to the budget constraint

$$\frac{M(j)}{P} + C(j) = \frac{M_0(j)}{P} + T + D(j) + \frac{W(j)L(j)}{P}, \tag{17}$$

where T denotes per capita real transfers from the Home government, $\frac{W(j)L(j)}{P}$ represents real labor income, $D(j)$ expresses real domestic profits, and $M_0(j)$ are initial nominal money holdings. Foreign individuals face an analogous problem.

[11] Note that, given the Cobb-Douglas preferences over traded goods (8) and the separability of individuals' utility functions, international equity trade would not affect equilibrium allocation (see eq. (23)). This implies that current accounts would be zero in an inter-temporal version of the model as well.

The first-order condition for individual j's (j^*'s) nominal money balances, $M(j)$ ($M^*(j^*)$), is given by:

$$\frac{1}{C(j)} = \chi \left(\frac{M(j)}{P}\right)^{-1} \qquad ; \qquad \frac{1}{C^*(j^*)} = \chi \left(\frac{M^*(j^*)}{P^*}\right)^{-1}. \tag{18}$$

Since money has value only for the current period, individuals equate the marginal utility from holding it to the opportunity cost of acquiring it. Notice that in such a model, money market equilibrium is equivalent to a cash in advance constraint.[12]

Governments in each country rebate all seignorage revenue in lump-sum transfers to households:

$$T = \frac{M}{P} - \frac{M_0}{P} \qquad ; \qquad T^* = \frac{M^*}{P^*} - \frac{M_0^*}{P^*}. \tag{19}$$

Aggregating all consumers' first order conditions, the total output demands are given by

$$Y_H = \frac{\gamma}{P_H}(PC + \mathscr{E}P^*C^*) \qquad ; \qquad Y_F^* = \frac{1-\gamma}{P_F}(PC + \mathscr{E}P^*C^*), \tag{20}$$

which, in turn, implies the following result

$$\frac{P_H Y_H}{P_F Y_F^*} = \frac{\gamma}{1-\gamma}. \tag{21}$$

Now, using eq. (19) together with the household's budget constraints (17) leads to

$$PC = P_H Y_H \qquad ; \qquad \mathscr{E}P^*C^* = PC^* = P_F Y_F^*, \tag{22}$$

i.e. the current account is always balanced. It is then straightforward to show that the ratio of Home to Foreign consumption is constant

$$\frac{C}{C^*} = \frac{\gamma}{1-\gamma}. \tag{23}$$

The exchange rate is therefore given by the ratio of Home to Foreign nominal expenditure[13]

$$\mathscr{E} = \frac{PC}{P^*C^*}. \tag{24}$$

Notice that, from the money demand (18), the exchange rate can be rewritten as the ratio of money supplies in the two countries as follows:

$$\mathscr{E} = \frac{M}{M^*}. \tag{25}$$

[12] In a dynamic version of the model, interest rates would appear in eq. (18); see for instance Obstfeld and Rogoff (1998).

[13] This result stems directly from the characteristics of current account balance and constant expenditure shares exhibited by the model.

Furthermore, the terms of trade are defined in the Home country as

$$TOT \equiv \frac{\mathscr{E} P_F^*}{P_H}. \tag{26}$$

A decrease in TOT constitutes a real appreciation of the domestic currency, i.e. an improvement in the Home terms of trade.

The rest of the paper will show how terms-of-trade adjustments and monetary conservatism play a key role in determining the welfare impact of wage demand.

4 Monetary policy

The two CB choose their non-cooperative policies simultaneously. The Home CB's problem is to maximize (10) with respect to the growth of nominal money supply m subject to (5), (18), (20), (25), taking nominal wages and m^* as given. The first-order condition can be written as

$$p = \frac{k(\tilde{l} - l) - \alpha(1-\gamma)}{(1-\alpha\gamma)\beta}, \tag{27}$$

where $\tilde{l} \equiv \alpha/k$ is the efficient (log) employment level (eq. 16). Since employment l is sub-optimally low owing to monopolistic distortions in labor markets, the monetary authority has an incentive to raise inflation so as to reduce the discrepancy between efficient and natural output. This is the standard Blanchard-Kiyotaki result (captured by the term $\tilde{l} - l$ in eq. (27)), whereby a positive monetary shock unambiguously improves domestic welfare in a closed economy (Blanchard and Kiyotaki, 1987).

Nevertheless, as noted by Corsetti and Pesenti (2001), in an open economy this effect is not sufficient to prevent a deflationary monetary policy.[14] Intuitively, money contraction reduces both consumption and output. But it also improves the terms of trade, thereby increasing consumption and reducing output further. It turns out that the reduction in the disutility of supplying labor services more than offsets the reduction in the utility from lower consumption since the "burden" of production is shifted to the other country through the improved terms of trade. Such an effect is captured by the negative term $-\alpha(1-\gamma)$ on the R.H.S. of eq. (27).

Similarly the Foreign CB maximizes (11) with respect to m^* subject to (5), (18), (20), (25), taking nominal wages and m as given. The first-order condition is given by

$$p^* = \frac{k(\tilde{l} - l^*) - \alpha\gamma}{(1-\alpha(1-\gamma))\beta^*}. \tag{28}$$

Alternatively, the two first-order conditions can be written explicitly in terms of money supplies as

[14] For an empirical evidence that relatively open countries experience lower inflation see Romer (1993), Lane (1997), and Campillo and Miron (1997).

follows:

$$m = \frac{k-\beta(1-\theta)\theta}{k+\beta\theta^2}w + \frac{\beta(1-\theta^*)\theta}{k+\beta\theta^2}l^*, \tag{29}$$

$$m^* = \frac{k-\beta^*(1-\theta^*)\theta^*}{k+\beta^*\theta^{*2}}w^* + \frac{\beta^*(1-\theta)\theta^*}{k+\beta^*\theta^{*2}}l, \tag{30}$$

where $\theta \equiv 1-\alpha\gamma$, $\theta^* \equiv 1-\alpha(1-\gamma)$.

Money supply response to domestic wages can be either accommodating or non-accommodating. Specifically, it depends on the degree of CB conservatism. On the one hand, a wage rise reduces employment, thereby entailing an expansive monetary policy (see eq. (27)). On the other hand, it increases inflation, thereby leading to a tightening policy. It turns out that, when the degree of *domestic* conservatism is relatively high ($\beta > \frac{k}{\theta(1-\theta)}$), CB counteracts an increase in domestic wages. Conversely, when it is sufficiently low ($\beta < \frac{k}{\theta(1-\theta)}$) monetary policy accommodates an increase in nominal wage (see eq. (29)). This result has been already investigated in the literature (e.g. Coricelli, Cukierman, and Dalmazzo, 2004; Lippi, 2003).[15] However, in an open economy set-up ($\gamma \neq 1$), there is a further channel of interaction. From eqs. (29) and (30), in fact, the following result can be derived.

Result 1 *An increase in the degree of CB conservatism leads to a more expansionary domestic monetary response to foreign employment.*

Intuitively, a rise in foreign money supply leads to an increase in foreign employment as well as a depreciation of the exchange rate. This improves the domestic terms of trade and reduces the perceived costs of a domestic inflationary policy. The Home CB is hence induced to expand its money supply. Moreover the more the CB cares about inflation (higher β), the larger is monetary accommodation in response to an increase in foreign employment. In other words, a higher degree of conservatism increases *strategic complementarity* between the money balances supplied by the two CBs.

Before turning to the wage-setting policy, it is convenient to express the level of employment as function of wages. The Nash equilibrium solution of monetary supplies is the intersection point of the two reaction functions (29) and (30) in the (m, m^*)-space. Appendix A shows that in this point the equilibrium level of employment can be written as follows:

$$l = \varepsilon_H w + \varepsilon_F w^* \qquad \varepsilon_H < 0,\ \varepsilon_F < 0, \tag{31}$$

$$l^* = \varepsilon_{F^*} w^* + \varepsilon_{H^*} w, \qquad \varepsilon_{F^*} < 0,\ \varepsilon_{H^*} < 0. \tag{32}$$

[15] Cukierman, Rodriguez, and Webb (1998) provide empirical evidence on the fact that highly conservative monetary authorities counteract wage increases, while in countries with less conservative CBs monetary policy is accommodating.

5 Wage setting and equilibrium

The u-th union controls the growth of the nominal wage u, $w(u)$ and anticipates that

$$\frac{\partial W}{\partial w(u)} = \frac{1}{n}\left(\frac{W(u)}{W}\right)^{-\sigma} \tag{33}$$

taking other unions' wages both at Home and abroad as given (see Appendix B). Eq. (33) is key to understand the model results. In a symmetric equilibrium ($W(u) = W$), as long as n is finite, an increase in the union's wage affects aggregate wage which, in turn, reduces aggregate employment by eqs. (31) and (32). Notice that the number of unions n can be interpreted as the degree of internalization of wage setting. Specifically, the higher is the number of unions the less unions perceive to affect aggregate variables.

Each union chooses its wage in the first stage of the game playing a Nash game with the other unions and acting as Stackelberg leader vis-à-vis the two monetary authorities. The reaction functions of the CBs are hence common knowledge for wage setters. This implies that the Home labor unions maximize their utility functions (12) subject to (17), (3), (31), and (32). Solving the first-order condition evaluated at the symmetric equilibrium $w(u) = w$ yields the following equilibrium employment (see Appendix C):

$$l = \tilde{l}\left(1 - \frac{1}{\eta}\right), \tag{34}$$

where $\eta \equiv -\mathrm{d}\log L(u)/\mathrm{d}\log(W(u)/P) > 1$ is the real consumption wage elasticity (in absolute value) of the demand for labor type $j \in u$. It is apparent that, as long as η is finite, equilibrium employment is below the efficient level $\tilde{l}$. More specifically, a lower labor demand elasticity implies that, for a given level of employment, nominal wage hikes yield higher marginal benefits in terms of consumption, thereby reducing wage restraints. Therefore η is a measure of the monopolistic power of unions. Rewriting eq. (34)

$$\frac{1}{\eta} = \frac{1 - s_h}{-\varepsilon_h} = \frac{\tilde{l} - l}{\tilde{l}}, \tag{35}$$

i.e. the elasticity of labor demand to *real* wages measures the percentage deviation of natural employment from efficient employment. The lower η, the higher is the perceived real wage obtained by unions in the wake of *nominal* wage claims. The term $s_h \in (0,1)$ in the numerator of eq. (35),

$$s_h \equiv \frac{\partial \log P}{\partial \log W(u)} = \frac{k\left(k + \beta^* \theta^{*2}\right)}{k^2 + \beta\beta^*\theta\theta^*(1-\alpha) + k\left(\beta\theta^2 + \beta^*\theta^{*2}\right)} \in (0,1), \tag{36}$$

is the elasticity of CPI to nominal wage u, and is negatively related to the monopolistic distortion in the labor market. An increase in wage u in fact raises the general price level, which in turn reduces the real

wages of union members. Similarly, an increase in labor demand elasticity to nominal wage,

$$
\begin{aligned}
-\varepsilon_h \equiv -\frac{\partial \log L(u)}{\partial \log W(u)} &= \sigma\left(1-\frac{1}{n}\right)-\varepsilon_H\frac{1}{n} \\
&= \sigma\left(1-\frac{1}{n}\right)+\frac{\beta\theta\left(k+\beta^*\theta^{*2}\right)}{k^2+\beta\beta^*\theta\theta^*(1-\alpha)+k\left(\beta\theta^2+\beta^*\theta^{*2}\right)}\frac{1}{n}, \qquad (37)
\end{aligned}
$$

implies that, for a given increase in $w(u)$, the reduction in employment and hence in labor income is more considerable. It turns out that a rise in ε_h and s_h leads to lower wage demands. Notice that eq. (37) defines the elasticity of domestic labor demand perceived by the u-th union as a weighted average of the elasticity of substitution between labor types and the elasticity of domestic aggregate labor demand. It turns out that, with atomistic wage setters ($n \to \infty$), eq. (37) boils down to the elasticity of substitution, and unions do not take into account the impact of their wage claims on aggregate employment. The weight of the elasticity of aggregate labor demand in eq. (37) is instead increasing in the union's size (lower n). With a single all-encompassing union ($n = 1$) each labor-type service receives the same wage, thereby preventing any substitution effect between labor types from operating.

Finally, from eqs. (27) and (34) the equilibrium rate of inflation is given by:

$$
p = \frac{\alpha}{(1-\alpha\gamma)\beta}\left[\frac{1}{\eta}-(1-\gamma)\right], \qquad (38)
$$

As noted in the section 4, with open-economy spillovers ($\gamma \neq 1$) monetary authorities are induced to resort to surprise monetary contractions because they perceive to affect the terms of trade. However, equilibrium employment (34) and inflation (38) depend on the labor market distortions captured by the elasticity η as well. In particular, the lower is η, the higher is inflation and the lower is employment (see eqs. (38) and (34)).

6 Analysis of labor demand elasticity η

6.1 Strategic mechanisms

In order to gain an insight of the strategic channels operating in η, it is convenient to rewrite the elasticities of labor demand to real wages η as follows:

$$
\eta = \left[\underbrace{\frac{1}{\sigma}}_{\substack{\text{substitution}\\ \text{effect}}}\left(1-\frac{\varepsilon_H}{n\varepsilon_h}\right)+\underbrace{(1-\alpha)}_{\substack{\text{output}\\ \text{effect}}}\frac{\varepsilon_H}{n\varepsilon_h}+\underbrace{\alpha(1-\gamma)\left(\frac{\varepsilon_H-\varepsilon_{H^*}}{\varepsilon_H}\right)}_{\text{terms-of-trade effect}}\frac{\varepsilon_H}{n\varepsilon_h}\right]^{-1}, \qquad (39)
$$

where $\frac{\varepsilon_H}{n\varepsilon_h} \in (0,1)$.

The incentive to set a higher nominal wage $w(u)$ relies on a weighted combination of three effects.

First, since other unions' strategies are taken as given, a u-th union perceives to increase its wage relative to other unions' wages ($W(u)/W$). However, an increase in the u-th union's wage raises the cost of labor inducing firms to substitute labor types $j \in u$ with other labor types $j \notin u$. This effect clearly depends on σ and is captured by the first term in eq. (39). Drawing on Lippi's (2003) terminology, is labeled "substitution effect". Note that, as long as the direct effect of $w(u)$ on w is less than one (i.e. in a symmetric equilibrium $\partial w/\partial w(u) = 1/n$), a union has an incentive to exploit its monopolistic power on the labor services market through the elasticity of substitution σ. In the extreme case of a single all-encompassing union ($n = 1$), ε_h is equal to ε_H, and the substitution effect disappears. A wage rise, in this case, leads to an equal proportional increase in aggregate wage without any possibility for the union of increasing its relative wage.

Second, a u-th union anticipates that its real production wage (i.e. $W(u)/P_H$) increases in the wake of a nominal wage rise through the reduction in aggregate output. This effect is captured by the second term in eq. (39) and, drawing on Lippi's (2003) terminology, is labeled "output effect". Specifically, from eq. (5), a nominal wage rise is perceived to increase the real production wage through the elasticity of aggregate employment to real production wage $(1-\alpha)^{-1}$.

In a closed economy, the producer price index coincides with the consumer price index. Therefore, in Lippi (2003) the output and substitution effects are the sole effects taken into account by unions in their wage setting process. In this model, eq. (39) shows that η is indeed constituted by the output and substitution effect. But it is further reduced by a third effect: the improvement in the terms of trade.[16]

Result 2 *The terms-of-trade effect is lower the more conservative is the foreign CB.*

In order to prove this result, notice that

$$\alpha(1-\gamma)\left(\frac{\varepsilon_H - \varepsilon_{H^*}}{\varepsilon_H}\right) = \alpha(1-\gamma)\left(\frac{k+\beta^*\theta^*(1-\alpha)}{k+\beta^*\theta^{*2}}\right)$$

is decreasing in the degree of Foreign CB conservatism. I label that mechanism the "terms-of-trade effect". Such an effect is present as long as the Home employment elasticity to Home wage (ε_H) is different from the Foreign employment elasticity to Home wage (ε_{H^*}). In this respect, one can easily show (see Table 1) that

$$\frac{\partial tot}{\partial w(u)} = \frac{\alpha(1-\gamma)}{n}(\varepsilon_H - \varepsilon_{H^*}) < 0,$$

where tot is the log of eq. (26). In words, each domestic union anticipates that a wage rise can improve the terms of trade through the difference between the elasticity of (aggregate) domestic and foreign employment. In such a case, a Home wage hike entails an improvement in the Home terms of trade which, in turn, reduces the consumer price index. As a result, the real consumption wage ($W(u)/P$) is perceived

[16] Among the first to highlight such effect, in a first generation of game-theoretic models *à la* Canzoneri and Henderson (1988), is Jensen (1993) who shows that the real exchange rate appreciation drives a wedge between the consumption and production real wage, thereby inducing unions to be more aggressive in their wage requests.

to rise because of the terms of trade improvement, encouraging nominal wage demands.[17] This effect is curtailed by the degree of Foreign CB conservatism. A higher β^* in fact increases the (absolute) elasticity of Foreign labor demand to Home wages (see Result 1), thereby reducing the (absolute) difference between ε_H and ε_H^*.

The domestic monetary response to domestic wages has been recently investigated in the literature (e.g. Lippi, 2003; Gnocchi, 2006; Coricelli, Cukierman, and Dalmazzo, 2006), while the *foreign* monetary response to domestic wages has been ignored by these studies. However, since in an open economy both Home and Foreign monetary policies are internalized by large unions, a rise in $w(u)$ is anticipated to affect Foreign employment as follows (see eq. (32)):

$$\begin{aligned}\varepsilon_{h^*} \equiv \frac{\partial \log L^*(u^*)}{\partial \log W(u)} = \frac{\partial \log L^*}{\partial \log W(u)} &= \varepsilon_{H^*}\frac{1}{n} \\ &= -\frac{\beta\beta^*(1-\theta)\theta\theta^*}{k^2+\beta\beta^*\theta\theta^*(1-\alpha)+k\left(\beta\theta^2+\beta^*\theta^{*2}\right)}\frac{1}{n}. \end{aligned} \tag{40}$$

Intuitively, an increase in the Home nominal wage u leads to higher inflation in the Foreign country through a rise in p_H^*. Since the (optimal) Foreign monetary policy balances the burden of the welfare loss between employment and inflation by moving employment and inflation into the opposite direction (see eq. (28)), Foreign employment falls in the wake of Home wage claims.

6.2 Collective bargaining coverage

This section assesses the real effects of the wage-bargaining system.

To this purpose, it is convenient to rewrite the real wage elasticity $1/\eta$ as follows:

$$\frac{1}{\eta} = \frac{1}{\sigma}\left(1-\frac{\varepsilon_H}{n\varepsilon_h}\right) + \frac{1}{\eta\big|_{n=1}}\frac{\varepsilon_H}{n\varepsilon_h}, \tag{41}$$

where

$$\eta\big|_{n=1} \equiv \left[1-\alpha+\alpha(1-\gamma)\left(\frac{\varepsilon_H-\varepsilon_{H^*}}{\varepsilon_H}\right)\right]^{-1} = \frac{k+\beta^*\theta^{*2}}{(1-\alpha)\beta^*\theta^*+k\theta}.$$

Eq. (41) is a weighted average measuring the monopolistic distortion in the labor market, whereby the higher $1/\eta$, more monopolistic power is perceived by unions.

Note that the "weight" entering in the labor demand elasticity η^{-1} is given by

$$\frac{\varepsilon_H}{n\varepsilon_h} = \frac{1}{1-\frac{\sigma(n-1)}{\varepsilon_H}} \in (0,1). \tag{42}$$

From the above expression is apparent that n and ε_H have two opposing effect on the weight attached to the elasticity of labor demand to real wage. More specifically, an increase in the number of unions

[17] Cavallari (2004) omits such a wedge between the real consumption wage elasticity and the real production wage elasticity of perceived labor demand. Thus, her results hinge only on the output and substitution effects.

reduces eq. (42), while an increase in aggregate labor demand elasticity raises it.

Result 3 *An increase in the number of unions, i.e. a more decentralized wage setting, raises (reduces) welfare and reduces (raises) inflation if* $\sigma > \eta\big|_{n=1}$ $\left(\sigma < \eta\big|_{n=1}\right)$.

The intuition for this ambiguous result stems directly from eq. (41). Since $1/\eta$ is a linear combination of $1/\sigma$ and $1/\eta\big|_{n=1}$, an increase in n puts more weight on the substitution effect operating in the labor demand elasticity, so that employment increases and inflation diminishes only if $\sigma > \eta\big|_{n=1}$ (see eqs. (34), (27), and (41)). Opposite effects occur when $\sigma < \eta\big|_{n=1}$.[18] Furthermore, since employment is inefficiently low, an increase in labor demand elasticity is accompanied by an increase in welfare as well. It follows that, a welfare improvement hinges on complementarity between labor market distortions and centralization of wage setting. More specifically, labor markets featuring sizeable monopolistic distortions (small σ) call for centralized wage bargaining. Viceversa, in presence of low monopolistic distortions (large σ) a decentralized wage-bargaining system performs better.

This result differs from Coricelli, Cukierman, and Dalmazzo (2004). They find that a larger number of unions always worsens economic performance at Home. The explanation of such a different prediction is due to the absence of a substitution effect in their model. As labor services are not substitutable in production, the output and terms-of-trade effects are always larger than the substitution effect which, in turn, implies that economic performance is unambiguously decreasing in the decentralization of wage bargaining.

It is worth noticing that the condition in Result 3 extends Lippi's (2003) finding. With $1 < n < \infty$, Lippi (2003) spells out how in a closed economy both the elasticity of substitution among labor types and the elasticity of aggregate labor demand to nominal wages affect η. Here, a domestic union also internalizes the elasticity of foreign labor demand to domestic wage through the foreign monetary policy. It turns out that not only substitution and output effect affect welfare, but also the terms-of-trade effect accounts for unions' wage demands in an open economy.

6.3 CB conservatism

How does the degree of domestic CB conservatism affect welfare?

Result 4 *As long as* $n \in (1, \infty)$*, an increase in CB conservatism* β *raises (reduces) welfare if* $\sigma < \eta\big|_{n=1}$ $\left(\sigma > \eta\big|_{n=1}\right)$.

A higher aversion to inflation of domestic CB implies that monetary policy accommodates wage hikes to a lesser extent, thereby leading to higher (in absolute value) aggregate labor demand elasticities ε_H. This has two opposing effect on η.

[18] Notice that, for given values of σ and $\eta\big|_{n=1}$, Result 3 entails a monotonic relation between the degree of centralization in wage setting and economic performance. This is in contrast with the U-shaped curve *à la* Calmfors and Driffill (1988). The main reason for the absence of a Calmfors-Driffill curve is that the model features a constant elasticity of substitution between labor types (see Guzzo and Velasco, 1999).

As noted above, the monopolistic distortion in the labor market $1/\eta$ is simply a weighted average of the strategic effects $1/\sigma$ and $1/\eta\big|_{n=1}$, where the weights are given respectively by $\left(1-\frac{\varepsilon_H}{n\varepsilon_h}\right)$ and $\left(\frac{\varepsilon_H}{n\varepsilon_h}\right)$.

Now, an increase in β does not have any direct impact on the three strategic mechanism (see Section 6.1). But it causes a rise in ε_H, thereby increasing the weight attached to the $1/\eta\big|_{n=1}$ component (see eq. (42)). As a result, if $\sigma < \eta\big|_{n=1}$, a more conservative CB is beneficial in terms of welfare because it reduces labor market distortions. Conversely, if $\left(\sigma > \eta\big|_{n=1}\right)$, the society would be better off by appointing a less conservative CB.

The ambiguous result in Result 4 is in contrast with Jensen (1993) and Coricelli, Cukierman, and Dalmazzo (2004) where a more conservative CB always boosts employment. As previously highlighted, their result hinges on the fact that the production function does not exhibit any substitution effect. In other words, their prediction is replicated in this model when the substitution effect is relatively low, so that conservatism has an increasing effect on employment.

Moreover, this paper extends the Lippi's (2003) findings in two respects. First, the real effects of domestic conservatism depend not only on the substitution and output effects, but also on the terms-of-trade effect. Second,

Result 5 *An increase in foreign CB conservatism β^* is always welfare improving.*

Differently from β, foreign CB conservatism β^* has two effects on labor market distortions. On the one side, it increases the weight of $\eta\big|_{n=1}$ in eq. (41). On the other side, it reduces the terms-of-trade effect (see Result 2), thereby increasing the labor demand elasticity η for any value of $\beta^* > 0$. The latter effect implies that a rise in foreign conservatism is unambiguously beneficial to economic performance.

7 Concluding remarks

The paper highlights how central bank's (CB) aversion to inflation ("conservatism") affects employment in a two country model with nominal rigidities and non-atomistic wage setters. The open-economy dimension yields a third channel through which monetary policy stance can affect wage demands.

The main findings are that three strategic mechanisms simultaneously operates on the wage setters' decisions: substitution, output, and terms-of-trade effect. Foreign CB's conservatism in particular reduces the extent of a terms-of-trade improvement in the wake of nominal wage increase. Thus a more conservative foreign CB leads to wage restraint.

Domestic CB conservatism instead may increase or decrease employment. However, this depends on the relative size of the three strategic effects. When the the output and terms-of-trade effects dominate the substitution effect, it is optimal to appoint a more conservative domestic CB. In this respect the Lippi's (2003) result, whereby conservatism of monetary policy and centralized wage setting affect equilibrium employment only through the output and substitution effect, is qualified so as to allow for the terms-of-trade effect.

Appendixes

A Derivation of monetary policies Nash equilibrium

Before deriving the optimal non-cooperative monetary policy, it is convenient to rewrite the key endogenous variables in the model in terms of nominal money supplies and wages. These variables, apart from constant additive terms, are presented in Table 1.[19]

Table 1: Fundamental variables in terms of money supplies and wages

$l = m - w$	$l^* = m^* - w^*$	(43)
$p_H = (1-\alpha)m + \alpha w$	$p_F^* = (1-\alpha)m^* + \alpha w^*$	(44)
$p = p_H + (1-\gamma)tot$	$p^* = p_F^* - \gamma tot$	(45)
$c_H = \alpha(m-w)$	$c_F^* = \alpha(m^* - w^*)$	(46)
$c_F = \alpha(m^* - w^*)$	$c_H^* = \alpha(m-w)$	(47)
$c = \gamma c_H + (1-\gamma)c_F$	$c^* = \gamma c_H^* + (1-\gamma)c_F^*$	(48)
$tot = \alpha(m - m^* - w + w^*)$	$e = m - m^*$	(49)

Eq. (29) in the text is obtained from the solution of the following problem

$$\max_m \Omega = \int_0^1 \left[U(j) - \chi \log\left(\frac{M(j)}{P}\right)\right] \mathrm{d}j - \frac{\beta}{2}p^2 \quad \texttt{s.to}\ (48),(43),(45).$$

A symmetric problem is solved by the Foreign CB yielding eq. (30). The Nash equilibrium is the point in the (m, m^*)-space where (30) and (29) intersect:

$$m = \frac{\left(k^2 - k\beta(1-\theta)\theta - \beta\beta^*(1-\theta)\theta\theta^* + k\beta^*\theta^{*2}\right)}{k^2 + \beta\beta^*\theta\theta^*(1-\alpha) + k\left(\beta\theta^2 + \beta^*\theta^{*2}\right)} w - \frac{\beta\beta^*\theta(1-\theta^*)\theta^*}{k^2 + \beta\beta^*\theta\theta^*(1-\alpha) + k\left(\beta\theta^2 + \beta^*\theta^{*2}\right)} w^*,$$

$$m^* = w^* - \frac{\beta^*\left(k + \beta\theta^2\right)\theta^*}{k^2 + \beta\beta^*\theta\theta^*(1-\alpha) + k\left(\beta\theta^2 + \beta^*\theta^{*2}\right)} w^* - \frac{\beta\beta^*(1-\theta)\theta\theta^*}{k^2 + \beta\beta^*\theta\theta^*(1-\alpha) + k\left(\beta\theta^2 + \beta^*\theta^{*2}\right)} w,$$

where $\theta \equiv 1 - \alpha\gamma$, $\theta^* \equiv 1 - \alpha(1-\gamma)$. In order to find the aggregate employment elasticities, I plug the Nash solution of money supplies into (43) as follows:

$$l = \underbrace{-\frac{\beta\theta\left(k + \beta^*\theta^{*2}\right)}{k^2 + \beta\beta^*\theta\theta^*(1-\alpha) + k\left(\beta\theta^2 + \beta^*\theta^{*2}\right)}}_{\varepsilon_H^{NMP}} w \underbrace{- \frac{\beta\beta^*\theta(1-\theta^*)\theta^*}{k^2 + \beta\beta^*\theta\theta^*(1-\alpha) + k\left(\beta\theta^2 + \beta^*\theta^{*2}\right)}}_{\varepsilon_F^{NMP}} w^*,$$

[19] They are obtained by using eqs. (5), (8)-(6), (20)-(23) and (26).

$$l^* = \underbrace{-\frac{\beta^*\left(k+\beta\theta^2\right)\theta^*}{k^2+\beta\beta^*\theta\theta^*(1-\alpha)+k\left(\beta\theta^2+\beta^*\theta^{*2}\right)}}_{\varepsilon_{F^*}^{NMP}} w^* \underbrace{-\frac{\beta\beta^*(1-\theta)\theta\theta^*}{k^2+\beta\beta^*\theta\theta^*(1-\alpha)+k\left(\beta\theta^2+\beta^*\theta^{*2}\right)}}_{\varepsilon_{H^*}^{NMP}} w.$$

B Derivation of eq. (33)

By normalizing the previous period nominal wage to unity, the current nominal wage can be expressed as

$$W(j) = 1 + w(j).$$

Consider that each union takes as given the wage set by other unions and that the wage is the same for all the workers of union u. From eq. (4) I have that

$$\begin{aligned}
\frac{\partial W}{\partial w(u)} &= \frac{\partial}{\partial w(u)}\left[\int_0^1 W(j)^{1-\sigma}\mathrm{d}j\right]^{\frac{1}{1-\sigma}} \\
&= \frac{\partial}{\partial w(u)}\left[\int_{j\in u} W(j)^{1-\sigma}\mathrm{d}j + \int_{j\notin u} W(j)^{1-\sigma}\mathrm{d}j\right]^{\frac{1}{1-\sigma}} \\
&= \frac{1}{n}\left[\frac{W(u)}{W}\right]^{-\sigma}.
\end{aligned}$$

C Derivation of union's first-order condition

The u-th union first-order condition is obtained by solving (12)

$$-nk\int_{j\in u}\log L(j)\frac{\partial \log L(j)}{\partial \log W(j)}\mathrm{d}j + \frac{W(j)L(j)}{PC(j)}\left[1+\frac{\partial L(j)}{\partial W(j)}\frac{\partial W(j)}{\partial \log W(j)}\frac{1}{L(j)} - \frac{\partial P}{\partial W(j)}\frac{\partial W(j)}{\partial \log W(j)}\frac{1}{P}\right] = 0. \tag{50}$$

From firms profit maximization, it turns out that in a symmetric equilibrium $WL/(PC) = \alpha$. Thus, I may write (50) as follows:

$$\alpha(1+\varepsilon_h - s_h) = k\varepsilon_h \log L, \tag{51}$$

where $s_h \equiv \partial \log P/\partial \log W(j)$. Using the definition of η into (51) yields eq. (34) in the text.

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