International Monetary Policy Cooperation Revisited: Conservatism and Non-Atomistic Wage Setting

by

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International monetary policy cooperation revisited: conservatism and non-atomistic wage setting*

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Abstract

This paper presents a simple model of policy coordination in line with the New Open Economy Macroeconomics literature. I extent the analysis on non-cooperative toward cooperative solutions by incorporating a collective wage bargaining system and conservative central banks. It turns out that previous results on international monetary policy cooperation are modified such that cooperation is welfare improving. The finding in the model relies on wage setters' perceptions about affecting monetary policy. It is shown that under cooperation wage setters perceive a tighter monetary policy, thereby inducing wage restraints.

Keywords: monetary policy games, international policy coordination, central bank conservatism, monopoly unions

JEL classification: E58, F41, F42, J51

1 Introduction

The importance of interdependence between the stabilization rule of a conservative central bank (CB) and collective wage bargaining was originally emphasized in Soskice and Iversen (1998, 2000) and Bratsiotis and Martin (1999), and recently reinvestigated in the literature (e.g. Coricelli, Cukierman, and Dalmazzo, 2004; Gnocchi, 2006). However, the issue of international monetary policy coordination and wage bargaining relies on linear versions of the Rogoff (1985a) model due to Canzoneri and Henderson (1988). In this respect, Jensen (1993) presents a two-country model of strategic wage setting and monetary policy regimes. His main result is that, in a world with flexible prices and exchange rates, international monetary policy cooperation is counterproductive. A cooperative regime is disadvantageous

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because monetary authorities worsen the domestically generated inflation bias (as e.g. Rogoff, 1985a). Since non-atomistic wage setters anticipate a more expansive monetary policy in the wake of wage rises, they will set higher wages yielding a greater equilibrium unemployment. The key point in this literature is in fact that the degree of monetary policy accommodation affects the behavior of wage setters. In particular, the degree of accommodation of the money supply to changes in the price level (i.e. conservatism) increases the elasticity of the labor demand curve, thereby worsening the trade-off between employment and wages faced by workers, and leading to lower rate of equilibrium unemployment; see Cukierman (2004) for a recent survey.

This paper examines macroeconomic interdependence and the need for policy coordination in a tractable micro-founded model in line with the New Open Economy Macroeconomics (NOEM) literature (e.g. Obstfeld and Rogoff, 2002; Corsetti and Pesenti, 2005; Devereux and Engel, 2003; Canzoneri, Cumby, and Diba, 2005). According to Canzoneri, Cumby, and Diba (2005), the main characteristics of a benchmark model for the study of macroeconomic interdependence are: "(1) a balanced current account, (2) log utility of consumption, (3) constant expenditure shares (on components of the composite consumption good), and (4) a log specification for the utility of money" (Canzoneri, Cumby, and Diba, 2005, p. 364).

In order to obtain gains from coordination, however, some assumptions of the simple framework have been relaxed in literature. Corsetti and Pesenti (2005) and Devereux and Engel (2003), for example, consider the case where the law of one price does not hold closely, i.e. the degree of exchange rate pass-through to import prices may be different from one. Obstfeld and Rogoff (2002) focus on more general specification of the representative household's utility function. Canzoneri, Cumby, and Diba (2005) introduce imperfectly correlated sectoral shocks, and conclude that sizable welfare gains from coordination can be generated in such a case in the standard Obstfeld and Rogoff (2002) setup.

A novel feature of this model is the introduction of collective wage bargaining agreements and conservative CBs in an otherwise standard NOEM model. The former assumption is due to the fact that "[i]n most countries in the OECD, the majority of workers have their wages set by collective bargaining between employers and trade unions at the plant, firm, industry or aggregate level" (Nickell, Nunziata, and Ochel, 2005, p. 6). The introduction of conservatism, i.e. a CB more averse to inflation than society, instead hinges on Rogoff's (1985b) proposal to delegate monetary policy to an independent and conservative CB so as to reduce the inflation bias associated with time inconsistent policies (Kydland and Prescott, 1977; Barro and Gordon, 1983). There is extensive empirical evidence suggesting that a higher level of CB conservatism negatively affects inflation (see e.g. Berger, de Haan, and Eijffinger, 2001).

The central question addressed in this paper is whether collective bargaining, modeled through a monopolistic labor union, and CB conservatism, captured by adding an inflation cost term to agents' utility, can generate welfare benefit of monetary cooperation in a simple symmetric benchmark model *à la* Canzoneri, Cumby, and Diba (2005). The main finding of the paper is that the introducing of strategic interactions between non-atomistic wage setters and conservative monetary authorities produces welfare gains in a cooperative monetary regime also in a benchmark model. This is in sharp contrast with

Obstfeld and Rogoff (2002), Corsetti and Pesenti (2005), and Devereux and Engel (2003) where welfare gains from coordination cannot be generated in the standard symmetric Obstfeld and Rogoff (2002) set-up.

The reason for this result stems from a tighter monetary policy *perceived* by wage setters under the cooperative monetary regime. As in Rogoff (1985a) and Benigno (2002), cooperation reduces the incentive to contract money supply. In this paper it is mainly due to two effects. Under a non-cooperative regime, the CB disregards foreign inflation and has the incentive to strategically improve the terms of trade. Both effects lead to a less expansive monetary policy than under cooperation. Nevertheless, in terms of equilibrium employment, it is relevant how unions anticipate the monetary wage response policies under either regime. Since a cooperative monetary authority incurs an additional cost from domestic wage rise via the change in inflation abroad, it is demonstrated that under cooperation monetary responses are perceived as being more stringent. This discourages wage demands to a larger extent because unions expect a less marginal benefit from their wage claims.

Moreover, such a finding is in contrast with the classical contributions to this issue (e.g. Jensen, 1993, 1997). Jensen (1997) shows that there can be beneficial effects from monetary cooperation only in presence of inflation averse wage setters. Interestingly, in this model, it is not necessary to assume inflation aversion *per se*. The inflationary costs of the CB perceived by the unions in the wake of wage rises are in fact sufficient to dampen wage claims under the cooperative regime in presence of nominal rigidities.

The rest of the paper is organized as follows: Section 2 presents the benchmark model. In Section 3, I analyze the efficient allocation and the macroeconomic interdependence exhibited by the model. Section 4 and 5 discuss the monetary policy and wage setting under the two monetary regimes respectively. Section 6 summarizes.

2 The model

I analyze the role of monetary policy coordination using a simple micro-founded general equilibrium model in the vein of the NOEM literature (e.g. Corsetti and Pesenti, 2001, 2005; Obstfeld and Rogoff, 2000, 2002). However, I extend the model by introducing a collective wage bargaining system and CB conservatism.

The economy consists of two countries, Home (H) and Foreign (F), each inhabited by a continuum of agents with population size normalized to 1. Home agents are indexed by j.[1] Each country is specialized in the production of a single traded good. There are no impediments or costs to trade across borders. For each type of goods, H and F, there exists a continuum of brands.

The model features (1) a balanced current account, (2) log utility of consumption, (3) constant expenditure shares on the goods entering in the consumption bundle in each country, and (4) log utility of

[1] Henceforth, economic variables in the Foreign country will be indexed by "*".

money. These are the key elements of a prototypical second generation model for the study of macroeconomic interdependence, as underlined in Canzoneri, Cumby, and Diba (2005).

I consider a two-stage game with the following timing. At the beginning of the period, producer prices and nominal wages are set simultaneously before the monetary stance. Each monopolistic competitive firm is atomistic so it sets the price of its brand taking the other firms' prices, wages and money supplies as given. Nominal wages are set simultaneously by a large monopolistic union in its country of origin. In doing that, each union takes producer prices and foreign wage as given, but internalizes money supply response to its wage in the two countries, i.e. each union acts as Stackelberg leader vis-à-vis monetary authorities and plays a Nash game with the other union. Finally, once nominal wages and producer prices are set, monetary policy is conducted in each country by an independent CB under a non-cooperative or cooperative regime. The prevailing regime is always known to unions when setting their wages.

Intuitively, the timing structure of the model entails producer prices and nominal wages being stickier than monetary stance. These characteristics are in line with a key feature of the data where nominal exchange rate changes are associated with almost one-to-one fluctuations in real exchange rates and in relative international prices (see e.g. Obstfeld, 2001). Moreover, the choice of modeling the game between labor unions and CBs as a Stackelberg game is supported by the fact that wage contracts are usually negotiated to cover at least a year, whereas monetary policy can be adjusted frequently (see Cukierman, 2004).

2.1 Households

Utility of a representative Home agent j is given by

$$U(j) = \log C(j) - \frac{k}{2}\left[\log L(j)\right]^2 + \log\left(\frac{M(j)}{P}\right), \tag{1}$$

where k is a positive preference parameter and $L(j)$ is a measure of hours worked. $C(j)$ is a Cobb-Douglas aggregate of the two available types of goods:

$$C(j) = 2C_H(j)^{1/2}C_F(j)^{1/2}; \tag{2}$$

$C_H(j)$ and $C_F(j)$ are the j-th individual consumption basket of the Home good and Foreign good respectively given by:

$$C_H(j) = \left[\int_0^1 C_H(j,z)^{(\theta-1)/\theta}\mathrm{d}z\right]^{\theta/(\theta-1)} \quad ; \quad C_F(j) = \left[\int_0^1 C_F(j,z)^{(\theta-1)/\theta}\mathrm{d}z\right]^{\theta/(\theta-1)},$$

where z is an index of brands, and $\theta > 1$ is the elasticity of substitution across brands. Isomorphic preferences on the two goods hold in the Foreign country.

The consumption-based price indexes expressed in domestic and foreign currency are

$$P = P_H^{1/2} P_F^{1/2} \qquad ; \qquad P^* = P_H^{*1/2} P_F^{*1/2}, \tag{3}$$

where

$$P_H = \left[\int_0^1 P_H(z)^{1-\theta} \mathrm{d}z\right]^{1/(1-\theta)} \qquad ; \qquad P_F = \left[\int_0^1 P_F(z)^{1-\theta} \mathrm{d}z\right]^{1/(1-\theta)}.$$

A formula parallel to the one above holds for the Foreign-denominated prices of Home and Foreign goods, P_H^* and P_F^*, respectively.

Throughout the paper, I assume that firms set prices in the sellers' local currency and the law-of-one-price holds, so that the cost of imported goods in the home consumption basket is simply the price of traded goods charged by foreign exporting firms, adjusted by the nominal exchange rate:

$$P_F(z) = E P_F^*(z) \qquad ; \qquad P_H^*(z) = P_H(z)/E, \tag{4}$$

where E is the nominal exchange rate (domestic currency per unit of foreign currency), and $P_H^*(z)$ and $P_F^*(z)$ are the prices of Home and Foreign brand z expressed in Foreign currency. Since agents' preferences are identical in the two countries, combining the law of one price with (3) leads to the consumption-based purchasing power parity (PPP):

$$EP^* = P. \tag{5}$$

A typical Home agent j maximizes (1) with respect to $C(j)$ and $M(j)$ subject to the budget constraint

$$M(j) + PC(j) + T(j) = M_0(j) + W(j)L(j) + D(j), \tag{6}$$

where $T(j)$ is a lump-sum tax and $M_0(j)$ is initial nominal money holdings. The household's income consists of her wage income, $W(j)L(j)$, and dividends, $D(j)$, received from all domestic firms.[2] Throughout the paper, I assume that the profits are entirely paid to shareholders as dividends. Foreign individuals face an analogous problem.

The household j's demands for a typical Home and Foreign brand are derived from cost minimization as follows:

$$C_H(j,z) = \frac{1}{2}\left[\frac{P_H(z)}{P_H}\right]^{-\theta}\left[\frac{P_H}{P}\right]^{-1} C(j) \tag{7}$$

$$C_F(j,z) = \frac{1}{2}\left[\frac{P_F(z)}{P_F}\right]^{-\theta}\left[\frac{P_F}{P}\right]^{-1} C(j), \tag{8}$$

with isomorphic demands by Foreigners. Note that, in a symmetric equilibrium ($P_H(z) = P_H$ and $P_F(z) =$

[2]Given the Cobb-Douglas preferences in consumption (2) and the separability of individuals' utility functions, the foreign equity trade is redundant. Moreover, the equilibrium holdings of international traded bonds would be zero at any time in an intertemporal version of our model (see Corsetti and Pesenti, 2001).

P_F), eqs. (7) and (8) exhibit the constant expenditure shares discussed above.

The first-order conditions for Home and Foreign households' nominal money balances are:

$$\frac{1}{C(j)} = \left(\frac{M(j)}{P}\right)^{-1} \qquad ; \qquad \frac{1}{C^*(j^*)} = \left(\frac{M^*(j^*)}{P^*}\right)^{-1}. \tag{9}$$

For a given wage, households are willing to supply whatever quantity of labor is required to clear the markets. The implication of monopolistic wage setting on labor supply will be discussed below.

2.2 Firms

From the consumption allocation derived in the previous section and aggregating across the Home and Foreign households, the demands faced by the various firms in the two countries are given by:

$$Y_H(z) = \frac{1}{2}\left[\frac{P_H(z)}{P_H}\right]^{-\theta}\left[\frac{P_H}{P}\right]^{-1}(C+C^*) \tag{10}$$

$$Y_F^*(z) = \frac{1}{2}\left[\frac{P_F^*(z)}{P_F^*}\right]^{-\theta}\left[\frac{P_F^*}{P^*}\right]^{-1}(C+C^*). \tag{11}$$

Technology is described by the following production functions:

$$Y_H(z) = L(z) \qquad ; \qquad Y_F^*(z) = L^*(z), \tag{12}$$

for all $z \in [0,1]$, i.e. all firms use a linear technology.

The Home-currency profits of a representative firm are hence as follows:

$$D_H(z) = \frac{1}{2}(P_H(z) - W)\left[\frac{P_H(z)}{P_H}\right]^{-\theta}\left[\frac{P_H}{P}\right]^{-1}(C+C^*), \tag{13}$$

while the Foreign-currency profits of Foreign firms are:

$$D_F^*(z) = \frac{1}{2}(P_F^*(z) - W^*)\left[\frac{P_F^*(z)}{P_F^*}\right]^{-\theta}\left[\frac{P_F^*}{P^*}\right]^{-1}(C+C^*). \tag{14}$$

Thus, each domestic firms z maximizes its profits by setting the relevant brand price, $P_H(z)$, subject to the demand constraint. The optimal price leads firms to charge a markup over the wage cost:

$$P_H(z) = P_H = \frac{\theta}{\theta-1}W \qquad ; \qquad P_F^*(z) = P_F^* = \frac{\theta}{\theta-1}W^*, \tag{15}$$

where I dropped the index z since the equilibrium is symmetric across firms within a given country.

2.3 Exchange rate determination and terms of trade

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

$$-T = \frac{M}{P} - \frac{M_0}{P} \qquad -T^* = \frac{M^*}{P^*} - \frac{M_0^*}{P^*}. \tag{16}$$

The first order conditions are identical for the agents within a given country. Thus, I drop the j index. The product market equilibrium requires that

$$P_H Y_H = 1/2(PC + EP^*C^*) \qquad ; \qquad P_F Y_F^* = 1/2(PC + EP^*C^*), \tag{17}$$

which implies the following result

$$\frac{P_H}{P_F} = \frac{Y_F^*}{Y_H}. \tag{18}$$

Now, using the government budget constraint (16) together with the individual budget constraints (6) yields balanced current accounts

$$PC = P_H Y_H \qquad ; \qquad EP^*C^* = PC^* = P_F Y_F^*, \tag{19}$$

from which Home and Foreign consumption need move together:

$$C = C^*. \tag{20}$$

Eqs. (18) and (19) imply that the exchange rate is equal to the ratio of national nominal expenditure

$$E = \frac{PC}{P^*C^*}. \tag{21}$$

This result stems directly from the characteristics of current account balance and constant expenditure shares exhibited by the model. Substituting the money demand (9) into the above expression, I may rewrite the exchange rate as the ratio of money supply in the two countries

$$E = \frac{M}{M^*}. \tag{22}$$

The terms of trade are defined in the Home country as

$$TOT \equiv \frac{EP_F^*}{P_H}. \tag{23}$$

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

3 The efficient allocation and the reduced form

In this section I derive the efficient allocation and the reduced-form of the model. The former is a useful benchmark for the analysis of optimal policy in the presence of nominal rigidities, while the latter shows macroeconomic interdependence in the two economies.

3.1 Efficient allocation

In order to describe the world's optimal allocation in any given period, I consider the solution of the following social planner's problem (see e.g. Galí and Monacelli, 2008):

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

subject to the feasibility constraint

$$Y_H = C_H + C_F \qquad ; \qquad Y_F^* = C_H^* + C_F^*$$

and the technological constraint

$$Y_H = L \qquad ; \qquad Y_F^* = L^*.$$

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

$$\frac{1}{2C_H} = \frac{1}{2C_F} = \frac{k \log L}{L}$$

$$\frac{1}{2C_H^*} = \frac{1}{2C_F^*} = \frac{k \log L^*}{L^*}$$

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

i.e. the planner would like to equate the marginal rate of substitution between consumption and leisure to the marginal product of labor. 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 social planner's problem:

$$C_H = C_F = C/2 \quad ; \quad C_H^* = C_F^* = C^*/2 \tag{24}$$

$$Y_H = L = C \quad ; \quad Y_F^* = L^* = C^* \tag{25}$$

$$\log L = 1/k \quad ; \quad \log L^* = 1/k. \tag{26}$$

3.2 Reduced form

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 consumer price level to unity, so that the log of these variables can be considered as an approximation of their percentage increase. It is assumed throughout the paper that the strategic choice variable of Home (Foreign) union and CB are respectively the nominal wage growth w (w^*) and the nominal money growth m (m^*).

Table 1: Reduced form of the model

$l = m - w$	$l^* = m^* - w^*$	(27)
$p_H = w$	$p_F^* = w^*$	(28)
$p = 1/2(m - m^* + p_F^* + p_H)$	$p^* = 1/2(m^* - m + p_F^* + p_H)$	(29)
$c_H = m - p_H$	$c_F^* = m^* - p_F^*$	(30)
$c_F = m^* - p_F^*$	$c_H^* = m - p_H$	(31)
$c = 1/2(m + m^* - p_F^* - p_H)$	$c^* = 1/2(m + m^* - p_F^* - p_H)$	(32)
$tot = m - m^* + p_F^* - p_H$	$e = m - m^*$	(33)

I assume a sequential game consisting of two stages under a cooperative and a non-cooperative monetary regime. In the first stage, all firms set their brand price as derived in section 2.2 and labor unions choose their own wages simultaneously, anticipating the subsequent moves of the two monetary authorities and taking prices set by firms as given. In the second stage, the two CBs choose simultaneously their monetary policies under a cooperative or non-cooperative monetary regime, taking as given wages and prices from the previous stage.[3] The model is then solved by backward induction.

The reduced form of the model (apart from constant terms) is summarized in Table 1 (see Appendix A for details). A Home monetary expansion ($m > 0$) depreciates the exchange rate. In the second stage, this effect worsens the terms of trade (33), thereby shifting demand to the good produced in the Home country (see (31) and (30)). As noted in Canzoneri, Cumby, and Diba (2005), exchange rate adjustments render foreign supply side unaffected by domestic monetary policy. Given domestic wages and prices, an increase in m leads to both a nominal ($p + c$) and real (c) consumption rise (see eqs. (7)). Conversely, the nominal exchange rate depreciation has no impact on c_F (eq. 31). c_F and l^* are hence insulated from Home monetary stance.

In the following section, I will assess how optimal policies are performed under the two different

[3]Following the literature on strategic interaction between wage setting and monetary policy, I assume a Stackelberg game between CB (follower) and unions (leader) (see Cukierman, 2004).

policy regimes, and next I turn to the question of how monetary regimes affect domestic wage setting.

4 Monetary policy

In this section I analyze the optimal stabilization policy of discretionary monetary policy disturbances, as in Benigno (2002). In either regime, unions exactly anticipate the optimal policies of the two monetary authorities. There is no cooperation between unions as well as no cooperation between unions and CBs. The CBs, instead, may act non-cooperatively or cooperatively.

4.1 Non-cooperative regime

As money growth is chosen after observing prices and wages, the monetary authority will take prices and wages as given. Drawing on Lippi (2003), I assume that the two independent monetary authorities aim at maximizing a targeting rule by setting the growth rate of money supply after wages have been negotiated. In doing that, each CB takes the money supply in the other country as given. However, following the example of recent literature on monetary policy evaluation, I ignore the money term in the utility function (e.g. Canzoneri, Cumby, and Diba, 2005; Devereux and Engel, 2003; Obstfeld and Rogoff, 2000).

Thus, the problem of the Home CB is given by:

$$\max_{m} \Omega = \int_0^1 \left[U(j) - \log\left(\frac{M(j)}{P}\right) \right] \mathrm{d}j - \frac{\beta}{2} p^2 \quad \texttt{s.to}\ (32), (27), (29), \texttt{and}\ \partial m^*/\partial m = 0, \tag{34}$$

while the Foreign CB solves the following problem:

$$\max_{m^*} \Omega^* = \int_0^1 \left[U^*(j^*) - \log\left(\frac{M^*(j^*)}{P^*}\right) \right] \mathrm{d}j^* - \frac{\beta}{2} p^{*2} \quad \texttt{s.to}\ (32), (27), (29), \texttt{and}\ \partial m/\partial m^* = 0. \tag{35}$$

The $\beta > 0$ parameter captures the CB degree of conservatism in the Home and Foreign country (Rogoff, 1985b).[4] By assuming symmetric targeting rule for the two CBs, I focus on countries with similar characteristics as in the spirit of the NOEM literature.

The first-order condition of (34) yields

$$p = \frac{k(\tilde{l} - l) - 1/2}{\beta/2}, \tag{36}$$

where $\tilde{l} \equiv 1/k$ is the efficient employment level given by eq. (26). Similarly, the solution to (35) yields

$$p^* = \frac{k(\tilde{l} - l^*) - 1/2}{\beta/2}. \tag{37}$$

[4] One could think of the quadratic costs of inflation entering in (35) and (34) as representing an inflation aversion specific to the CB stemming from an explicit statutory or implicit goal of price stability (e.g. Betts and Devereux, 2000).

Table 2: Aggregate labor demand elasticities to wages under a non-cooperative regime

$$l = \underbrace{-\frac{k\beta}{2k(2k+\beta)}}_{\varepsilon_H^C} w + \underbrace{\frac{k\beta}{2k(2k+\beta)}}_{\varepsilon_F^C} w^* \qquad l^* = \underbrace{\frac{k\beta}{2k(2k+\beta)}}_{\varepsilon_{H^*}^C} w - \underbrace{\frac{k\beta}{2k(2k+\beta)}}_{\varepsilon_{F^*}^C} w^* \tag{38}$$

$$p = \underbrace{\frac{k}{2k+\beta}}_{s_H^{NC}} w - \underbrace{\frac{k}{2k+\beta}}_{s_F^{NC}} w^* \qquad p^* = \underbrace{-\frac{k}{2k+\beta}}_{s_{H^*}^{NC}} w + \underbrace{\frac{k}{2k+\beta}}_{s_{F^*}^{NC}} w^* \tag{39}$$

Thus, the optimal monetary policy hinges on equating marginal benefit of an inflationary monetary policy to marginal cost, respectively given by the terms on the R.H.S. and L.H.S. of eqs. (36) and (37). For a given (explicit) marginal cost of inflation ($\beta/2p$), an expansionary monetary policy has two opposing effects. First, as long as employment l is below the efficient level $\tilde{l}$, the monetary authority has an incentive to raise inflation so as to shrink the discrepancy between efficient and natural output. This is the standard Blanchard-Kiyotaki result in which a positive monetary shock unambiguously improves domestic welfare (Blanchard and Kiyotaki, 1987). Second, as found in Corsetti and Pesenti (2001), in an open economy the CB has an incentive to strategically improve its terms of trade, (see eq. (33)), thereby implementing a too contractive monetary policy. Specifically, "[t]he reduction in the utility derived from consumption is more than compensated by the reduction in the disutility of producing effort, because the 'burden' of production is shifted to the other country through the improved terms of trade" (Benigno, 2002, p. 185). Such an effect is captured by the negative term on the R.H.S. of eqs. (36) and (37). It turns out that the inflationary bias equilibrium does not necessary arise in this model.

The Nash equilibrium is derived by combining the Home CB reaction function (36) with the Foreign CB reaction function (37). Solving eq. (36) for money supply yields Home policy in terms of Home and Foreign wages.

Table 2 presents the elasticities of aggregate labor demand and prices to nominal wages after plugging the Nash equilibrium monetary reaction function into (27) and (29), disregarding constant terms and preset prices. These are, in other words, the "perceived" elasticities by unions in the two countries.

A domestic wage increase reduces employment, thereby inducing the domestic CB to ease its policy so as to boost employment. From eq. (36), a domestic wage rise will trigger the following monetary reaction:

$$-k\frac{\partial l}{\partial w} = \frac{\beta}{4}\frac{\partial e}{\partial w} \tag{40}$$

In words, if the CB does not care about inflation ($\beta = 0$), the rise in money supply will be equal to the wage increase so as to redress the employment level (i.e. $\frac{\partial m}{\partial w} = 1$). In such a case a unit wage rise is

perceived as not having any effect on aggregate employment (see eqs. (40) and (38)). Inflation, instead, is expected to raise because of the exchange rate depreciation.

When the CB cares about inflation ($\beta > 0$), the domestic monetary authority desired response toward a domestic wage increase is less expansive. Thus, the perceived labor demand elasticity will be greater than zero in absolute terms. Moreover, in the extreme case of $\beta \to \infty$, an increase in nominal wages will not cause any change in the perceived exchange rate and, hence, in the general price level. The optimal monetary policy in the wake of a wage increase will simply imply $\frac{\partial m}{\partial w} = \frac{\partial m^*}{\partial w}$ (see eq. (40)).

It is worth noticing that a domestic wage rise is perceived to raise foreign employment via the terms of trade effect. In fact, a domestic monetary expansion leads to an exchange depreciation which, in turn, move consumption toward foreign good. The same mechanism explains why wage rises have opposite impact on price expressions (39).

4.2 Cooperative regime

Under a cooperative regime, the CBs solve the following problem

$$\begin{aligned} \max_{m,m^*} 1/2\Omega + 1/2\Omega^* \quad = \quad & 1/2\left[\int_0^1 \left[U(j) - \log\left(\frac{M(j)}{P}\right)\right] \mathrm{d}j - \frac{\beta}{2}p^2\right] \\ & +1/2\left[\int_0^1 \left[U(j^*) - \log\left(\frac{M(j^*)}{P^*}\right)\right] \mathrm{d}j^* - \frac{\beta}{2}(p^*)^2\right] \\ & \texttt{s.to}\ (32), (27),\ (29) \qquad (41) \\ & \texttt{and}\ \partial m^*/\partial m = 0,\ \partial m/\partial m^* = 0 \qquad (42) \end{aligned}$$

The corresponding first-order conditions in terms of prices and employment are given by

$$p = p^* + \frac{k}{\beta/2}(\tilde{l} - l), \tag{43}$$

$$p^* = p + \frac{k}{\beta/2}(\tilde{l} - l^*). \tag{44}$$

Result 1 *Monetary policy is more expansive under a cooperative regime.*

The optimal monetary policy requires equating marginal benefit of inflating (terms on R.H.S. of eqs. (43) and (44)) to marginal cost (terms on L.H.S. of eqs. (43) and (44)). It is apparent that a move from a non-cooperative to a cooperative regime raises marginal benefits of the CB for a given level of inflation. In fact, comparing eqs. (36) and (43)), a domestic CB will implement a more expansive monetary policy under a cooperative regime because of higher marginal benefit associated with. A symmetrical reasoning can be applied to the Foreign country.

A more expansionary monetary policy under a cooperative regime is consistent with literature on international policy coordination (e.g. Benigno, 2002; Rogoff, 1985a). Intuitively, under cooperation, the

monetary authorities realize that they cannot affect the terms of trade, but can reduce inflation abroad. The latter aspect is neglected in Benigno (2002) because of the benevolent CB assumption ($\beta = 0$).

The sizeable global money expansion under cooperation (Result 1) might be expected to induce a domestic CB to respond more expansively toward a domestic wage increase. However, a novel feature of the model is summarized in the following result.

Result 2

i. Non-cooperative wage response policies in both countries are more expansive than cooperative ones.

ii. Labor demand elasticity to nominal wages are higher under a cooperative monetary regime.

How is monetary policy perceived by wage setters under a cooperative regime? A domestic wage rise has the following impact on the optimal monetary policy:

$$-k\frac{\partial l}{\partial w} = \frac{\beta}{2}\frac{\partial e}{\partial w}. \tag{45}$$

Comparing eqs. (40) and (45), it is apparent that, for a given labor demand elasticity, the cooperative monetary response will be more costly in terms of exchange rate depreciation and, hence, inflation. Intuitively, under the non-cooperative regime a domestic monetary authority does not internalize the impact of exchange rate depreciation on foreign inflation. Conversely, in the cooperative regime, a depreciation of exchange rate is perceived as increasing domestic inflation at home and reducing marginal benefit via lower inflation abroad. These two effects are equal in size; therefore, the increase in marginal cost in the wake of wage demands is larger under a cooperative monetary regime and explains the first part of Result 2.

As to the second part of Result 2, it is worth noticing that the elasticity of domestic labor demand perceived by unions is increasing (in absolute value) in the tightening of domestic monetary response to wage. Since cooperative wage response policies are more stringent, Result 2 states that with cooperative monetary policies, a domestic nominal wage increase reduces employment mostly in the domestic country.

Thus, solving eq. (44) and (43) for money supplies and plugging the solutions into (27) and (29), I may rewrite (perceived) aggregate labor demand and inflation in a cooperative equilibrium as illustrated in Table 3.

As noted above, if the CB does not care about inflation ($\beta = 0$), the rise in money supply will be equal to the wage increase so as to redress the employment level as in the case of non-cooperative regime. In such a case unions do not perceive to affect employment, and the cooperative solution coincides with the competitive allocation as in Benigno (2002). Conversely, if the CB cares about inflation ($\beta > 0$), the CB will accommodate to a lesser extent, and the perceived labor demand elasticity by unions will be different from zero (see Table 3). In the extreme case of $\beta \to \infty$, the CB will only care about inflation, and the

Table 3: Aggregate labor demand elasticities to wages under a cooperative regime

$$l = \underbrace{-\frac{\beta}{2(k+\beta)}}_{\varepsilon_H^C} w + \underbrace{\frac{\beta}{2(k+\beta)}}_{\varepsilon_F^C} w^* \qquad l^* = \underbrace{\frac{\beta}{2(k+\beta)}}_{\varepsilon_{H^*}^C} w - \underbrace{\frac{\beta}{2(k+\beta)}}_{\varepsilon_{F^*}^C} w^* \tag{46}$$

$$p = \underbrace{\frac{k}{2(k+\beta)}}_{s_H^C} w - \underbrace{\frac{k}{2(k+\beta)}}_{s_F^C} w^* \qquad p^* = \underbrace{-\frac{k}{2(k+\beta)}}_{s_{H^*}^C} w + \underbrace{\frac{k}{2(k+\beta)}}_{s_{F^*}^C} w^* \tag{47}$$

optimal monetary policy would be such that $p = p^*$, i.e. $m = m^*$. Note that in the two extreme cases of CB conservatism, both the cooperative and non-cooperative monetary policies perceived by unions coincide.

5 Wage setting and gains from monetary policy cooperation

I now turn to wage determination. In each country workers are organized in a monopolistic labor union.[5] In setting the growth of the nominal wage, each union anticipates that it will affect aggregate employment under either regime according to expressions derived in Tables 2 and 3.

I assume that each union disregards real balances and acts benevolently, i.e. it maximizes the utility of its members. Thus, the Home union aims at solving the following problem in either regime:[6]

$$\max_w V = \int_0^1 \left[U(j) - \log\left(\frac{M(j)}{P}\right) \right] \mathrm{d}j \qquad \begin{array}{l} \texttt{s.to}\ (32), (38)\ \texttt{or}\ (46), \\ \texttt{and}\ \partial w^*/\partial w = 0. \end{array} \tag{48}$$

Employment in the two monetary regimes is derived from the first-order condition (see Appendix B):

$$l^r = \tilde{l}\left(1 - \frac{1}{\eta^r}\right), \qquad r \in (NC, C) \tag{49}$$

where $\eta^r \equiv -\varepsilon_H^r/(1 - s_H^r)$ is the real consumer wage elasticity (in absolute value) to the perceived labor

[5] One could think of a single union as a small number of unions coordinating their wage policies effectively enough to act as a single union. However, the main results of the paper are not being invalidated by considering intermediate degrees of collective bargaining coverage as for example in Lippi (2003).

[6] The benevolent union hypothesis is in line with the trade union behavior surveyed by Oswald (1985). A strand of literature, following Cubitt (1992), examines strategic interactions between monetary policy and wage setting under the assumption that unions are also concerned about inflation. I do not pursue this literature here.

demand in regime r. It is apparent that equilibrium employment is below the efficient level $\tilde{l}$ in either regime as long as η is finite. In particular, a higher real wage elasticity boosts equilibrium employment since it raises the marginal benefit of wage restraints. In other words, η is a measure of the monopolistic distortions in the labor market: a lower labor demand elasticity implies that nominal wage hikes have smaller consequences for employment (higher monopolistic power), thereby inducing higher wage demands. Conversely, a larger value of η implies more severe repercussions in terms of employment in the wake of wage claims, thereby curbing monopolistic power in the labor market. Moreover, eqs. (36) and (43) point out how inflation is related to labor market performance.

Now, in order to assess the monetary regime effect on welfare, it is sufficient to compare the two real wage elasticities to labor demands:

$$\eta^{NC} = \frac{\beta}{2(k+\beta)} < \eta^{C} = \frac{\beta}{k+2\beta}. \tag{50}$$

It turns out that not only do CBs act differently across monetary regimes, but also wage setters do. The perception of a more restrictive monetary policy under a cooperative regime leads unions to moderate their wage demands. They in fact anticipate that a harsher monetary response curbs the possibility of achieving higher consumption, i.e. higher marginal benefits, thereby inducing wage restraint. Moreover, the higher the degree of conservatism, β, the higher is the real wage elasticity.

Result 3 *The move from a non-cooperative to a cooperative monetary regime is welfare improving as long as* $0 < \beta < \infty$.

For a given level of CB conservatism β, eqs. (49) and (50) reveal that employment is higher in a cooperative regime. This suggests that monetary cooperation may have some benefits in a benchmark model via its impact on labor market distortions. Since $\eta^{C} > \eta^{NC}$, the equilibrium level of employment is higher under a cooperative regime. In order to find the equilibrium level of consumption, I substitute the firms' first order conditions (15) into eq. (32) as follows:

$$c = 1/2(m - w + m^* - w^*) = 1/2(l + l^*) = c^*,$$

where the second equality stems from using eq. (27). Since the equilibrium level of employment is equal across countries, welfare can be rewritten in equilibrium as:

$$u = l - \frac{k}{2}l^2 = u^*,$$

which is clearing increasing in l as long as employment is below its efficient level $\tilde{l}$.

As noted in the previous section, with a floating exchange rate, cooperative monetary authorities are perceived by unions to resort to less expansion because of the impact of money supply on inflation abroad. Therefore, introducing a conservative CB into a NOEM model modifies the optimal monetary policies under the two regimes.

The real effect of conservatism on real wage elasticity is in line with the literature on the strategic interaction between international monetary policies and large unions (Soskice and Iversen, 1998, 2000; Bratsiotis and Martin, 1999). This literature highlights that policies that ensure low inflation also create lower rates of equilibrium unemployment.

The paper result is interesting when viewed alongside the results of Jensen (1993, 1997) and other works on cooperation and CB conservatism. The traditional approach to international monetary policy coordination in presence of large unions is built in Jensen (1993, 1997). The main conclusion of his analysis is that, if wage setters do not care about inflation, policymakers cooperation is counterproductive. In order to obtain positive effects on economic performance from monetary cooperation, wage setters should also be inflation averse (Jensen, 1997).

According to Result 3, an international monetary policy cooperation is instead beneficial in presence of a conservative CB and non-atomistic wage setting without resorting to inflation aversion *per se*. Here, in a micro-founded setting, the introduction of nominal rigidities cause unions to anticipate a more restrictive monetary policy under a cooperative regime. A cooperative monetary authority, in fact, incurs an additional cost from wage claims, and this discourages wage demands to a larger extent. Moreover, in contrast to Obstfeld and Rogoff (2002), Corsetti and Pesenti (2005), and Devereux and Engel (2003), I conclude that welfare gains from coordination can be generated in the standard benchmark model by introducing a standard policy game between non-atomistic wage setters and conservative monetary authorities.

6 Conclusion

I have developed a tractable two-country model suitable for international monetary policy coordination analysis. As an extension, I have introduced collective bargaining system and monetary conservatism in an otherwise standard NOEM model with nominal rigidities. The main goal has been to assess the prediction of the traditional international policy coordination literature.

The paper has shown in a micro-founded framework that, in contrast to the traditional approach to international monetary policy coordination and non-atomistic wage setting, coordinated policies are welfare improving. The explanation hinges on the interaction between monopolistic unions and monetary policies under a non-cooperative and cooperative monetary regime. A cooperative monetary authority is perceived by wage setters as implementing a tighter response toward domestic wage hikes. Such an effect discourages wage claims and increases employment in the economy.

A Derivation of the reduced form

In a symmetric equilibrium with flexible prices, indexed by the subscript 0, all prices in a given currency are identical

$$P_0 = \frac{\theta}{\theta - 1} W_0,$$

purchasing power parity holds

$$P_0 = E_0 P_0^*,$$

the aggregate outputs, labor worked, and consumption are equalized in both countries

$$Y_0 = Y_0^* = L_0 = L_0^* = C_0,$$

and profits are

$$\frac{D_0}{P_0 C_0} = \frac{D_0^*}{P_0^* C_0^*} = \frac{1}{\theta}.$$

From the above results, after taking into account the government's budget constraint, eq. (6) may be log-linearized around a flexible equilibrium as follows:

$$\hat{p} + \hat{c} = \frac{\theta - 1}{\theta}(\hat{w} + \hat{l}) + \frac{\hat{d}}{\theta} \qquad ; \qquad \hat{p}^* + \hat{c}^* = \frac{\theta - 1}{\theta}(\hat{w}^* + \hat{l}^*) + \frac{\hat{d}^*}{\theta}, \tag{A.1}$$

where a hat " ˆ " stands for log-difference from the flexible equilibrium, i.e. $\hat{x} = x - x_0$.

The monetary authority takes prices and wages as given. However, following Lippi (2003), I assume that the CBs do not take profits d as given. Therefore, from eq. (13), the Home and Foreign CBs anticipate that

$$d = m \qquad ; \qquad d^* = m^*. \tag{A.2}$$

The reduced form of the model in Table 1 is obtained combining eqs. (3), (22), (12), (15), (A.1), (23), and (A.2), and disregarding constant terms.

B Derivation of the union's first-order condition

From eqs. (A.1) and (27), consumption may be rewritten as

$$c = w + l - p. \tag{B.1}$$

The first-order condition of the problem (48) is obtained substituting (B.1) into the utility function and using the elasticities given in Tables 2 and 3 as follows:

$$1 + \varepsilon_H^r - s_H^r - k\varepsilon_H^r l = 0 \qquad r \in [NC, C]. \tag{B.2}$$

Eq. (49) in the text is obtained by dividing the above expression by $1 - s_H^r$ and using the real wage definition $\eta^r \equiv -\mathrm{d}\log L^r / \mathrm{d}\log(W/P^r)$.

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