Monetary conservatism and fiscal coordination in a monetary union*

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Abstract

In a monetary union time inconsistency provides the rationale for central bank conservativeness and against the coordination of national fiscal policies. We show that this result is based on the implicit assumption of exogenous labor markets and that, once wage setters' behavior is explicitly modelled, the economic performance can be improved by fiscal policy coordination and a less conservative monetary policy stance.

1 Introduction.

In a monetary union as the EMU, time inconsistency provides the rationale for a conservative central bank (CCB) and against the coordination of national fiscal policies (Beetsma and Bovenberg, 1998).[1] Fiscal coordination would eliminate the disciplining effect of monetary unification and worsen the strategic position of a CCB. We show that this result is determined by the assumption of exogenous labour market distortions, which has been challenged by a number of papers, showing that labour market distortions are endogenous to the macropolicy regime in place.[2] The coordination of

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[1]See Beetsma *et al.* (2001) for a recent survey.

[2]See Cukierman and Lippi (1999, 2001); Guzzo and Velasco (1999); Lippi (2002, 2003); Soskice and Iversen (1996, 2000), among many others. See Cukierman (2004) for a recent survey.

national fiscal policies is beneficial when the labor market distortion is endogenously determined by unions' strategy. Paradoxically, results of the kind of Beetsma and Bovenberg (1998) only hold for a "populist" central bank.

The remainder of the paper is organized as follows. In section 2 we formally describe the argument against fiscal coordination and in favor of central bank conservativeness. Section 3 shows how the above result is reversed once the strategic interaction between policy-makers and wage setters is considered. Section 4 concludes.

2 The case of exogenous real wages.

The Monetary Union is composed of n symmetric economies. Each economy is characterized by two players: the government and a monopoly labor union. Monetary policy is delegated to a common central bank. The supply function is

$$x_i = \pi - \pi^e - t_i - \tilde{x}_i, \tag{1}$$

where output deviations from the competitive non-distortionary baseline level in country i, x_i, are caused by tax distortions, t_i, exogenous labor market distortions due to monopolistic unions, $\tilde{x}_i$,[3] and inflation surprises, $\pi - \pi^e$ (π^e defines inflation expectations).

Each government's loss function is defined over inflation, output and public expenditure deviations from the target, $g_i - \tilde{g}$:

$$G_i = \frac{1}{2}\left[\alpha_{\pi f}\pi^2 + x_i^2 + \alpha_{gf}\left(g_i - \tilde{g}\right)^2\right] \tag{2}$$

In setting the public expenditures level, the government faces a balanced budget constraint:[4]

$$g_i = t_i \tag{3}$$

The loss function of the independent common central bank (CCB, henceforth) is quadratic in inflation and Union-wide output deviations from a non-distortionary equilibrium:

$$V = \frac{1}{2}\left[\alpha_{\pi m}\pi^2 + \left(\sum_{i=1}^{n}\frac{x_i}{n}\right)^2\right] \tag{4}$$

where $\alpha_{\pi m} > \alpha_{\pi f}$, i.e. the central bank is conservative. The central bank directly controls the inflation rate.

[3] More exactly, $\tilde{x}_i$ is defined as the real wage mark-up over the competitive wage rate.

[4] For the sake of simplicity we neglect the seigniorage component of the budget and the debt service payments.

The timing of the game is as follows. First, each trade union sets inflation expectations;[5] second, each government sets taxes; third, the CCB chooses the monetary policy. The model is solved by backward induction.

The CCB's reaction function is easily derived from equations (1) and (4):

$$\pi = -\frac{1}{\alpha_{\pi m}} \sum_{i=1}^{n} \frac{x_i}{n} \Rightarrow \pi = \frac{1}{1+\alpha_{\pi m}} \left(\pi^e + \sum_{i=1}^{n} \frac{t_i + \tilde{x}_i}{n} \right) \tag{5}$$

Higher expected inflation or higher taxes and wage distortions induce the CCB to accommodate.

Government i's first-order condition is:

$$\alpha_{\pi f} (\pi) \frac{\partial \pi}{\partial t_i} + x_i \left(-1 + \frac{\partial x}{\partial \pi} \frac{\partial \pi}{\partial t_i} \right) + \alpha_{gf} (g_i - \tilde{g}) = 0. \tag{6}$$

Each government anticipates the CCB reaction to its tax policy so that inflation will increase following a rise in the tax rate in order to protect employment. Without fiscal coordination each government behaves as if

$$\frac{\partial \pi}{\partial t_i} = \frac{1}{n(1+\alpha_{\pi m})} \tag{7}$$

whereas under fiscal policy coordination the anticipated inflation response to taxes is obtained by setting $n = 1$. The following solutions for output distortions and taxes is obtained:

$$x_i = -A^{-1} \alpha_{gf} (\tilde{x} + \tilde{g}) \tag{8}$$

$$t_i = A^{-1} \left\{ \alpha_{gf} \tilde{g} - \left[\left(\frac{\alpha_{\pi f}}{\alpha_{\pi m}} - 1 \right) \frac{1}{n(1+\alpha_{\pi m})} + 1 \right] \tilde{x} \right\} \tag{9}$$

where $A = \left[\frac{\alpha_{\pi f}}{\alpha_{\pi m}} - 1 \right] \frac{1}{n(1+\alpha_{\pi m})} + 1 + \alpha_{gf} > 0$.

It is easy to see that fiscal coordination worsens output distortions. The economic intuition for this result is as follows. National fiscal policy-makers anticipate the central bank's inflationary response to their actions, but cannot fully internalize the adverse effects of their choices on inflation expectations. This, in turn, generates a tax/spending bias. The decentralization of national fiscal policies mitigates this effect, as national policy-makers underestimate the CCB reaction to their actions. By contrast, fiscal coordination leads to a more aggressive fiscal stance generating greater output distortions for any given real wage target ('BB effect').

[5] More exactly, each labor union sets the nominal wage at a level compatible with the expected desired real wage, on the basis of rational expectations about future inflation.

3 The case of endogenous real wages.

In the previous section we have assumed that each wage setters set the nominal wage as a mark up over an exogenous real wage target. In logs: $w_i = \tilde{x}_i + p^e$ where p^e defines the expected price level. This section extends the analysis by assuming the following loss function for the wage setters (Oswald, 1985; Booth, 1995):

$$U_i = -\tilde{x}_i q + \frac{x_i^2}{2} \tag{10}$$

where q is a preference parameter. Thus, in addition to the real wage, the labor union's loss function includes concern for output distortions (unemployment aversion). In the remainder of the paper we assume that unions bargain over the expected real wage.[6] The timing of the game is as in the previous section. However, in this case the union sets $w_i = \tilde{x}_i^* + p^e$, where $\tilde{x}_i^*$ minimizes (10).

The solution of the model depends on the assumptions about the interactions between national unions and governments. There are four possible cases: union cooperation and fiscal cooperation; union cooperation and fiscal non-cooperation; union non-cooperation and fiscal cooperation; unions non cooperation and fiscal non cooperation. In this section we discuss the first two cases.[7]

If unions cooperate, we get:

$$x_i = -\left(\frac{A}{\alpha_{gf}}\right) q \tag{11}$$

$$\tilde{x}_i = \left(\frac{A}{\alpha_{gf}}\right)^2 q - \tilde{g} \tag{12}$$

$$t_i = \tilde{g} - \left(\frac{A}{\alpha_{gf}} - 1\right)\left(\frac{A}{\alpha_{gf}}\right) q \tag{13}$$

This implies that:

1. In contrast with the previous case, output distortions are independent of the policy-makers public expenditure targets. For a given equilibrium level of output distortions, a change in the public expenditure target symmetrically shifts taxes and the real wage rate in opposite directions. In fact, taxes and labour market distortions are strategic

[6] In the literature it is sometimes assumed that unions bargain over the nominal wage. The different implications of the two assumptions are discussed in Lippi (2002). In an appendix, available upon request, we derive the solutions for the case of nominal wage bargaining, which confirm our results.

[7] In an appendix, available upon request, we show that our results hold for the complete taxonomy.

substitutes. Moreover, any increase in q is met by a tax reduction and vice versa. The rationale for this result is that an increase in the union's marginal rate of substitution between the real wage and the output distortion will raise the wage claim. As governments are concerned with output, that induces a tax reduction.

2. The impact of CCB conservatism on output distortions is obtained from equation (11):

$$\frac{\partial x_i}{\partial \alpha_{\pi m}} = -\frac{q}{\alpha_{gf}} \frac{\partial A}{\partial \alpha_{\pi m}} = \frac{q}{\alpha_{gf}} \frac{\alpha_{\pi f} + 2\alpha_{\pi f}\alpha_{\pi m} - \alpha_{\pi m}^2}{n\left(1+\alpha_{\pi m}\right)^2 \alpha_{\pi m}^2} \tag{14}$$

   We can infer that output is maximized for a finite value of the degree of CCB conservativeness, i.e., $\alpha_{\pi m} = \alpha_{\pi f} + \sqrt{\alpha_{\pi f}\left(1+\alpha_{\pi f}\right)}$. Moreover, by defining $\alpha_{\pi m}^*$ as the degree of CCB conservatism such that the loss function of each fiscal policy-maker is minimized, it is intuitively obvious that $\alpha_{\pi f} < \alpha_{\pi m}^* < \infty$.[8] To understand this result we should focus on how a change in the degree of central bank conservatism affects the strategic substitutability of tax and labour market distortions. For instance, starting from an initial condition where $\alpha_{\pi m} = \alpha_{\pi f}$, a relative increase in the first parameter – i.e. a move towards conservatism – lowers the sensitivity of taxes to real wage distortions, see (9). This, in turn, raises the negative effect of a real wage increase on output and disciplines unions.

3. Under a conservative CCB national output is negatively related to the number of Monetary Union members. In fact, from (11) we have:

$$\frac{\partial x_i}{\partial n} = -\frac{q}{\alpha_{gf}} \frac{\partial A}{\partial n} = \frac{q}{\alpha_{gf}} \left(\frac{\alpha_{\pi f}}{\alpha_{\pi m}} - 1\right) \frac{1}{n^2\left(1+\alpha_{\pi m}\right)} < 0 \tag{15}$$

   Thus, when (10) holds fiscal coordination has a disciplining effect and lowers output distortions. The underlying intuition is as follows. When (10) holds, taxes and the wage mark up are strategic substitutes. From (9) it is easy to see that government coordination reduces the sensitivity of taxes to real wage distortions. This, in turn, raises the negative effect of a real wage increase on output and disciplines unions. This effect always dominates the familiar BB effect on taxes, rendering fiscal coordination desirable.

4. Inspection of (15) makes it clear that, paradoxically, the conclusions of the previous section conclusions would only hold for a populist CCB. In this case the sign of inequality would in fact be reversed. The threat

[8] Formally, the optimal degree of conservativeness solves the following expression: $\alpha_{\pi m}\left(\alpha_{\pi m}^2 + \alpha_{\pi f}\right)\frac{\partial A}{\partial \alpha_{\pi m}} - \alpha_{\pi f} A = 0$. Numerical simulations indicate that the positive solution of this 4th-order equation is also unique.

of a CCB inflationary policy would discipline fiscal policy-makers. Coordinated governments would be even more cautious as they fully internalized the CCB inflationary reaction. However, if (10) holds, fiscal restraint will only be to the advantage of unions, which set a real wage that more than compensates fiscal restraint.

4 Conclusions.

Our results have far-reaching consequences for the debate on EMU institutional arrangements for fiscal policies. Further research should reconsider the rationale for the passive coordination implied by the *Stability and Growth Pact* and take into account the possibility that, in a unionized labour market, wage and tax distortions are strategic substitutes.

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Appendices not to be published (for the referee only)

Appendix A – Derivation of equations (1) and (3)

In each country, the representative price-taking firm maximizes its net profit:

$$P\left(1-\tau_i\right)Y_i - W_i L_i \tag{A1}$$

where $Y_i = L_i^a$ is the production function, P and W_i respectively define the price and wage levels, and τ_i is the sales-tax rate.

The standard first-order condition is:

$$P\left(1-\tau_i\right)\alpha L_i^{a-1} = W_i \tag{A2}$$

The next step is the definition of the nominal wage rate which obtains in a unionized labour market:

$$W_i = W^C\left(1+\mu_i^U\right)P^e \tag{A3}$$

where W^C is the exogenous real wage that would obtain in a competitive labour market, $\left(1+\mu_i^U\right)$ defines the real wage mark-up over the competitive rate and P^e is the expected price level.[9] Taking logs, we get

$$y_i = \frac{a}{1-a}\left(p - t_i - w^c - \tilde{x}_i - p^e\right) + \frac{a}{1-a}\ln a \tag{A4}$$

where $\tilde{x}_i = \ln\left(1+\mu_i^U\right)$, $t_i = -\ln\left(1-\tau_i\right)$. Assuming that the non-distorted real output is $\bar{y} = \frac{a}{1-a}\left(-w^c + \ln a\right)$, and normalizing at 1 the price level in the previous period, we can rewrite the above equation as:

$$x_i = \left(\pi - \pi^e - \tilde{x}_i - t_i\right) \tag{A5}$$

[9] In this class of models wages are pre-determined w.r.t. prices, thus nominal wages are set conditionally to the price level expectation.

where $x_i = \left(\frac{a}{1-a}\right)^{-1}(y_i - \bar{y}_i)$

To derive the government balanced budget equation (3), consider the following identity

$$\tau_i Y_i = GEXP_i \tag{A6}$$

where $GEXP_i$ defines the level of government expenditure. Straightforward manipulations show that

$$(1-\tau_i) = \left(1 - \frac{GEXP_i}{Y_i}\right) \tag{A7}$$

Hence, setting $g_i = -\ln\left(1 - \frac{GEXP_i}{Y_i}\right)$, equation (3) obtains.

Appendix B – Derivation of the equilibria under real wage bargaining

B.1 Union non-cooperation

Consider the case where neither unions nor fiscal policy-makers cooperate. In each country, the national trade union minimizes (10) by setting $\tilde{x}_i$ conditional to (5), (6) and the rational expectations constraint $\pi^e = E[\pi]$.

To solve the model we proceed as follows.

1. By substituting (5) and (7) into (6) we obtain:

$$-\frac{\alpha_{\pi f}}{\alpha_{\pi m}}\sum_{j=1}^{n}\frac{x_j}{(1+\alpha_{\pi m})\,n^2} - x_i\left(1 - \frac{1}{(1+\alpha_{\pi m})\,n}\right) + \alpha_{gf}(g_i - \tilde{g}) = 0 \tag{B1}$$

2. Then, by using (1) and (3), we get:

$$\rho_1^N x_i + \rho_2^N \sum_{j=1, j\neq i}^{n} x_j = \alpha_{gf}(\pi^e - \pi + \tilde{x}_i + \tilde{g}) \tag{B2}$$

where $\rho_1^N = -\left(\frac{\frac{\alpha_{\pi f}}{n\alpha_{\pi m}} - 1}{(1+\alpha_{\pi m})n} + 1 + \alpha_{gf}\right) < 0$ and $\rho_2^N = -\frac{\alpha_{\pi f}}{\alpha_{\pi m}}\frac{1}{(1+\alpha_{\pi m})n^2} < 0$.

3. Summing up equations (B2) for each country, we obtain:

$$\rho_1^N \sum_{j=1}^{n} x_j + \rho_2^N (n-1)\sum_{j=1}^{n} x_j = \alpha_{gf}\sum_{j=1}^{n}(\pi^e - \pi + \tilde{x}_i + \tilde{g}) \tag{B3}$$

4. Straightforward manipulations of (B3) yield

$$\sum_{j=1,j\neq i}^{n} x_j = \frac{\alpha_{gf}}{\rho_1^N + \rho_2^N (n-1)} \sum_{i=1}^{n} (\pi^e - \pi + \tilde{x}_i + \tilde{g}) - x_i \tag{B4}$$

5. By substituting (B4) into (B2), we get:

$$x_i = \frac{\alpha_{gf}}{A^N} (\tilde{x}_i + \pi^e - \pi + \tilde{g}) - \sum_{j=1,j\neq i}^{n} \frac{\alpha_{gf} \rho_2^N (\pi^e - \pi + \tilde{x}_i + \tilde{g})}{\rho_1^N + \rho_2^N (n-1)} \tag{B5}$$

where $A^N = \frac{\left(\rho_1^N - \rho_2^N\right)\left(\rho_1^N + \rho_2^N (n-1)\right)}{\rho_1^N + \rho_2^N (n-2)} < 0$.

6. By assuming the rational expectations constraint and minimizing (10) subject to (B5), we finally get:

$$x_i^{NN} = \frac{A^N}{\alpha_{gf}^2} q = \frac{\left(\rho_1^N - \rho_2^N\right)\left(\rho_1^N + \rho_2^N (n-1)\right)}{\alpha_{gf}^2 \left[\rho_1^N + \rho_2^N (n-2)\right]} q < 0 \tag{B6}$$

$$\pi^{NN} = -\frac{1}{\alpha_{\pi m}} \frac{A^N}{\alpha_{gf}^2} q > 0 \tag{B7}$$

$$\tilde{x}_i^{NN} = -\left[1 - \frac{1 - \frac{\alpha_{\pi f}}{\alpha_{\pi m}}}{(1 + \alpha_{\pi m}) n} + \alpha_{gf}\right] \frac{A^N q}{\alpha_{gf}^2} - \tilde{g} \tag{B8}$$

$$t_i^{NN} = \tilde{g} + \left[1 - \frac{1 - \frac{\alpha_{\pi f}}{\alpha_{\pi m}}}{(1 + \alpha_{\pi m}) n}\right] \frac{A^N q}{\alpha_{gf}^2} \tag{B9}$$

Notice that:

$$\lim_{\alpha_{\pi m} \longrightarrow +\infty} \pi^{NN} = 0 \tag{B.10a}$$

$$\lim_{\alpha_{\pi m} \longrightarrow +\infty} x^{NN} = -\frac{1 + \alpha_{gf}}{\alpha_{gf}} q \tag{B10.b}$$

$$\alpha_{\pi m} \longrightarrow +\infty \Longrightarrow \frac{\partial \pi^{NN}}{\partial \alpha_{\pi m}} < 0 \tag{B.10c}$$

Therefore, due to the quadratic nature of preferences,.an infinite degree of conservativeness is never optimal.[10]

Consider now the case of union non-cooperation and fiscal cooperation. Each fiscal policy-maker internalizes the effect of his policy choices on the other policy-makers' welfare. Thus government i's first-order condition is obtained by setting $\sum_{j=1}^{n} \frac{\partial G_j}{\partial t_i} = 0$. Equation (6) becomes

$$\left(\frac{1 - \frac{\alpha_{\pi f}}{\alpha_{\pi m}}}{(1 + \alpha_{\pi m}) n} - 1 - \alpha_{gf}\right) x_i + \frac{1 - \frac{\alpha_{\pi f}}{\alpha_{\pi m}}}{n (1 + \alpha_{\pi m})} \sum_{j=1,j\neq i}^{n} x_j = \alpha_{gf} (\pi^e - \pi + \tilde{x}_i + \tilde{g})$$

[10] The convergence from the top of the derivative as $\alpha_{\pi m} \longrightarrow +\infty$ is computed by separately considering the limits of its numerator and denominator.

By using the same method as above, we obtain

$$\begin{aligned}
x_i^{NC} &= \frac{A^C}{\alpha_{gf}} q < 0 && \text{(B11)}\\
\pi^{NC} &= -\frac{A^C}{\alpha_{\pi m}} \frac{q}{\alpha_{gf}} && \text{(B12)}\\
\tilde{x}_i^{NC} &= -\left[(1+\alpha_{gf}) - \frac{1-\frac{\alpha_{\pi f}}{\alpha_{\pi m}}}{(1+\alpha_{\pi m})\, n} \right] \frac{A^C}{\alpha_{gf}^2} q - \tilde{g} && \text{(B13)}\\
t_i^{NC} &= \tilde{g} + \left[1 - \frac{1-\frac{\alpha_{\pi f}}{\alpha_{\pi m}}}{1+\alpha_{\pi m}} \right] \frac{A^C}{\alpha_{gf}^2} q && \text{(B14)}
\end{aligned}$$

where $A^C = \frac{(\rho_1^C - \rho_2^C)(\rho_1^C + \rho_2^C(n-1))}{\rho_1^C + \rho_2^C(n-2)} < 0$, $\rho_1^C = -\left(\frac{\frac{\alpha_{\pi f}}{n\alpha_{\pi m}} - 1}{1+\alpha_{\pi m}} + 1 + \alpha_{gf} \right) < 0$, $\rho_2^C = -\frac{\alpha_{\pi f}}{n\alpha_{\pi m}} \frac{1}{1+\alpha_{\pi m}} < 0$.

Since the asimptitic properties of inflation and output gap as $\alpha_{\pi m} \longrightarrow +\infty$ qre the same discussed in equations (16)-(16), even in this case the optimal degree of conservativeness is finite.

After some straightforward manipulations, it can be shown that fiscal coordination always reduces output distortions when the central banker is conservative. In fact, $x_i^{NC} > x_i^{NN}$ if :

$$A^C - A^N = \frac{(\rho_1^C - \rho_2^C)\left[\rho_1^C + \rho_2^C(n-1)\right]}{\rho_1^C + \rho_2^C(n-2)} - \frac{(\rho_1^N - \rho_2^N)\left[\rho_1^N + \rho_2^N(n-1)\right]}{\rho_1^N + \rho_2^N(n-2)} > 0 \quad \text{(B15comp)}$$

Since

$$\begin{aligned}
\left[\rho_1^N + \rho_2^N(n-2)\right]\left[\rho_1^C + \rho_2^C(n-2)\right] &> 0\\
(\rho_1^N - \rho_2^N)\left(\rho_1^N + \rho_2^N(n-1)\right)\left[\rho_1^C + \rho_2^C(n-2)\right] &< 0,
\end{aligned}$$

condition (B15comp) is satisfied if:

$$\left(\frac{\rho_1^C - \rho_2^C}{\rho_1^N - \rho_2^N} \right) \left(\frac{\rho_1^N + \rho_2^N(n-1) - \rho_2^N}{\rho_1^N + \rho_2^N(n-1)} \right) \left(\frac{\rho_1^C + \rho_2^C(n-1) - \rho_2^C}{\rho_1^C + \rho_2^C(n-1)} \right)^{-1} < 1 \quad \text{(B17)}$$

Condition (B17) always obtains because $0 < \frac{\rho_1^C - \rho_2^C}{\rho_1^N - \rho_2^N} < 1$ and $\frac{\rho_1^C + \rho_2^C(n-1)}{\rho_1^C + \rho_2^C(n-2)} > \frac{\rho_1^N + \rho_2^N(n-1)}{\rho_1^N + \rho_2^N(n-2)}$.

B.2 Union cooperation

Union i's first-order condition is now obtained by setting

$$\sum_{j=1}^{n} \frac{\partial U_j}{\partial \tilde{x}_i} = 0 \quad \text{(B18)}$$

Consider the case of fiscal non-cooperation. Taking into account that (16) holds for each country, we rewrite (B18) as:

$$-q+\frac{\alpha_{gf}}{A^N}x_i-\frac{\alpha_{gf}\rho_2^N}{\rho_1^N+\rho_2^N(n-1)}\sum_{j=1,j\neq i}^{n}x_j=0 \tag{B19}$$

Under a symmetrical equilibrium, $\sum_{j=1,j\neq i}^{n} x_j=(n-1)\,x_i$. Then straightforward manipulations show that conditions (11), (12) and (13) hold. By contrast, when fiscal policy-makers cooperate, condition (B19) becomes:

$$-q+\frac{\alpha_{gf}}{A^C}x_i-\frac{\alpha_{gf}\rho_2^C}{\rho_1^C+\rho_2^C(n-1)}\sum_{j=1,j\neq i}^{n}x_j=0 \tag{B20}$$

and we easily get the solutions presented in the text:

$$x^{CC} = -\left[\frac{\frac{\alpha_{\pi f}}{\alpha_{\pi m}}-1}{1+\alpha_{\pi m}}+1+\alpha_{gf}\right]\frac{q}{\alpha_{gf}} \tag{B21}$$

$$\pi^{CC} = \frac{1}{\alpha_{\pi m}}\left[\frac{\frac{\alpha_{\pi f}}{\alpha_{\pi m}}-1}{1+\alpha_{\pi m}}+1+\alpha_{gf}\right]\frac{q}{\alpha_{gf}} \tag{B22}$$

$$\tilde{x}_i^{CC} = \left[\frac{\frac{\alpha_{\pi f}}{\alpha_{\pi m}}-1}{1+\alpha_{\pi m}}+1+\alpha_{gf}\right]^2\frac{q}{\alpha_{gf}^2}-\tilde{g} \tag{B23}$$

$$t_i^{CC} = \tilde{g}-\left[\frac{\frac{\alpha_{\pi f}}{\alpha_{\pi m}}-1}{1+\alpha_{\pi m}}+1+\alpha_{gf}\right]\left[\frac{\frac{\alpha_{\pi f}}{\alpha_{\pi m}}-1}{1+\alpha_{\pi m}}+\alpha_{gf}\right]\frac{q}{\alpha_{gf}^2} \tag{B24}$$

Appendix C – Nominal wage bargaining

C.1 Union non-cooperation

Let us now consider the case of nominal wage bargaining. Each national union sets the nominal wage rate at the beginning of the game; the real wage rate is determined *ex post* by the equilibrium price level. If unions do not cooperate, the loss function:

$$U_i=-(w_i-p^e)\,q+\frac{x_i^2}{2} \tag{C1}$$

is minimized with respect to the nominal wage rate, w_i, conditional to the rational expectation $p^e=\pi^e=E[\pi]=\pi=-\frac{1}{\alpha_{\pi m}}\sum_{j=1}^{n}\frac{x_j}{n}$.[11] Equation (1)

[11] Nominal wage bargaining does not affect the first-order conditions of the CCB and governments.

becomes:

$$x_i = -(w_i - \pi) - t_i \tag{C2}$$

since $\tilde{x}_i = w_i - \pi^e$.

The union first-order condition is:

$$q_i \left(1 - \frac{\partial \pi}{\partial w_i}\right) - \frac{\partial x_i}{\partial w_i} x_i = 0 \tag{C3}$$

Thus we need to identify $\frac{\partial \pi}{\partial w_i}$ and $\frac{\partial x_j}{\partial w_i}$, which depend on the fiscal regime.

When fiscal policy-makers do not cooperate, we use equation (C2) to redefine government i's first-order condition (B2):

$$\left(\rho_1^N - \frac{\alpha_{gf}}{\alpha_{\pi m}} \frac{1}{n}\right) x_i + \left(\rho_2^N - \frac{\alpha_{gf}}{\alpha_{\pi m}} \frac{1}{n}\right) \sum_{j=1, j\neq i}^{n} x_j = \alpha_{gf} (w_i + \tilde{g}) \tag{C4}$$

By summing up equations (C4) for each country, we obtain:

$$\begin{aligned} x_i &= \alpha_{gf} \left[\frac{\left[\rho_1^N + \rho_2^N (n-2) - \frac{\alpha_{gf}}{\alpha_{\pi m}} \frac{n-1}{n}\right] (w_i + \tilde{g})}{\left(\rho_1^N - \rho_2^N\right) \left(\rho_1^N + (n-1)\rho_2^N - \frac{\alpha_{gf}}{\alpha_{\pi m}}\right)} \right] + \\ &\quad -\alpha_{gf} \left[\sum_{j=1, j\neq i}^{n} \frac{\left[\rho_2^N - \frac{\alpha_{gf}}{\alpha_{\pi m}} \frac{1}{n}\right] (w_j + \tilde{g})}{\left(\rho_1^N - \frac{\alpha_{gf}}{\alpha_{\pi m}} \frac{1}{n}\right) + \left(\rho_2^N - \frac{\alpha_{gf}}{\alpha_{\pi m}} \frac{1}{n}\right)(n-1)} \right] \end{aligned} \tag{C5}$$

From equations (C2), (C3) and (5), we get:

$$x_i = \left(\frac{\partial x_i}{\partial w_i}\right)^{-1} \left(1 + \frac{1}{\alpha_{\pi m}} \frac{1}{n} \sum_{j=1}^{n} \frac{\partial x_j}{\partial w_i}\right) q_i \tag{C6}$$

and thus:

$$x_i^{Nn} = -\frac{\left(\rho_1^N - \rho_2^N\right)\left(\rho_1^N + (n-1)\rho_2^N - \frac{\alpha_{gf}}{\alpha_{\pi m}}\right) + \frac{\rho_1^N}{n\alpha_{\pi m}}}{\left[\rho_1^N + \rho_2^N (n-2) - \frac{\alpha_{gf}}{\alpha_{\pi m}} \frac{n-1}{n}\right]} q < 0 \tag{C7}$$

$$\pi = \frac{\left(\rho_1^N - \rho_2^N\right)\left(\frac{\alpha_{gf}}{\alpha_{\pi m}} - \rho_1^N - (n-1)\rho_2^N\right) - \frac{\rho_1^N}{n\alpha_{\pi m}}}{\alpha_{\pi m}\left[\frac{\alpha_{gf}}{\alpha_{\pi m}} \frac{n-1}{n} - \rho_1^N - \rho_2^N (n-2)\right]} q \tag{C8}$$

$$t_i^{Nn} = \tilde{g} - \frac{\left[\rho_1^N + \rho_2^N (n-1)\right]\left(\rho_1^N - \rho_2^N\right)\left(\rho_1^N + (n-1)\rho_2^N - \frac{\alpha_{gf}}{\alpha_{\pi m}}\right) + \frac{\rho_1^N}{n\alpha_{\pi m}}}{\alpha_{gf}\left[\rho_1^N + \rho_2^N (n-2) - \frac{\alpha_{gf}}{\alpha_{\pi m}} \frac{n-1}{n}\right]} q \tag{C9}$$

Since the asimptitic properties of inflation and output gap as $\alpha_{\pi m} \longrightarrow +\infty$ are the same discussed in equations (16)-(16), an infinite degree of conservativeness is never optimal.

In the case of fiscal coordination it is easy to show that:

$$x_i^{Cn} = -\frac{\left(\rho_2^C-\rho_1^C\right)\left(\rho_1^C+(n-1)\rho_2^C-\frac{\alpha_{gf}}{\alpha_{\pi m}}\right)+\frac{\rho_1^C}{n\alpha_{\pi m}}}{\left[\rho_1^C+\rho_2^C(n-2)-\frac{\alpha_{gf}}{\alpha_{\pi m}}\frac{n-1}{n}\right]}q<0 \tag{C10}$$

$$\pi = \frac{\left(\rho_2^C-\rho_1^C\right)\left(\rho_1^C+(n-1)\rho_2^C-\frac{\alpha_{gf}}{\alpha_{\pi m}}\right)+\frac{\rho_1^C}{n\alpha_{\pi m}}}{\alpha_{\pi m}\left[\rho_1^C+\rho_2^C(n-2)-\frac{\alpha_{gf}}{\alpha_{\pi m}}\frac{n-1}{n}\right]}q \tag{C11}$$

$$\begin{aligned} t_i^{Cn} &= \tilde{g}+\frac{\rho_1^C q}{n\alpha_{\pi m}\alpha_{gf}\left[\rho_1^C+\rho_2^C(n-2)-\frac{\alpha_{gf}}{\alpha_{\pi m}}\frac{n-1}{n}\right]}+ \\ &+\frac{\left(\rho_2^C-\rho_1^C\right)\left(\rho_1^C+(n-1)\rho_2^C-\frac{\alpha_{gf}}{\alpha_{\pi m}}\right)q}{\alpha_{gf}\left[\rho_1^C+\rho_2^C(n-2)-\frac{\alpha_{gf}}{\alpha_{\pi m}}\frac{n-1}{n}\right]\left[\rho_1^N+\rho_2^N(n-1)\right]^{-1}} \end{aligned} \tag{C12}$$

Since the asimptitic properties of inflation and output gap as $\alpha_{\pi m}\longrightarrow+\infty$ are the same discussed in equations (16)-(16), an infinite degree of conservativeness is never optimal also in this case.

Fiscal cooperation is beneficial. In fact

$$x_i^{Cn}-x_i^{Nn}=\frac{(n-1)(n-2)\left[z_1+(n-1)z_2\right]\alpha_{\pi f}}{(1+\alpha_{\pi m})\alpha_{\pi m}n^2 z_3 z_4}>0 \tag{C13}$$

because

$$\begin{aligned} z_1 &= \alpha_{\pi m}^2(1+\alpha_{\pi f})(\alpha_{\pi f}+\alpha_{\pi m}+\alpha_{gf}(1+\alpha_{\pi m}))n^2+\alpha_{\pi f}(3\alpha_{\pi f}+\alpha_{\pi m})n+ \\ &\quad +2\alpha_{\pi f}^2\alpha_{\pi m}>0 \\ z_2 &= \alpha_{\pi m}\left((1+\alpha_{\pi f})\alpha_{\pi m}+\left[\alpha_{\pi f}+\alpha_{\pi m}(1+\alpha_{gf})\right](1+\alpha_{\pi m})\right)(\alpha_{\pi f}+ \\ &\quad +\alpha_{\pi m}+\alpha_{gf}(1+\alpha_{\pi m}))n^3+\alpha_{\pi f}(2\alpha_{\pi f}+3(\alpha_{\pi m}+\alpha_{\pi f}))n^2+\alpha_{\pi f}\alpha_{\pi m} \\ &\quad (3(\alpha_{\pi m}+\alpha_{\pi f})+2\alpha_{gf}(1+\alpha_{\pi m}))n+2\alpha_{\pi f}^2>0 \\ z_3 &= (\alpha_{\pi m}+\alpha_{gf}(1+\alpha_{\pi m}))\alpha_{\pi m}n^2+2\alpha_{\pi f}+n(n-2)\alpha_{\pi f}+n(n-1) \\ &\quad (1+\alpha_{\pi f})\alpha_{\pi m}>0 \\ z_4 &= \alpha_{\pi f}+(\alpha_{\pi m}n+\alpha_{gf}(1+\alpha_{\pi m}))\alpha_{\pi m}n+(n-1)\alpha_{\pi f}\alpha_{\pi m}>0 \end{aligned}$$

C.2 Union cooperation

Consider union cooperation. The first-order condition (C1) becomes:

$$q_i\left(1-\frac{\partial\pi}{\partial w_i}\right)-\frac{\partial x_j}{\partial w_i}-\sum_{j=1,j\neq i}^{n}\left(q_j\frac{\partial\pi}{\partial w_i}+\frac{\partial x_j}{\partial w_i}x_j\right)=0 \tag{C14}$$

Under fiscal non-cooperation, equation (C14) can be solved as:

$$w_i=\left(\frac{A}{\alpha_{gf}}+\frac{1}{\alpha_{\pi m}}\right)q-\tilde{g} \tag{C15}$$

It would be straightforward to show that solutions (11)-(13) are connected with $(C15)$

Under fiscal cooperation, equation (C14) can be solved as:

$$w_i = \left(1 + \frac{\frac{\alpha_{\pi f}}{\alpha_{\pi m}} - 1}{1 + \alpha_{\pi m}} + \alpha_{gf}\right)\left(2 + \frac{\frac{\alpha_{\pi f}}{\alpha_{\pi m}} - 1}{(1 + \alpha_{\pi m})\,\alpha_{gf}} + \frac{1}{\alpha_{gf}}\right)\frac{q}{\alpha_{gf}} - \tilde{g} \quad \text{(C16)}$$

which is connected with the solutions (16)-(16). Thus, as shown in Lippi (2002), under union cooperation nominal and real bargaining lead to identical results.