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WHO'S AFRAID OF THE BIG BAD CENTRAL BANK?
UNION-FIRM-CENTRAL BANK INTERACTIONS AND INFLATION IN A MONETARY UNION

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Abstract:

Existing models of union-firm-central bank interaction focus on the impact which the central bank has on union behaviour in setting wages. This paper considers an alternative explanation for wage moderation, based on firm-specific factors, whereby the probability of bankruptcy and exit disciplines firms and unions. The exit of firms is a source of employment fluctuation that the union tries to stabilize. We also show that the formation of a monetary union in this model increases the probability of firm exit and may further moderate union wage demands for any given degree of central bank conservativeness.

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1. Introduction

In the last few years a number of papers have emerged modeling the behavior of firms and trade unions and how they influence the strategic actions of the monetary authorities. Within this framework, particular attention has been paid to the impact which the formation of a monetary union might have on wage and price-setting behavior in an imperfectly competitive setting, and hence on central bank actions.

There are two main strands to this literature. The first focuses on the implications for monetary policy if unions setting wages are inflation-averse (see Cubitt, 1992, Skott, 1997, Cukierman and Lippi, 1999a, Guzzo and Velasco, 1999, Soskice and Iversen, 2000, Coricelli et al., 2000a, Lawler, 2001). These models show that, whilst unions with monopoly power set wages above their competitive level, they moderate their wage demands to some extent in the face of the central bank's (CB) actions. This is because unions realize that the CB will try to react to the high unemployment by generating higher inflation. As unions dislike inflation, they choose to moderate their wage push. This literature generates an interesting paradox: in theory it might be preferable to appoint "populist" or "more liberal" CB who is much more concerned about unemployment or output than inflation as this is what moderates union wage demands. In fact, there are additional features of these models, such as imperfectly competitive firms and stochastic disturbances, which to some extent offset the "liberal CB" result (see Coricelli et al. 2000a, and Lawler, 2001). The result can also be affected by the degree of competition between unions (see Cukierman and Lippi, 1999a) and different assumptions abut the "outside option" which unions face (Berger et al., 2001).

The second strand considers the impact on the union-CB game of the formation of a Monetary Union (MU). This can be modeled in a number of ways:

(i) As a change in the competitive conditions in the labor market (the number and size of unions) following the formation of the MU (Cukierman and Lippi, 199b, Calmfors, 1998, Coricelli et al., 2000 a,b).

(ii) As an increase in competition in goods markets (Coricelli et al., 2000b) and hence on labor markets.

(iii) As an increased incentive to undertake labor market reforms (especially in the European context, see Calmfors, 1998).

(iv) As a shift in the strategic interactions between CB and unions (Cavallari, 2000, Coricelli et al.,2000b, Rantala 2001).

In the contributions in (i) an (ii), the degree of wage-aggressiveness by unions is affected by the degree of decentralisation in labor markets, and the presence of non-atomistic firms, and hence the formation of a MU impacts on the equilibrium real wage and unemployment rate. By introducing these considerations, a stronger case can be made for a conservative CB to be put at the helm of the MU. In (iii) it is argued that the formation of the MU will induce labor market reforms. In (iv), the formation of the MU, by setting up a new CB, changes the incentive structure for the monetary authorities and therefore leads to changes in the strategic interactions with unions and firms.

A crucial point to note is that almost all of the existing literature has chosen to explain wage settlements from factors external to the firm, such as inflation (cost of living) and the “big bad CB”, as opposed to “inside” or firm-specific factors. Then, the key strategic interaction is between the trade unions and the CB. The degree of wage pressure imposed by the unions is dependent on their perception of the trade-off in the CB’s preferences between the pursuit of an unemployment target and an inflation target. Firms only play a significant strategic role in the contributions of Coricelli et al. (2000a,b). But even in these models, the non-atomistic firms essentially exert an additional disciplining effect on unions, as wage-setters face a downward-sloping derived demand for labor in each sector.

In fact, most evidence from micro-economic data (see Gregory et al., 1985, Layard et al., 1991) suggests that, possibly with exception of Scandinavian countries, factors internal to the firm, such as risk of redundancy or firm profitability do seem to matter in wage-setting. We therefore propose a model were inside factors are key variables in modeling wage-setting. The model emphasizes how an important source of money non neutrality, which is the key result of the literature in this field, might hinge on the impact which unions perceives their actions have on employers as well as on the strategic interactions between unions and the CB. In our framework, firms are faced with the possibility of exit from the market following the realization of idiosyncratic shocks. Unions realize that firm exit has a negative impact on employment, and set their wages taking into account of the impact which their actions have on firms' profitability. We show that, even in a version of the model where firms are atomistic, this disciplining effect is such that a more conservative CB exerts a moderating effect on wage settlements. In our view this result, which hinges on the unions' concern for the variability of employment, is more realistic that models where unions' concerns for inflation lead to a notion of a CB that is more liberal than society.

Our model also has natural implications for EMU. Coricelli et al. (2000b) point out that, insofar as EU impacts on the elasticity of labor demand (through increased competition), it will tend to moderate wage claims. Our focus on the bankruptcy risk facing firms implies that, for any given degree of CB conservativeness, the loss of monetary policy sovereignty further moderates unions' wage-setting behavior. As a result, we find that, ceteris paribus, a CB in a MU needs to be less conservative. The reason why this happens is twofold. On one hand the ECB will react to domestic shocks only to the extent that they modify macroeconomic conditions for the union as a whole. Therefore, unions will anticipate an increase in employment volatility. On the other hand, EMU monetary policy will react to shocks affecting other EMU members. To the extent that such shocks are not transmitted to the domestic economy, this will lead to a further increase in domestic volatility. Essentially our model falls into category (iv) of the models of MU and firm-union-CB strategic interactions highlighted previously: joining a MU modifies the nature of the trade-off facing the unions and affects their wag-setting behavior. In this sense, our results are akin to Cavallari (2000), but the source of the disciplining effect is different.

The rest of the paper is structured as follows. In Section 2 we briefly survey the existing literature and set our approach in the context. In Section 3 we present our theoretical model. In Section 4 we consider the case of entry to a MU. Section 5 concludes. Some mathematical arguments are reported in the Appendix.

2. Literature Survey

Models in this field mostly consider a two-stage game between a Rogoff-type central banker (CB) and a monopoly union (or a number of unions *n*). The typical union is assumed to care about the real wage received by its members and the deviations of unemployment among its members from a desired target level. In addition to that, several contributions (i.e. Cubitt, 1992 and 19995, Skott, 1997, Cukierman and Lippi, 1999a, Coricelli et al. 2000a) also make the assumption that the union might be averse to inflation *per se*.[1] The union moves first and sets its wage taking as given the nominal wage of all other unions (if the model effectively considers the case of $n > 1$) and the reaction function of the CB. In the second stage, the CB takes nominal wages as given and chooses the rate of inflation so as to minimize a quadratic loss function defined over unemployment and inflation.

Using this basic framework, Cukierman and Lippi (1999a) show that, where there is a single monopoly union with positive aversion to inflation, then social welfare is maximized by an ultra-liberal CB; that is, by a CB who does not care about inflation and is only concerned with unemployment stabilization. Intuitively, since the union dislikes inflation and the ultra liberal CB is ready to inflate at an extremely rate in response to even the slightest increase of unemployment above its natural rate, wages will be set at their competitive level so to maintain unemployment in equilibrium. The same logic extends to the case where there is more than one union: provided that *n* is not too large, then higher levels of social welfare are achieved with a CB that is more liberal than society, albeit not ultra-liberal.

The "ultra-liberal CB" result is obtained also by Guzzo and Velasco (1999). Their analytical setting differ from the one adopted by Cukiermann and Lippi (1999a), but they

[1] The issue of why the loss function of the union should include a term in inflation is not discussed in detail by many authors. Coricelli et al. (2000b) effectively consider the case where unions are not averse to inflation *per se*. Lawler (2001) suggests that unions' inflation aversion might be justified by the fact that individual/social welfare functions include a term in inflation. The same point emerges in Guzzo and Velasco 1998), who specify union utility as the sum of individual worker utilities. Berger et al. (2001) point out that , given that if the real wage already enters the loss function, then inflation aversion should only matter insofar as workers' outside option (unemployment benefits or non-human wealth) are not indexed.

too assume that unions might be averse to inflation *per se*. However, whilst in Cukierman and Lippi the optimality of the ultra-liberal CB is determined only for the case of a monopoly union, in Guzzo and Velasco the result holds for $n > 1$. Lawler (2001) features the normative analysis of a model of strategic interaction between an inflation-averse monopoly union and a CB. As in Cukierman and Lippi (1999a), a case for an "ultra-liberal CB" emerges and it is essentially motivated by the same dynamics. The introduction of stochastic productivity shocks however moderates the "ultra-liberal CB" results.

Coricelli, Cukierman and Dalmazzo (2000a) generalize the framework of Cukierman and Lippi to include : (i) price-setting firms[2] and (ii) a monetary authority that affects the price level and inflation only indirectly through its choice of money supply. The game has three stages. In the first stage, each of *n* unions chooses its nominal wage so to minimize its loss function. In doing that, each union takes the nominal wages of other unions as given and anticipates the reaction of the monetary authority and of firms to its wage choice. In the second stage, the monetary authority chooses the nominal stock of money so to minimize its Rogoff-type loss function. The CB takes the wage choices of unions as given and anticipates the pricing reaction of firms. In the third stage, each firm sets the price to maximize real profits. In doing that, firms take money supply and wages as given.

A key results obtained by Coricelli et al. (2000a) is that when there is more than one union and unions care sufficiently more about unemployment among their members than about inflation, then an "ultra-conservative" CB is able to reduce inflation and aggregate unemployment to their minimal possible levels. The result hinge on the fact that a more conservative CB reduces money supply in response to a wage push and this worsens the consequences of wage aggressiveness for unemployment. Unions that are sufficiently averse to unemployment relative to inflation will be thus forced to moderate their wage demands, so that both inflation and unemployment will remain low. The special case of $n = 1$ however restores the optimality of the "ultra-liberal" CB.

[2] See also Soskice and Iversen (2000).

As noted in the introduction, the impact of a monetary union (MU) on union-firm-CB strategic games has been modeled in different ways.[3] Adopting the same framework as Cukierman ad Lippi (1999a), Cukierman and Lippi (1999b) interpret the formation of MU as an increase in the number of unions *n*. A larger *n* then implies that each union internalizes a smaller fraction of the inflationary effects of its wage demands and hence it tends to become more aggressive. This effect is however partially offset by the increased competition among unions which follows from the increase in labor mobility that is associated with the formation of a MU.

Coricelli et al. (2000b) extend the setting of Coricelli et al. (2000a) to investigate open economy interactions. The formation of the MU has a twofold effect in their model: (i) it reduces the size of each firm and (ii) it increases the degree of competition in product markets and hence in labor market. As in Cukierman and Lippi (1999b) the first effect works in the sense of increasing wage aggressiveness and therefore inflation and unemployment. The second effect instead works in the opposite direction: stronger competition implies that for any increase in the wage demanded by a generic union, the increase in unemployment among union's members is greater. Furthermore, when a union demands higher wages for its members, the aggregate price level in the MU goes up. This reduces real money balances and depresses average unemployment. A sufficiently conservative CB will react to the wage push by reducing the nominal stock of money, thus further reducing employment in the MU. It then follows that with a more conservative CB, expected inflation and unemployment are lower.

In Cavallari (2000) the formation of a MU gives rise to a change in the nature of the game between firms, unions and CB. More specifically, the switch from a regime of uncoordinated monetary policies to a MU with a common monetary policy induces wage setters to behave less aggressively, provided that the unified CB is not too conservative. This result follows from the fact that unions correctly perceive in the new regime the stronger incentive that the single CB has to generate surprise inflation. In the uncoordinated

[3] The strand of the literature that interprets the formation of a MU as an increased incentive to undertake labor market reforms (see Calmfors, 1998) is not surveyed here as labor market reform has not been fully integrated into game-theoretic models of CB-union interactions.

game, national CBs are restrained from generating surprise inflation due to the exchange rate costs associated with unilateral monetary expansions. However, these costs disappear when the MU is formed and monetary policy delegated to a common CB. Thus, for any given level of conservativeness, the inflationary bias of the common CB is higher. This in turn makes unions more moderate. On the other hand, the model also incorporates a strategic effect analogous to the one discussed by Cukierman and Lippi (1999b). Which of the two effects prevails then depends upon the degree of conservativeness of the CB. When the common CB is sufficiently liberal, the wage moderation effect prevails, but this might be not enough to compensate for the higher inflationary bias, so that equilibrium inflation in the MU would be higher than under the uncoordinated monetary policy regime. Cavallari suggests that if supra-national unions are created that are able to internalize the higher incentive to accommodate wage inflation of the single CB, then an equilibrium with lower inflation an be achieved. This is because a less conservative CB increases the inflationary awareness of the supra-national union to a sufficient extent to compensate for the increased inflationary bias.

Rantala (2001) focuses on the strategic effects of the change in environment for labor unions. The formation of a MU implies that unions interact with a common CB (rather than with national CBs) that has only one policy instrument available. This means that the monetary response to unilateral wage increases in one country will be necessarily symmetric. Furthermore, as in Cavallari (2000), the common CB internalizes the real exchange rate effect of expansionary monetary policies and this increases its degree of inflationary bias. Faced with this new environment for monetary policy, unions will adapt their behavior. The characterization of the final equilibrium will depend upon the degree of conservativeness of the common CB. In particular, union-wide employment increases (relative to the case where countries do not join in a MU) only if the common CB is sufficiently conservative. Inflation instead certainly higher in the MU for al values of the degree of conservativeness of the CB.

3. Model set-up

The model describes the interactions among three players: firms, unions and Central Bank (CB). The preferences, payoffs and constraints that characterise each of them are described below. Then, the equilibrium outcome of these interactions is characterised.

3.1 *Firms and the aggregate economy*

The economy consists of N firms. The production function of generic firm *i* is specified as a Cobb-Douglas augmented by a firm-specific shock z_i:

(1) $Y_i = AL_i^{\alpha} K^{(1-\alpha)} \exp^{z_i}$

where *Y*, *L*, *K* denote output, labor input and capital input respectively and *A* and α are two positive parameters.

The firm-specific shock can be decomposed into a systematic component (*z*) and an idiosyncratic component (x_i). For analytical tractability of the model, both *z* and x_i are assumed to be uniformly distributed with zero mean and compact supports [z^+, -z^+] and [x^+, -x^+]. The variance of the systematic component *z* is denoted by σ_z^2. Firm profits are given by:

(2) $\Pi = Y_i P - WL_i - C$

where *P* is the unit price of output, *W* is the unit price of labor and *C* denotes debt service payments. We do not explicitly model the liability side of firms bank sheets. We simply assume that a debt contract exists for each firm and that the amount of debt is identical for each firm. That is, the amount of debt service payments in this model is identical across firms.

Firms operate as long as profits are non-negative. From equation (2) the operativity-condition is thus:

$$(3)\quad \frac{WL_i}{Y_i P} + \frac{C}{Y_i P} \leq 1$$

The model is then log-linearised around a non-distortionary steady state. (see the Appendix for details).

Labor input l_i is defined from the first order condition for the maximization of firm's profits:

$$(4)\quad l_i = \frac{1}{1-\alpha}\left[z_i - (w-p)\right]$$

and, from equation (4), total production is given by:

$$(5)\quad y_i = \frac{1}{1-\alpha}\left[-\alpha(w-p) + z_i\right].$$

Substituting (5) and (6) into (4) and then re-arranging terms we can express the operativity-condition in terms of realizations of the idiosyncratic components of the shock z_i:

$$(6)\quad (w-p)\alpha + (c-p)(1-\alpha) - z \leq x_i$$

We assume that the pre-determined wage w is defined as expected inflation (p^e) plus a bargained mark-up set by the union:

$$(7)\quad w = \hat{w} + p^e$$

By the same token, we assume that debt service payments are pre-determined[4] and set as:

(8) $c = \hat{c} + p^e$

Given (6), (7) and (8) the probability of survival of a firm can be formally expressed as:

$$(9)\quad q = \int_{x^*}^{x^+} \frac{dx}{2x^+} = \left(\frac{1}{2} + \frac{z - \alpha\hat{w} - \hat{c}(1-\alpha) + (p - p^e)}{2x^+} \right)$$

where x^* is the value of x_i that satisfies condition (8) as an equality.

Equation (9) states that the risk of bankruptcy (that is, the inverse of the probability of survival) increases for negative realization of the stochastic component z and the higher the bargained mark-up decided by the union and decreases the greater the extent of surprise inflation. Thus, both the union and the CB affect the probability of survival through their strategic behavior. In particular, it is clear that a more aggressive union *ceteris paribus* lowers q. The argument we propose is that CB conservativeness affects employment variability through its impact on the probability of survival and therefore induces wage moderation in a volatility averse union.

3.2 Central Bank

The CB is assumed to follow an "implicit" Taylor rule of the type:

$$(10)\qquad p - p^e = -\frac{z}{\alpha + \chi^*}$$

[4] Our assumption is simply that debt interest payments are indexed to take account of inflation. Clearly in a richer model this might depend on the monetary regime, but as our focus is not how the liability side of the firms' balance sheet evolves over the cycle this is left for further research. Note that we assume that, if a firm cannot meet interest payments it exits and industry and that $\hat{c}$ is predetermined. Again, in a richer model one might model how debt interest payments vary over the cycle and whether firms can borrow to meet existing payments. However, there will be some level of interest payments which will have to be met if the firm is to continue to operate. In our model this is given exogenously and does not vary with any of the exogenous shocks. This assumption is sufficient for the conclusions of the model to hold.

where χ^* is a non-negative weight that reflects the degree of inflation aversion of the CB and p^e denotes the rational expectation taken over p [5]

The theoretical literature on central banking has shown that a monetary rule such as (10) can be obtained as the reaction function of a CB whose objective is the minimization of quadratic loss function defined over output and inflation. As a matter of fact, in the Appendix we derive equation (10) starting from an objective function for the CB specified as $L^{CB} = (1/2)[y^2 + \chi p^2]$. In this case the parameter χ^* in (10) is proportional to the degree of conservativeness χ; that is, $\partial\chi^*/\partial\chi > 0$.

The clear implication of (10) is that the degree of conservativeness affects the probability of survival q. Its effect depends on the sign of z. For negative realizations of the shock, a more conservative CB pursues a less expansionary monetary policy and hence reduces the probability of survival. For positive realizations of the shock, instead, the conservative CB takes a less restrictive monetary stance relative to a more liberal banker (focused on output stabilization) and the consequence is a greater probability of survival.

Associated with the effect on the probability of survival is the effect that CB has on the variance of aggregate employment. As intuitively discussed below (and more formally in the Appendix) an increase in the degree of conservativeness implies, for any state of the world, a greater variance of employment. The consequence is that if the union is volatility averse, then it can decide to moderate wage demands to compensate for the increased volatility generated by the conservative CB.

3.3. Union

We assume centralized wage setting behavior. The monopoly union bargains the wage $\hat{w}$ so to maximize its utility function, taking into account the reaction of the CB as summarized by the Taylor rule (10). In the literature, several different forms have been proposed for the objective function of the union. As just mentioned, the disciplining

[5] It is straightforward to re-write (10) into a standard Taylor rule. That is why we define the monetary rule as “implicit” Taylor rule.

channel we intend to investigate builds on the costs that higher CB conservativeness implies in terms of employment variability for a volatility averse union. For this reason we simply let the utility of the union be a function of the bargained wage and of the variance of employment. We therefore abstract from the assumption that the union is averse to inflation *per se* and hence from the analysis of the associated disciplining mechanisms (as discussed in Section 2, this is extensively done in a number of existing contributions). Our union thus maximizes:

$$(11) \qquad L^U = \hat{w} - \psi Var(l)$$

where ψ is a non-negative parameter.

The objective function incorporates a fundamental trade off. On the one hand, the union is tempted to increase its wage demands so to raise the first term on the right hand side. On the other hand, a greater bargained wage increases employment variability and, for any given degree of CB conservativeness and state of the world, the union bears larger costs represented by the increase of the second term on the right hand side. The equilibrium is determined by the first order condition for the maximization problem

3.4. Wage discipline effect of CB conservativeness

In the Appendix we show that the solution of the maximization problem of the union yields:

$$(12) \quad \hat{w} = \frac{1}{2\psi\sigma_z^2\left[\tilde{\rho}_1\frac{\partial l^e}{\partial \hat{w}} + \tilde{\rho}_2\frac{\partial q^e}{\partial \hat{w}}\right]^2} - (1/2)\frac{\tilde{\rho}_2}{\left[\tilde{\rho}_1\left(\frac{\partial l^e}{\partial \hat{w}}\right) + \tilde{\rho}_2\left(\frac{\partial q^e}{\partial \hat{w}}\right)\right]}$$

where $\tilde{\rho}_1 = \frac{1}{1-\alpha}\left[1 - \frac{1}{\alpha + \chi^*}\right]$ and $\tilde{\rho}_2 = \frac{1}{2x^+}\left[1 - \frac{\alpha}{\alpha + \chi^*}\right]$

The equilibrium bargained wage is inversely correlated to the degree of CB conservativeness. As χ^* increases, the denominator of the first term on the right hand side goes up, whilst the denominator of the second term on the same side goes down (notice in fact that the partial derivatives of l^e and q^e are negative). However, since the second term has a minus in front, the overall effect is unambiguous and the equilibrium value of $\hat{w}$ is smaller the more conservative the CB.

The reason why conservativeness has a wage moderation effect is that, from the point of view of the union, the more conservative the CB is, the higher the costs associated to volatility of employment for any given state of the world (that is, realization of the shock). Not surprisingly, the effect of an increase in the degree of conservativeness on the bargained wage is smaller the smaller ψ: a union that cares relatively less about volatility is not willing to trade-off a lower bargained wage for more stability. Notice also that an increase in the variance of the stochastic parameter reduces the bargained wage and this effect is stronger the more averse to volatility the union is and the more conservative the CB is. The intuition for this result is again that the union moderates its wage demands to compensate the effect in terms of employment variability of an increase in the variance of z. If the union faces an already consistent source of volatility, such as a more conservative CB, and/or it is highly averse to volatility, then the incentive to moderate wage demands is stronger.

4. The formation of a monetary union

We model entry in a monetary union by assuming that the monetary rule for the common CB is given by:

$$(13) \qquad p - p^e = -\frac{z^*}{\alpha + \chi^*}$$

where $z^* = \mu z + \lambda$ and $\mu < 1$, $\lambda > 0$.

According to (13), the common CB reacts to a union-wide shock z^* which is only partly correlated with the country-specific shock z. The intuition underlying the specification of the union-wide shock can be given as follows. Party of the domestic-economy shock (1-μ) is purely asymmetric, i.e. it has a counterpart of opposite sign occurring elsewhere in the union, so that the common CB does not react to it. In addition, the common CB reacts to shocks elsewhere in the Union, which do not affect the domestic economy. This latter reaction represents a source of monetary policy disturbance for the domestic country and it is represented by the random variable λ. By assumption, λ is uniformly distributed with zero mean, supports $-\lambda^+$ and λ^+ and variance equal to σ_λ^2.

The objective function of the union is still represented by equation (11) and the first order condition for its maximization yields the following solution for the bargained wage (see Appendix for algebraic details):

$$(14)\quad \hat{w}_{MU} = \frac{1}{2\psi\sigma_z^2\left[\rho_1\frac{\partial l^e}{\partial\hat{w}}+\rho_2\frac{\partial q^e}{\partial\hat{w}}\right]^2+2\psi\sigma_\lambda^2\left[\delta_1\frac{\partial l^e}{\partial\hat{w}}+\delta_2\frac{\delta q^e}{\partial\hat{w}}\right]^2}+ \\ +\frac{-\frac{1}{2}\left(2\psi\sigma_z^2\rho_2\right)\left[\rho_1\frac{\partial l^e}{\partial\hat{w}}+\rho_2\frac{\partial q^e}{\partial\hat{w}}\right]-\frac{1}{2}\left(2\psi\sigma_\lambda^2\right)\left[\delta_1\frac{\partial l^e}{\partial\hat{w}}+\delta_2\frac{\delta q^e}{\partial\hat{w}}\right]}{2\psi\sigma_z^2\left[\rho_1\frac{\partial l^e}{\partial\hat{w}}+\rho_2\frac{\partial q^e}{\partial\hat{w}}\right]^2+2\psi\sigma_\lambda^2\left[\delta_1\frac{\partial l^e}{\partial\hat{w}}+\delta_2\frac{\delta q^e}{\partial\hat{w}}\right]^2}$$

Inspection of equations (12) and (14) reveals that the equilibrium bargained wage in the monetary union is smaller for any degree of CB conservativeness (again see the Appendix for algebraic details). The intuition is that entry in the monetary union entails a loss of monetary policy stabilization and adds a source of disturbance. Both effects work in the sense of increasing employment variance and therefore contribute to reinforce the wage moderation result. It thus follows that, *ceteris paribus*, the common CB in a monetary union needs to be less conservative(than in a regime of uncoordinated monetary policies) to obtain a given wage moderation effect.

5. Conclusions and directions of future research.

We presented a model of union-firms-central bank interactions and inflation. Its distinctive feature is that firms face a positive probability of death following the realizations of an idiosyncratic supply shock. The exit of firms is a source of employment fluctuation that the union tries to stabilize. This in turn leads to a moderation of wage demands. The union discipline effect is stronger the more conservative the central bank. We modeled the formation of a monetary union as an increase in the probability of each firm's death. This follows from the observation that, due to asymmetric shocks across EMU members, entering the union entails a loss of monetary stabilization policies. Faced with this higher risk of bankruptcy, the union further moderates its wage demands for any given degree of central bank conservativeness. Both the two fundamental results of this exercise are obtained under plausible sufficient conditions concerning the size of the parameters of the model.

The analysis we proposed has interesting and innovative implications. In particular, it appears that the formation of the EMU can induce wage moderation and hence lower inflation without the need to make the degree of conservativeness of the ECB dramatically higher than the one of national monetary authorities. On the contrary, the increased probability of death that firms face once monetary policy is delegated to the common central bank implies that *ceteris paribus*, this common central bank does not need to be more conservative.

The work can be extended in a number of ways. First of all, we focused on a single monopoly union. The obvious question to address next is how results change when a decentralized wage setting behavior is assumed. At first glance, the key mechanism of our model should still operate and unions would moderate their wage demands in response to a positive probability of firms' death. However, in a decentralized setting, the presence of a competition effect may make results less linear than in the monopoly union case. Second, it would be interesting to incorporate the positive-profit constraint directly into the utility function of the unions. More generally, a micro-founded version of the model might yield additional insights, especially concerning the possibility for players to use wage indexation as an instrument.

Appendix

A1. The model expressed in deviations from non distortionary steady state.

Derivation of condition (4). Start with the level equation:

$$\frac{\mathbf{WL}}{\mathbf{YP}} + \frac{\mathbf{C}}{\mathbf{YP}} \leq 1 \qquad \text{(A1)}$$

Assuming a steady state where profits are zero[6]:

$$\overline{\mathbf{W}}\overline{\mathbf{L}} + \overline{\mathbf{C}} = \overline{\mathbf{Y}}\overline{\mathbf{P}} \qquad \text{(A2)}$$

and log-linearising we get

$$\vartheta(w + l) + (1 - \vartheta)c \leq y + p \qquad \text{(A3)}$$

where $\vartheta = \dfrac{\overline{WL}}{\overline{P}\,\overline{Y}}$

Then, we assume that in (1) $AK^{(1-\alpha)}$ is constant and normalized at 1. The first-order condition for the profit-maximising firm is

$$(\frac{W}{P}) = \alpha(L)^{\alpha-1} \exp^{z_i} \qquad \text{(A4)}$$

Taking logs and considering only deviations from steady state values, yields:

$$w - p = (\alpha - 1)l + z_i \qquad \text{(A5)}$$

Correspondingly, output deviations from steady state amount to:

$$y = \alpha l + z_i \qquad \text{(A6)}$$

[6] For simplicity we assume that all firms' liabilities take the form of debt.

From (A5) and (A6) we obtain (4) and (5) in the text. Substituting (A5) and (A6) into (A3) and rearranging, we get

$$\alpha(w-p)+(c-p)(1-\alpha)\leq -z_i \qquad \text{(A7)}$$

taking into account that $z_i = z + x_i$, and substituting (7) and (8) into (A7) we obtain the probability of firm survival (9).

A2. Definition of employment variance and first order condition of the union in the basic (no monetary union) case.

The variance of employment is formally defined as:

$$\text{(A6)} \quad Var(l) = E[lq - E(lq)^2]^2 = \int_{-z^+}^{z^+}\int_{-x^+}^{x^+}(l - l^e q^e)^2 \frac{dx}{2x^+}\frac{dz}{2z^+}$$

where :

$$l = \frac{1}{1-\alpha}\left[z_i - \hat{w} + (p - p^e)\right] \quad \text{and} \quad l^e = -\frac{\hat{w}}{1-\alpha};$$

$$q = \frac{1}{2} + \frac{z - \alpha\hat{w} + \alpha(p - p^e)}{2x^+} \quad \text{and} \quad q^e = \frac{1}{2} - \frac{\alpha\hat{w}}{2x^+}$$

and z^+ -z^+ are the supports of the distribution of z.

From the definitions of l and q and their expected values it is possible to write:

$$\text{(A7a)} \quad l = l^e + z\tilde{\rho}_1 \text{ where } \tilde{\rho}_1 = \frac{1}{1-\alpha}\left[1 - \frac{1}{\alpha + \chi^*}\right]$$

$$\text{(A7b)} \quad q = q^e + z\tilde{\rho}_2 \text{ where } \tilde{\rho}_2 = \frac{1}{2x^+}\left[1 - \frac{\alpha}{\alpha + \chi^*}\right]$$

Substituting (A7a) and (A7b) into (A6) and re-arranging terms we have:

(A8) $$E[lq - l^e q^e]^2 = \int_{-z^+}^{z^+} \left\{ z\left[\tilde{\rho}_1 l^e + \tilde{\rho}_2 q^e\right] + \left[z^2 - E(z)^2\right]\tilde{\rho}_1\tilde{\rho}_2 \right\}^2 \frac{dz}{2z^+}$$

Solving the integral yields the following definition for the variance:

(A9) $$E\left[lq - l^e q^e\right]^2 = \sigma_z^2\left(\tilde{\rho}_1 l^e + \tilde{\rho}_2 q^e\right)^2 - \left(\sigma_z^2\right)^2 (\tilde{\rho}_1\tilde{\rho}_2)^2$$

where σ_z^2 is the variance of the stochastic component *z*.

Notice that the variance is increasing in the bargained wage. An increase in the degree of conservativeness increases the first term on the right hand side, but also reduces the second term on the same side. However, from the point of view of the union, this second term is completely exogenous and does not influence its wage-setting behavior. Thus a more conservative CB makes the union more willing to moderate the wage in order to compensate the positive effect that conservativeness has on employment volatility.

The equilibrium on the trade-off incorporated in the utility function of the union (equation (11) in the text, is found by solving the maximization problem. The first order condition is specified as:

(A10) $$\frac{\partial L^U}{\partial \hat{w}} = 1 - 2\psi\sigma_z^2\left(\tilde{\rho}_1 l^e + \tilde{\rho}_2 q^e\right)\left(\tilde{\rho}_1 \frac{\partial l^e}{\partial \hat{w}} + \tilde{\rho}_2 \frac{\partial q^e}{\partial \hat{w}}\right) = 0$$

and hence:

(A11) $$\left(\tilde{\rho}_1 l^e + \tilde{\rho}_2 q^e\right) = \frac{1}{2\psi\sigma_z^2\left(\tilde{\rho}_1 l^e + \tilde{\rho}_2 q^e\right)\left(\tilde{\rho}_1 \frac{\partial l^e}{\partial \hat{w}} + \tilde{\rho}_2 \frac{\partial q^e}{\partial \hat{w}}\right)}$$

To obtain equation (12) in the text it is then sufficient to substitute l^e and q^e with their definitions expressed as functions of the bargained wage, isolate the bargained wage on the right hand side and make use of the two following relations:

(A12a) $\dfrac{\partial l^e}{\partial \hat{w}} = -\dfrac{1}{1-\alpha}$ and (A12b) $\dfrac{\partial q^e}{\partial \hat{w}} = -\dfrac{\alpha}{2x^+}$

To formally evaluate the impact of CB conservativeness of the equilibrium bargained wage $\hat{w}$ we need to consider the sign of the derivative of (12) with respect to χ^*. To do this, first re-write (12) as follows:

$$\text{(A13)} \quad \hat{w} = \frac{1}{2\psi\sigma_z^2\left[\tilde{\rho}_1 \dfrac{\partial l^e}{\partial \hat{w}} + \tilde{\rho}_2 \dfrac{\partial q^e}{\partial \hat{w}}\right]^2} + (1/2)\frac{\tilde{\rho}_2}{\left[\tilde{\rho}_1\left(\dfrac{1}{1-\alpha}\right) + \tilde{\rho}_2\left(\dfrac{\alpha}{2x^+}\right)\right]}$$

The derivative of the first term with respect to χ^* is certainly negative. The derivative of the second term is given by:

(A.14)

$$\frac{\partial\left[(1/2)\tilde{\rho}_2 \Big/ \left(\tilde{\rho}_1 \dfrac{1}{1-\alpha} + \tilde{\rho}_2 \dfrac{\alpha}{2x^+}\right)\right]}{\partial \chi^*} = \frac{1}{2}\frac{1}{\left(\tilde{\rho}_1 \dfrac{1}{1-\alpha} + \tilde{\rho}_2 \dfrac{\alpha}{2x^+}\right)^2}\left[\frac{\alpha}{(\alpha+\chi^*)2x^+}\left(\tilde{\rho}_1 \frac{1}{1-\alpha}\right) + {} - \frac{\tilde{\rho}_2}{(\alpha+\chi^*)^2(1-\alpha)^2}\right]$$

After substituting for the definitions of $\tilde{\rho}_1$ and $\tilde{\rho}_2$ (from equation A7a and A7b) it appears that the first term on the right hand side (the term outside square brackets) is positive whilst the second term (inside square brackets) is negative, since it reduces to $(\alpha/\alpha+\chi*)[\alpha-1]$. The derivative is thus unambiguously negative: CB conservativeness induces wage moderation.

A3 Employment variance and first order condition of the union in the monetary union case.

In the case of a monetary union, where the common CB operates according to the Taylor rule (13), employment variance is defined as follows:

$$\text{(A15)}\quad E(lq-l^e q^e)^2 = \int_{-z^+}^{z^+} \left\{ z\left[\rho_2 l^e + \rho_1 q^e\right] + \left[z^2 - E(z)^2\right]\rho_1\rho_2 \right\}^2 \frac{dz}{2z^+} + \\ + \int_{-\lambda^+}^{\lambda^+} \left\{ -\lambda\left[\delta_2 q^e + \delta_1 l^e\right] + \left[\lambda^2 - E(\lambda)^2\right]\delta_1\delta_2 \right\}^2 \frac{d\lambda}{2\lambda^+} + \\ + \int_{-z^+}^{z^+}\int_{-\lambda^+}^{\lambda^+} \left\{ -\lambda z[\delta_1\rho_2 + \rho_1\delta_2]^2 \right\}^2 \frac{dzd\lambda}{2z^+ 2\lambda^+}$$

where

$$\rho_1 = \frac{1}{1-\alpha}\left(1-\frac{\rho}{\alpha+\chi*}\right);\ \rho_2 = \frac{1}{2x^+}\left(1-\frac{\alpha\rho}{\alpha+\chi*}\right);\ \delta_1 = \frac{1}{(1-\alpha)(\alpha+\chi*)};\ \delta_2 = \frac{1}{2x^+(\alpha+\chi*)}$$

and λ^+ $-\lambda^+$ are the supports of the distribution of λ.

Note that the third term of the definition of the variance does not include the bargained wage. This implied that we do not need to make the covariance explicit. The variance can be thus defined as:

$$E[lq - l^e q^e]^2 = \sigma_z^2 \left(\rho_1 l^e + \rho_2 q^e\right)^2 - \left(\sigma_z^2\right)^2 (\rho_1 \rho_2)^2 - \left(\sigma_\lambda^2\right)^2 (\delta_1 \delta_2)^2 + \sigma_\lambda^2 \left(\delta_2 q^e + \delta_1 l^e\right)^2 + \\ + \int_{-z^+}^{z^+} \int_{-\lambda^+}^{\lambda^+} \{-\lambda z[\delta_1 \rho_2 + \delta_2 \rho_1]\}^2 \frac{dz d\lambda}{2z^+ 2\lambda^+} \tag{A16}$$

where σ_λ^2 is the variance of the shock λ.

The first order condition for the maximization of the objective function of the union is therefore:

(A17)

$$\frac{\partial L^U}{\partial \hat{w}} = 1 - 2\psi\sigma_z^2 \left(\rho_1 l^e + \rho_2 q^e\right)\left(\rho_1 \frac{\partial l^e}{\partial \hat{w}} + \rho_2 \frac{\partial q^e}{\partial \hat{w}}\right) - 2\psi\sigma_\lambda^2 \left(\delta_1 l^e + \delta_2 q^e\right)\left(\delta_2 \frac{\partial q^e}{\partial \hat{w}} + \delta_1 \frac{\partial l^e}{\partial \hat{w}}\right) = 0$$

By substituting for q^e and l^e in equation (A17) and making use of (A12a) and (A12b) when re-arranging terms the first order condition can be re-expressed in terms of the bargained wage as follows:

$$1 - 2\psi\sigma_z^2 \hat{w}\left[\rho_1 \frac{\partial l^e}{\partial \hat{w}} + \rho_2 \frac{\partial q^e}{\partial \hat{w}}\right]^2 - \frac{1}{2}\left(2\psi\sigma_z^2 \rho_2\right) - 2\psi\sigma_\lambda^2 \hat{w}\left[\delta_1 \frac{\partial l^e}{\partial \hat{w}} + \delta_2 \frac{\partial q^e}{\partial \hat{w}}\right]^2 + \\ - \frac{1}{2}\left(2\psi\sigma_\lambda^2 \delta_2\right) = 0 \tag{A18}$$

Equation (14) in the text is the obtained by re-arranging terms in (A18).

To evaluate the impact of entry in the monetary union on wage demands we compare the equilibrium bargained wage obtained for the monetary union case (equation (14)) with the equilibrium bargained wage in the basic (non monetary union) case (equation (12)). The difference between the two can be written as follows:

(A19) $\hat{w}_{MU} - \hat{w} =$

$$\left\{\frac{1}{2\psi\sigma_z^2\left[\rho_1\frac{\partial l^e}{\partial\hat{w}}+\rho_2\frac{\partial q^e}{\partial\hat{w}}\right]^2+2\psi\sigma_\lambda^2\left[\delta_1\frac{\partial l^e}{\partial\hat{w}}+\delta_2\frac{\partial q^e}{\partial\hat{w}}\right]^2}-\frac{1}{2\psi\sigma_z^2\left[\tilde{\rho}_1\frac{\partial l^e}{\partial\hat{w}}+\tilde{\rho}_2\frac{\partial q^e}{\partial\hat{w}}\right]}\right\}-$$

$$\left\{+\frac{1}{2}\frac{\left(2\psi\sigma_z^2\rho_2\right)\left(\rho_1\frac{\partial l^e}{\partial\hat{w}}+\rho_2\frac{\partial q^e}{\partial\hat{w}}\right)+\left(2\psi\sigma_\lambda^2\delta_2\right)\left(\delta_1\frac{\partial l^e}{\partial\hat{w}}+\delta_2\frac{\partial q^e}{\partial\hat{w}}\right)}{2\psi\sigma_z^2\left[\rho_1\frac{\partial l^e}{\partial\hat{w}}+\rho_2\frac{\partial q^e}{\partial\hat{w}}\right]^2+2\psi\sigma_\lambda^2\left[\delta_1\frac{\partial l^e}{\partial\hat{w}}+\delta_2\frac{\partial q^e}{\partial\hat{w}}\right]^2}-\frac{1}{2}\frac{\tilde{\rho}_2}{\left[\tilde{\rho}_1\frac{\partial l^e}{\partial\hat{w}}+\tilde{\rho}_2\frac{\partial q^e}{\partial\hat{w}}\right]}\right\}$$

The first term on the right hand side is unambiguously negative. The second term (call it Δ) can be re-written as:

$$\text{(A20)}\quad \Delta=\frac{\frac{1}{2}2\psi\sigma_z^2\left[\rho_1\frac{\partial l^e}{\partial\hat{w}}+\rho_2\frac{\partial q^e}{\partial\hat{w}}\right]\left\{\rho_2\left(\tilde{\rho}_1\frac{\partial l^e}{\partial\hat{w}}+\tilde{\rho}_2\frac{\partial q^e}{\partial\hat{w}}\right)-\tilde{\rho}_2\left(\rho_1\frac{\partial l^e}{\partial\hat{w}}+\rho_2\frac{\partial q^e}{\partial\hat{w}}\right)\right\}}{\left\{2\psi\sigma_z^2\left[\rho_1\frac{\partial l^e}{\partial\hat{w}}+\rho_2\frac{\partial q^e}{\partial\hat{w}}\right]^2+2\psi\sigma_\lambda^2\left[\delta_1\frac{\partial l^e}{\partial\hat{w}}+\delta_2\frac{\partial q^e}{\partial\hat{w}}\right]^2\right\}\left\{\left[\tilde{\rho}_1\frac{\partial l^e}{\partial\hat{w}}+\tilde{\rho}_2\frac{\partial q^e}{\partial\hat{w}}\right]\right\}}+$$

$$\frac{\frac{1}{2}2\psi\sigma_\lambda^2\left[\delta_1\frac{\partial l^e}{\partial\hat{w}}+\delta_2\frac{\partial q^e}{\partial\hat{w}}\right]\left\{\delta_2\left(\tilde{\rho}_1\frac{\partial l^e}{\partial\hat{w}}+\tilde{\rho}_2\frac{\partial q^e}{\partial\hat{w}}\right)-\tilde{\rho}_2\left(\delta_1\frac{\partial l^e}{\partial\hat{w}}+\delta_2\frac{\partial q^e}{\partial\hat{w}}\right)\right\}}{\left\{2\psi\sigma_z^2\left[\rho_1\frac{\partial l^e}{\partial\hat{w}}+\rho_2\frac{\partial q^e}{\partial\hat{w}}\right]^2+2\psi\sigma_\lambda^2\left[\delta_1\frac{\partial l^e}{\partial\hat{w}}+\delta_2\frac{\partial q^e}{\partial\hat{w}}\right]^2\right\}\left\{\left[\tilde{\rho}_1\frac{\partial l^e}{\partial\hat{w}}+\tilde{\rho}_2\frac{\partial q^e}{\partial\hat{w}}\right]\right\}}$$

The sign of the term depends on the numerator (call it N), which simplifies to:

(A21)

$$\mathrm{N}=\frac{1}{2}2\psi\sigma_z^2\left[\rho_1\frac{\partial l^e}{\partial\hat{w}}+\rho_2\frac{\partial q^e}{\partial\hat{w}}\right]\left[\frac{\partial l^e}{\partial\hat{w}}\left(\rho_2\tilde{\rho}_1-\tilde{\rho}_2\rho_1\right)\right]+\frac{1}{2}2\psi\sigma_\lambda^2\left[\delta_1\frac{\partial l^e}{\partial\hat{w}}+\delta_2\frac{\partial q^e}{\partial\hat{w}}\right]\left[\frac{\partial l^e}{\partial\hat{w}}\left(\delta_2\tilde{\rho}_1-\tilde{\rho}_2\delta_1\right)\right]$$

The terms inside round brackets are both positive. Since the partial derivatives of both l^e and q^e are negative, this implies an overall positive sign for the numerator N. However recall that in equation (A19), the term Δ has a minus in front, so that its overall sign is negative. In the end, the difference in equation (A19) is the sum of two negative terms and it is therefore negative. This means that $\hat{w} > \hat{w}_{MU}$ and hence that the formation of a monetary union has a wage moderation effect. As noted in the text, this follows from the impact that the formation of the monetary union has on the volatility of employment.

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