MONETARY POLICY IN EMU WHEN THE TRANSMISSION IS ASYMMETRIC AND UNCERTAIN

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Abstract

In this paper we address the issue of how transmission uncertainty could affect the choice between a federal monetary policy based on national data and one on aggregated data.We find that the uncertainty about the transmission process increases the need to take into account information about national economies in the formulation of optimal monetary policies in a monetary union.

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1 Introduction

The conduct of monetary policy in Euroland is made difficult because of the existence of asymmetries within the union. Asymmetries exist both at the level of the macroeconomic shocks to which members of the union are subjected and at the level of the transmission of monetary policies. Recent theoretical analysis has shown that the existence of asymmetries in the transmission of monetary policy actions of the ECB calls for a design of monetary policies that takes into account national data. Thus, in order for monetary policies to be set optimally it is not sufficient to use aggregated (euro) data on inflation and output gaps, but also to consider non-aggregated national data on these same variables if asymmetries in the transmission of monetary policies exist (see De Grauwe (2000) and Gros and Hefeker (2002)). Empirical evidence seems to support this view in the case of the Federal Reserve System of Central Banks in the United States (see Meade and Sheets (2002), and Heinemann and Hüfner (2002)).

The previous conclusion has been derived in the context of models in which there is no uncertainty about the transmission process. The issue that arises here is whether this conclusion continues to hold when uncertainty about the transmission process exists.

Monetary policy transmission uncertainty is also an important issue in the European context. According to several economists (see, among others, Dornbusch, Favero and Giavazzi (1998), Mihov (2001) and ECB (2001)), the creation of EMU is likely to have strengthened the degree of uncertainty surrounding the transmission of monetary policy measures within the Union.

The optimal design of monetary policy when transmission uncertainty exists has been analysed in detail in the theoretical literature. The main insight provided by this literature is that transmission uncertainty may call for more caution from the monetary authorities. Faced with this kind of uncertainty, the authorities will tend to stabilize less that when no such uncertainty exists (see Brainard (1967) for the original argument and Söderström (1999) and Peersman and Smets (1999) for an application to the European context)[1].

In this paper, we develop a model of a monetary union in which the transmission of policy induced changes in the interest rate is asymmetric. We first do this when there is no uncertainty about this transmission process. We then extend the model allowing for uncertainty in the transmission process. We are thus able to analyse how the uncertainty and asymmetry issues interact and how this interaction may impinge on the choice of a monetary strategy in EMU.

[1]Empirical evidence on the caution principle is more ambiguous (see European Central Bank (2001)).

2 National *versus* Union-wide Aggregation: how to deal with transmission heterogeneity?

2.1 The modelling framework

We use a standard macroeconomic model and apply it to a monetary union framework. The asymmetry is introduced in the model by considering that the features of the national Phillips curves differ from one country to the other, so that:

$$U_i = U_i^* - a_i \cdot (\pi_i - \pi_i^e) + \varepsilon_i$$

i is the country $i = 1, 2, ..., N$

U_i is the unemployment rate in the country i and U_i^* is its natural counterpart. a_i denotes the transmission parameter of (unexpected) inflation impulses to the unemployment gap. As our objective is to analyse the implications of asymmetries in transmission, we assume that this coefficient differs across countries.

We will not assume asymmetry in the shocks. This has been done elsewhere (see De Grauwe (2000)). We focus on the asymmetries in the transmission process because this is where the uncertainty will arise (see *infra*). Thus, we suppose that $\varepsilon_i = \varepsilon$ for all i. Put differently, we intend to analyse a world of symmetric shocks that are transmitted asymmetrically and in which there is uncertainty about this transmission process.

π_i refers to the inflation rate of country i. It will be assumed that when the countries in the model form a monetary union the inflation rate is the same in all countries. We have two reasons to do this. First, as it is usually the case in the literature, we suppose that the monetary authorities directly control the inflation rate. Second, as monetary policy is determined in a centralised fashion when a monetary union exists, the member countries share common monetary conditions in the Union, which should lead to the same rates of inflation. There is of course evidence indicating that inflation rates in the eurozone differ across countries. However, it is likely that those inflation differentials are very much influenced by the Balassa-Samuelson effect. Since this is primarily a structural feature, it is not very much influenced by monetary policy.

The single monetary policy in a monetary union can be designed in two ways.

1- First, the Common Central Bank may choose to minimise a weighted average of national loss functions. We define this strategy as a **national aggregation** (**NA**) procedure. The national loss function depends on the squared deviations of inflation and output from target levels in the following way:

$$L_i \equiv (\pi_i)^2 + b \cdot (U_i - U_i^*)^2$$

where b denotes the relative weight of the unemployment gap with respect to inflation in the loss function. Note that for the sake of convenience we set the target rate of inflation equal to 0. In addition, we assume that the unemployment target of the authorities coincides with the natural unemployment. As a result, we disregard issues relating to credibility. Indeed, we want to emphasize that the monetary authorities are likely to face the heterogeneity in the transmission of monetary policy, their potential time-inconsistency notwithstanding.

In the (NA) scenario therefore, the central bank of the monetary union determines its optimal strategy by minimising the "average" of the loss functions of the member countries in the Union[2]:

$$\Lambda^{NA} \equiv \sum_{i=1}^{i=N} \mu_i \cdot L_i$$

μ_i is the weight associated to country i in the computation of the aggregate loss function. We have: $\sum_{i=1}^{i=N} \mu_i = 1$.

As the inflation rate is common to all the member countries, we may rewrite the former expression as:

$$\Lambda^{NA}(\pi) = (\pi)^2 + b \cdot \sum_{i=1}^{i=N} \mu_i \cdot (U_i - U_i^*)^2 \tag{1}$$

Since $(U_i - U_i^*)$ depends on the (rationally) unexpected component of the (common) inflation rate, Λ^{NA} will be a function of π (for a given value of the shock, ε). In the following, we define π^{NA} as the optimal inflation rate under the NA strategy (ie. the one for which Λ^{NA} is minimal).

2- The second scenario refers to a strategy where the Central Bank minimizes a loss function defined in terms of Union-wide aggregate variables, i.e. an average inflation rate and an average unemployment rate. We designate such a strategy as a **euro-aggregation** (**EA**) procedure, which we specify as follows:

$$\begin{aligned} U_E &\equiv \sum_{i=1}^{i=N} \mu_i \cdot U_i \\ U_E^* &\equiv \sum_{i=1}^{i=N} \mu_i \cdot U_i^* \\ \pi_E &\equiv \sum_{i=1}^{i=N} \mu_i \cdot \pi_i = \pi \end{aligned}$$

[2]By convention, X_i^{NA} (resp. X_i^{EA}) will refer in the following to the value taken by the (endogenous) variable X_i when the so-called national-aggregation (resp. Union-wide) strategy is implemented by the central bank.

where the subscript E refers to a variable defined at the Union level.

The relevant loss function may then be defined as follows:

$$\begin{aligned}\Lambda^{EA} &\equiv (\pi)^2 + b \cdot (U_E - U_E^*)^2 \\ \Lambda^{EA}(\pi) &= (\pi)^2 + b \cdot \left[\sum_{i=1}^{i=N} \mu_i \cdot (U_i - U_i^*)\right]^2 \end{aligned} \tag{2}$$

Because of the linearity of the national Phillips relationships, the aggregation rule allows for the existence of a Union-wide Phillips "curve" between the aggregate inflation rate and the "mean" unemployment gap. Thus we have

$$U_E = U_E^* - a_E \cdot (\pi - \pi^e) + \varepsilon$$

with $a_E \equiv \sum_1^N \mu_i \cdot a_i$, which could be qualified as the *mean* transmission parameter.

Again we observe that Λ^{EA} is a function of π. In the following we define π^{EA} as the optimal inflation rate under the EA strategy (ie the one for which Λ^{EA} is minimal).

Finally, both strategies have to be compared using a common welfare measure. As we consider an explicit heterogeneity in the transmission mechanisms, the benchmark used is the weighted average of the ex ante (expected) national losses obtained under each of the two alternatives. Thus welfare is defined as:

$$W \equiv E_\varepsilon \left[\sum_{i=1}^{i=N} \mu_i \cdot L_i\right] \tag{3}$$

where E_ε is the expectation operator taken with respect to the distribution of ε. We posit $E_\varepsilon[\varepsilon] = 0$ and $E_\varepsilon\left[\varepsilon^2\right] = \sigma_\varepsilon^2$. Note that $W = E_\varepsilon\left[\Lambda^{NA}\right]$.

2.2 Comparison of the strategies

We now examine the properties of the two strategies in more detail.

1- Under the first scenario, the Central bank determines π^{NA} such that it minimises Λ^{NA} subject to the constraint of national Phillips "curves" prevailing in the member countries while taking as given the value of the shock (ε) and the private sector's expectations of the inflation rate implemented under this strategy (π^e). Thus, we have

$$\begin{aligned}\pi^{NA} &= \arg\min_{\pi} \Lambda^{NA} \\ & \quad s.t. \left\{ \begin{array}{c} \pi^e, \ \varepsilon \ given \\ U_i = U_i^* - a_i \cdot (\pi - \pi^{e,}) + \varepsilon, \ \text{for } i = 1, 2, ..., N \end{array} \right.\end{aligned}$$

Solving this program (including the computation of the rational expected inflation rate at equilibrium) leads to:

$$\begin{aligned}\pi^{NA} &= \frac{ba_E}{1+b\left(a_E^2+\theta_{a_E}^2\right)}\varepsilon \\ &= \Omega_{NA}\cdot\varepsilon\end{aligned}$$

with: $\Omega_{NA} \equiv \dfrac{ba_E}{1+b\left(a_E^2+\theta_{a_E}^2\right)}$ and $\theta_{a_E}^2 \equiv \sum_1^N \mu_i \cdot (a_i - a_E)^2$ which is a measure of the dispersion in the national transmission parameters[3]. Thus, $\theta_{a_E}^2$ measures the asymmetry in the transmission process

We observe that when the asymmetry in the transmission process increases, the authorities' optimal inflation rate reacts less to shocks. The counterpart of this lessening in the inflation variability is an increasing volatility of the national unemployment rate with the size in the transmission asymmetry. This is seen from the following expression of the equilibrium unemployment rate (obtained by substituting the optimal inflation rate in the Phillips curve):

$$U_i^{NA} = U_i^* + (1-\Omega_{NA}\cdot a_i)\cdot\varepsilon$$

2- Under the second scenario, the Central Bank minimises the loss function based on the Union-wide unemployment and inflation rates. The constraint is then given by the Union-wide Phillips relationship. We obtain:

$$\begin{aligned}\pi^{EA} &= \arg\min_{\pi}\Lambda^{EA} \\ & s.t. \begin{cases}\pi^e,\ \varepsilon \ given \\ U_E = U_E^* - a_E\cdot(\pi-\pi^e)+\varepsilon\end{cases}\end{aligned}$$

which leads to:

$$\begin{aligned}\pi^{EA} &= \frac{ba_E}{1+ba_E^2}\varepsilon \\ &= \Omega_{EA}\cdot\varepsilon\end{aligned}$$

with $\Omega_{EA} \equiv \dfrac{ba_E}{1+ba_E^2}$.

[3]Besides, we have the following relation: $\overline{a_E^2} = a_E^2 + \theta_{a_E}^2$ with $\overline{a_E^2} \equiv \sum_1^N \mu_i \cdot a_i^2$

Note that this is the same optimal inflation rate which would be obtained if the model had been applied to the case of a single country (whose role is played in our framework by the monetary union).

As in the first scenario the equilibrium level of the national unemployment rates can be obtained by substituting the optimal inflation rate into the national Phillips curves, i.e.:

$$U_i^{EA} = U_i^* + (1 - \Omega_{EA} \cdot a_i) \cdot \varepsilon$$

From these results we conclude that under a strategy which aims at minimising the variability of *Union-wide* variables, the asymmetry in the transmission of the common supply shocks does not act as a motive for changing the inflation rate and, thereby, for affecting the variability of the national unemployment rates.

A welfare comparison of both strategies goes through the computation of the weighted average of expected national losses after having substituted the relevant values of the inflation and unemployment rates in (3). We obtain

$$W^{NA} = \left[(\Omega_{NA})^2 + b \cdot \sum_{i=1}^{i=N} \mu_i \cdot (1 - \Omega_{NA} \cdot a_i)^2 \right] \cdot \sigma_\varepsilon^2 \qquad (4)$$

$$W^{EA} = \left[(\Omega_{EA})^2 + b \cdot \sum_{i=1}^{i=N} \mu_i \cdot (1 - \Omega_{EA} \cdot a_i)^2 \right] \cdot \sigma_\varepsilon^2 \qquad (5)$$

The relative benefits of a national aggregation strategy *versus* a Union-wide procedure are thus given by the differential loss, $\Delta W \equiv \frac{1}{\sigma_\varepsilon^2} \left(W^{EA} - W^{NA} \right)$, ie:

$$\Delta W = (\Omega_{EA})^2 - (\Omega_{NA})^2 + b \cdot \sum_{i=1}^{i=N} \mu_i \cdot \left[(1 - \Omega_{EA} \cdot a_i)^2 - (1 - \Omega_{NA} \cdot a_i)^2 \right] \qquad (6)$$

Simplifying this expression[4] leads to:

$$\Delta W \equiv [(\Omega_{EA}) - (\Omega_{NA})] \cdot \Omega_{EA} \cdot b \cdot \theta_{a_E}^2 \qquad (7)$$

which is positive as $\Omega_{EA} > \Omega_{NA}$.

[4]On this point, it seems that Gros and Hefeker (2002, p.10) have (mistakenly?) obtained conditions which are superfluous with respect to the result they derive.

Thus adopting a national aggregation perspective is better than relying on a Union-wide strategy.

The comparison of the two loss functions may enlight the reasons why the NA strategy has to be favored[5].

Indeed, let define the unemployment gap, U_i^g, as: $U_i^g \equiv U_i - U_i^*$. Manipulating the loss functions, given by equations (1) and (2), we obtain[6]:

$$\begin{aligned} \Lambda^{NA}(\pi) &= \Lambda^{EA}(\pi) + b \cdot \left(\sum_{i=1}^{i=N} \mu_i \cdot \left(U_i^g - U_E^g\right)^2 \right) \\ &= \Lambda^{EA}(\pi) + b \cdot \theta_{U^g}^2 \end{aligned} \tag{8}$$

with $\theta_{U^g}^2 \equiv \sum_{i=1}^{i=N} \mu_i \cdot \left(U_i^g - U_E^g\right)^2$, which can be considered as a measure of the dispersion between the national unemployment rates.

Deriving this expression leads to two interesting and interrelated properties:

- First, we observe that the two strategies are equivalent if and only if there is no dispersion between the unemployment gaps $\left(\theta_{U^g}^2 = 0\right)$ and/or there is no output goal in the loss function of the monetary authorities ($b = 0$).
- Second, given the framework we have retained, there is *only one* strategy which would satisfy the welfare maximising criteria we have imposed (eq. 3), namely the choice of the national aggregation procedure. Put differently, $\Lambda^{NA}\left(\pi^{NA}\right) < \Lambda^{NA}\left(\pi^{EA}\right)$.

3 Introducing parameter transmission uncertainty in an heterogeneous monetary union

In the foregoing, we have shown that adopting a national aggregation perspective is unambiguously a better strategy to deal with asymmetries in the transmission mechanisms than to rely on Union-wide aggregates. The question that arises now is whether this conclusion is maintained when we introduce uncertainty about the transmission mechanisms.

[5]See Annex A for further results on this comparison.

[6]The properties of the mean operator imply that $\sum_{i=1}^{i=N} \mu_i \cdot \left(U_i^g - U_E^g\right) = 0$.

3.1 Uncertainty at different levels of aggregation

The latter question is addressed in the model in the following way. Let suppose that the creation of the monetary Union modifies the Phillips relationship between national variables so that the coefficient a_i can no more be known with certainty by the authorities in charge of the common monetary policy but must be considered as a random variable.

In order to account for this change in regime and to distinguish from non-random variables in the model, we redefine the national Phillips curve slope parameter of country i as $\widetilde{a}_i$:

$$U_i = U_i^* - \widetilde{a}_i \cdot (\pi - \pi^e) + \varepsilon \tag{9}$$

We thus obtain N random variables which, to simplify the analysis, we suppose to be identically and independently distributed with:

$$\begin{aligned} E_a(\widetilde{a}_i) &= a_i, \quad \forall i = 1, ..., N \\ cov_a(\widetilde{a}_i, \widetilde{a}_j) &= \begin{cases} 0 & \text{if } i \neq j \\ \sigma_a^2 & \text{if } i = j \end{cases} \quad i, j = 1, ..., N \end{aligned}$$

where the subscript a refers to the common (marginal) distribution law of the system of the N random variables[7]. Furthermore we suppose that $\widetilde{a}_i$ and ε are not correlated (for all i)

By applying the aggregation rule on the transmission parameters, we are able to characterise the statistical properties of the Union-wide transmission coefficient (which thereby becomes a random variable), $\widetilde{a}_E \equiv \sum_1^N \mu_i \cdot \widetilde{a}_i$. Indeed, we obtain[8]:

$$\begin{aligned} E_a(\widetilde{a}_E) &= a_E \\ var_a(\widetilde{a}_E) &= \sigma_a^2 \cdot \left(\sum_{i=1}^{i=N} \mu_i^2 \right) \\ &\equiv \sigma_{a_E}^2 \end{aligned}$$

Finally, the welfare criterium has to be adjusted to take the presence of uncertainty into account: it is thus based on the expectation of a weighted average of the national loss functions, with respect to both the distribution of

[7] Assuming that the covariances between the $\widetilde{a}_i$ would not be equal to zero (and thus that some of the transmission mechanisms would be linked), would not change the results qualitatively. See why in Annex B.

[8] It is interesting to note thus that, in such a model, it is not possible to introduce parameter uncertainty at the Union level without taking it into account at the national level. Such an assumption would violate the aggregation principle. It would be possible to consider this distinction if the Phillips relationships were not linear. But in this case, solutions would be hardly tractable (see Bean (1997)).

the error term and the random coefficient (which we assume to be independent). Thus we use in the following, $\widetilde{W} \equiv E_{\varepsilon,a}\left[\sum_{i=1}^{i=N}\mu_i \cdot L_i\right]$.

1- Let look, first, at the Union-wide strategy (euro-aggregation). In an uncertain setting, the Central Bank considers the expected value of the loss function defined in terms of the Union-wide variables with respect to the distribution of $\widetilde{a}_E$. This reflects the assumption that the authorities manage optimally the uncertain effects of the policy they intend to design. Thus, the monetary authorities seek $\widetilde{\pi}^{EA}$ such as:

$$\widetilde{\pi}^{EA} = \arg\min_{\pi} E_{a_E}\left[\Lambda^{EA}\right]$$

subject to the constraint:

$$U_E = U_E^* - \widetilde{a}_E \cdot (\pi - \pi^e) + \varepsilon$$

and π^e and ε taken as given.

Solving this program leads to:

$$\begin{aligned} \widetilde{\pi}^{EA} &= \frac{ba_E}{1 + ba_E^2 + b\sigma_{a_E}^2}\varepsilon \\ &= \widetilde{\Omega}_{EA} \cdot \varepsilon \end{aligned}$$

with $\widetilde{\Omega}_{EA} \equiv \dfrac{ba_E}{1 + ba_E^2 + b\sigma_{a_E}^2}$.

To find out the value of the unemployment gap prevailing in country i, we have to substitute for the equilibrium values of π and π^e in the random, national Phillips curve equation (9). We obtain:

$$\widetilde{U}_i^{EA} = U_i^* + \left(1 - \widetilde{\Omega}_{EA} \cdot \widetilde{a}_i\right) \cdot \varepsilon$$

After the relevant substitutions, the expected value of the welfare loss function (with respect to both the distribution of ε and $\widetilde{a}_i$), obtains as follows:

$$\widetilde{W}^{EA} = \left[\left(\widetilde{\Omega}_{EA}\right)^2 \left(1 + b \cdot \sigma_a^2\right) + b \cdot \sum_{i=1}^{i=N} \mu_i \left(1 - \widetilde{\Omega}_{EA} \cdot a_i\right)^2\right] \cdot \sigma_\varepsilon^2$$

2- We now analyse the national aggregation strategy in an uncertain context. In this framework, the Central Bank takes uncertainty into account by considering the expected value of the weighted average of the national loss functions with respect to the common distribution law of the $\widetilde{a}_i$. Thus, the monetary authorities seek $\widetilde{\pi}^{NA}$ such as:

$$\widetilde{\pi}^{NA} = \arg\min_{\pi} E_a \left[\Lambda^{NA}\right]$$

subject to the constraint of the N national ("random") Phillips relationships:

$$U_i = U_i^* - \widetilde{a}_i \cdot (\pi - \pi^e) + \varepsilon_i = 1, 2, ..., N$$

and π^e and ε taken as given.

The optimal inflation rate is given by:

$$\begin{aligned} \widetilde{\pi}^{NA} &= \frac{ba_E}{1 + ba_E^2 + b\theta_{a_E}^2 + b\sigma_a^2}\varepsilon \\ &= \widetilde{\Omega}_{NA} \cdot \varepsilon \end{aligned}$$

with $\widetilde{\Omega}_{NA} \equiv \dfrac{ba_E}{1 + ba_E^2 + b\theta_{a_E}^2 + b\sigma_a^2}$ and $\theta_{a_E}^2$ still defined as $\sum_1^N \mu_i \cdot (a_i - a_E)^2$.

This leads to the following equilibrium unemployment and welfare loss :

$$\begin{aligned} \widetilde{U}_i^{NA} &= U_i^* + \left(1 - \widetilde{\Omega}_{NA} \cdot \widetilde{a}_i\right) \cdot \varepsilon \\ \widetilde{W}^{NA} &= \left[\left(\widetilde{\Omega}_{NA}\right)^2 \left(1 + b \cdot \sigma_a^2\right) + b \cdot \sum_{i=1}^{i=N} \mu_i \left(1 - \widetilde{\Omega}_{NA} \cdot a_i\right)^2\right] \cdot \sigma_\varepsilon^2 \end{aligned}$$

Whatever the strategy followed by the common central bank (euro *versus* national aggregation), the introduction of uncertainty in the model has two effects.

- First, the uncertainty in the transmission process (measured by σ_a^2) has an ambiguous effect on welfare (either considered from the viewpoint of $\widetilde{W}^{NA}$ or $\widetilde{W}^{EA}$). On the one hand, it increases welfare through the presence of the term $b\sigma_a^2$ in the loss function. On the other hand it affects welfare negatively because $\widetilde{\Omega}_{EA}$ (or $\widetilde{\Omega}_{NA}$) depends negatively on σ_a^2. Thus, the net impact of transmission uncertainty on welfare depends on the relative strength of these two effects. This result is in accordance with the literature (see Letterie (1997)) and allows for looking at the optimal level of uncertainty with respect to welfare.

- We also find that $\widetilde{\Omega}_{EA} < \Omega_{EA}$ and $\widetilde{\Omega}_{NA} < \Omega_{NA}$. This means that in the case of transmission uncertainty the optimal inflation rate is less sensitive to shocks than in the absence of uncertainty. This reflects the so-called *brainardian principle* according to which the monetary authorities refrain from counteracting shocks too much if they know that such an intervention will add to the variability in the economy because of its random effectiveness. This smoothing effect prevails in the model, whatever the strategy followed by the monetary authorities.

3.2 Does uncertainty reinforce the case for a national perspective?

We are now ready to assess how the presence of uncertainty may impinge on the choice between the two strategies we have envisaged so far.

1- We first compare how transmission uncertainty affects the optimal inflation rate under the two strategies.

Our main finding is that *transmission uncertainty has a stronger impact on the optimal inflation rate in the case of national aggregation than in the case of euro aggregation.*

Proof: $\left(\widetilde{\pi}^{EA}\right) - \left(\widetilde{\pi}^{NA}\right) > \left(\pi^{EA}\right) - \left(\pi^{NA}\right)$. This differential effect results from the fact that $\sigma_a^2 \geq \sigma_{a_E}^2$ (what is in turn implied by the aggregation rule as $\sum_{i=1}^{i=N} \mu_i^2 \leq 1$).

As a consequence, when uncertainty prevails, the impact of a shock on the optimal inflation rate is reduced more when the authorities follow a national aggregation procedure than when they use euro-aggregation (relative to the no uncertainty case). Thus transmission uncertainty makes the central bank more cautious under national than under euro aggregation. This result prevails even if the random national Phillips slope parameters are correlated (see Annex B).

The different results concerning the inflation rate may be summarized by the following inequality chain (for a positive value of the common shock):

$$\widetilde{\pi}^{NA} < \left(\widetilde{\pi}^{EA} <?> \pi^{NA}\right) < \pi^{EA}$$

2- Second we compare the welfare losses associated with the two strategies.

Again, *this comparison favors the national aggregation procedure.*

Proof, let us define the differential loss as $\Delta\widetilde{W} \equiv \frac{1}{\sigma_\varepsilon^2}\left(\widetilde{W}^{EA} - \widetilde{W}^{NA}\right)$. After substituting, we obtain,

$$\Delta\widetilde{W} = \left(1+b\sigma_a^2\right)\cdot\left[\left(\widetilde{\Omega}_{EA}\right)^2-\left(\widetilde{\Omega}_{NA}\right)^2\right] + b\cdot\sum_{i=1}^{i=N}\mu_i\cdot\left[\left(1-\widetilde{\Omega}_{EA}\cdot a_i\right)^2-\left(1-\widetilde{\Omega}_{NA}\cdot a_i\right)^2\right]$$

which simplifies to:

$$\Delta\widetilde{W} = \left[\left(\widetilde{\Omega}_{EA}\right)-\left(\widetilde{\Omega}_{NA}\right)\right]\cdot\widetilde{\Omega}_{EA}\cdot b\cdot\left[\theta_{a_E}^2+\left(\sigma_a^2-\sigma_{a_E}^2\right)\right]$$

This expression is unambiguously positive as $\left(\widetilde{\Omega}_{EA}\right)-\left(\widetilde{\Omega}_{NA}\right)>0$ and $\left(\sigma_a^2-\sigma_{a_E}^2\right)>0$.

Compared to the certainty case (see equation(7)) the impact of uncertainty on the welfare loss operates at two levels:

- On the one hand, it affects the value of the reaction coefficient ($\widetilde{\Omega}_{NA}$ and $\widetilde{\Omega}_{EA}$) such that we have $\left(\widetilde{\Omega}_{EA}\right)-\left(\widetilde{\Omega}_{NA}\right)>(\Omega_{EA})-(\Omega_{NA})$
- On the other hand, it acts also in an additive way, through the difference between the variances of the Phillips curve slope parameters, $\left(\sigma_a^2-\sigma_{a_E}^2\right)$ which is positive.

These two effects increase the loss from using euro aggregation relative to the loss from using national aggregation. From the foregoing, we conclude that transmission uncertainty reinforces the result that in the presence of asymmetries in the transmission process the monetary authorities should use a national aggregation procedure rather than follow a euro aggregation strategy.

4 Conclusion

The design of monetary policies in a monetary union is particularly challenging. One such challenge arises from the fact that the member countries have maintained many of their idiosyncrasies. These have the effect of creating asymmetries in the transmission of common shocks. In this paper we confirmed that when asymmetries in the transmission exist, the common central bank can improve the quality of monetary policy making by using national information about inflation and the output gap, instead of focusing only on the union-wide aggregates.

The main contribution of this paper consists in analysing whether this conclusion holds when the authorities face uncertainty about these different national transmission processes. We found that this uncertainty *reinforces* the need to use national data on inflation and output gaps. The insistence of the ECB to use only union-wide aggregated information about these variables is therefore likely to be suboptimal.

5 References

Bean C. (1997), "The convex Phillips curve and macroeconomic policymaking under uncertainty", *manuscript*, London School of Economics, September

De Grauwe P. (2000), "Monetary policies in the presence of asymmetries", *Journal of Common Market Studies*, vol. **38** (4), November, p. 593-612.

Dornbusch R., Favero C. and F. Giavazzi (1998), "Immediate challenges for the European Central Bank", *Economic Policy*, **26**, April, p. 15-52.

European Central Bank (2001), "Monetary policy-making under uncertainty", *Monthly Bulletin*, January, p 43-55.

Gros D. and C. Hefeker (2002), "One size must fit all: national divergences in a monetary union", *German Economy Review*, vol. **3** (3), August, p 1-16.

Heinemann, F., and Hüfner, F., (2002), "Is the View from the Eurotower Purely European? National Divergence and ECB Interest Rate Policy", *Discussion Paper*, Centre for European Economic Research, University of Mannheim, N°$02-69$, October.

Letterie W. (1997), "Better monetary control may decrease the distortion of stabilisation policy: a comment", *Scandinavian Journal of Economics*, vol. **99** (3), September, p. $463-470$

Meade E. and N. Sheets (2002), "Regional influences on U.S. monetary policy: some implications for Europe", *International Finance Discussion Papers*, Board of Governors of the Federal Reserve System, N°721, February.

Mihov I. (2001), "One monetary policy in EMU: monetary policy implementation and transmission in the European Monetary Union", *Economic Policy*, **33**, October, p. 371-406

Peersman G. and F. Smets (1999), "The Taylor rule: a useful monetary benchmark for the euro area?", *International Finance*, vol. **2** (1), April, p. $85-116$.

Söderström U. (1999),"Monetary Policy under Uncertainty."*Ph.D. Dissertation*, Stockholm School of Economics.

6 Annexes

6.1 Annex A: loss comparison in the absence of uncertainty

As seen p.8, the comparison of the losses favors the choice of a national aggregation perspective with respect to one relying on a Union-wide strategy (see equation (8)). This result comes from two effects appearing in equation (6) and which may play in opposite directions:

- First, the Euro-aggregation strategy implies a higher volatility in the inflation rate ($\Omega_{EA} \geq \Omega_{NA}$). Indeed, under this strategy, the Central Bank does not take the heterogenous structures of national transmission mechanisms in the Union into account which would otherwise play as an incentive to lessen the sensitivity of the optimal inflation rate to the supply shock. This result obtains whether or not the weight on output stabilisation in the loss function is more than one.
- The term $\sum_{i=1}^{i=N} \mu_i \cdot \left[(1-\Omega_{EA} \cdot a_i)^2 - (1-\Omega_{NA} \cdot a_i)^2 \right]$ in equation (6) can be positive or negative. It can be shown (see *infra*) that, in the case where the asymmetry in the transmission $\left(\theta_{a_E}^2\right)$ is large enough and the output weight (b) in the loss function not too small, this term is positive. In that case the national aggregation procedure contributes to reduce the unemployment variability relative to the euro-aggregation strategy[9].

To go further on the last result, let define the differential welfare loss from the viewpoint of unemployment variability associated with a Union-wide aggregation strategy as ΔW^{UN}.

$$\Delta W^{UN} \equiv \left(\sum_{i=1}^{i=N} \mu_i \cdot \left[(1-\Omega_{EA} \cdot a_i)^2 - (1-\Omega_{NA} \cdot a_i)^2 \right] \right)$$

If ΔW^{UN} is negative, such a procedure has to be favored. We may rewrite ΔW^{UN} as:

$$\begin{aligned} & (\Omega_{NA} - \Omega_{EA}) \cdot \left[2a_E - \overline{a_E^2} \cdot (\Omega_{EA} + \Omega_{NA}) \right] \\ = \; & (\Omega_{NA} - \Omega_{EA}) \cdot \frac{2a_E}{\left(1 + b\overline{a_E^2}\right)\left(1 + ba_E^2\right)} \cdot \left[1 + ba_E^2 - \frac{b^2}{2} \overline{a_E^2} \theta_{a_E}^2 \right] \end{aligned}$$

As $(\Omega_{NA} - \Omega_{EA})$ is negative, the differential loss will be negative if and only if $\left[1 + ba_E^2 - \frac{b^2}{2} \overline{a_E^2} \theta_{a_E}^2 \right]$ is positive.

$\left[1 + ba_E^2 - \frac{b^2}{2} \overline{a_E^2} \theta_{a_E}^2 \right]$ may be defined in turn as a function of b. Indeed we have:

$$P(b) = -\frac{b^2}{2} \cdot \overline{a_E^2} \cdot \theta_{a_E}^2 + ba_E^2 + 1$$

As the discriminant $\left(\Delta \equiv \left(a_E^2\right)^2 + 2 \cdot \overline{a_E^2} \cdot \theta_{a_E}^2 \right)$ is positive, this second order polynomial has two roots

[9]In that case, the two effects play in the same direction which favors the national aggregation procedure

$$\Delta_1 = \frac{a_E^2 + \sqrt{\Delta}}{a_E^2 \cdot \theta_{a_E}^2} > 0$$
$$\Delta_2 = \frac{a_E^2 - \sqrt{\Delta}}{a_E^2 \cdot \theta_{a_E}^2} < 0$$

Thus, $P(b)$ will be positive if and only if $b \in [0\ ;\ \Delta_1]$ as b can only take positive values.

At this stage, the question is to know how Δ_1 behaves when $\theta_{a_E}^2$ varies.

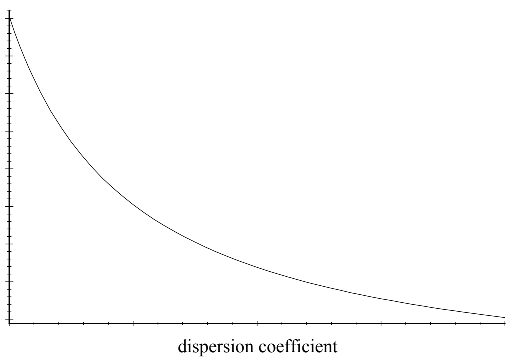
We have:

$$\lim_{\theta_{a_E}^2 \to 0^+} \Delta_1\left(\theta_{a_E}^2\right) = +\infty$$
$$\lim_{\theta_{a_E}^2 \to +\infty} \Delta_1\left(\theta_{a_E}^2\right) = 0$$

By the way, for $\theta_{a_E}^2$ and a_E^2 strictly positive, $\Delta_1\left(\theta_{a_E}^2\right)$ may be re-written as:

$$\Delta_1\left(\theta_{a_E}^2\right) = \frac{1 + \sqrt{1 + \frac{2\cdot\theta_{a_E}^2}{a_E^2} \cdot \left(1 + \frac{\theta_{a_E}^2}{a_E^2}\right)}}{\theta_{a_E}^2 \left(1 + \frac{\theta_{a_E}^2}{a_E^2}\right)}$$

From this expression we conclude that $\frac{\partial \Delta_1\left(\theta_{a_E}^2\right)}{\partial \theta_{a_E}^2} < 0$. Thus, $\Delta_1\left(\theta_{a_E}^2\right)$ is an hyperbolic, monotonically decreasing function of $\theta_{a_E}^2$.



Thus, for small values of $\theta_{a_E}^2$, $P(b)$ will be positive whatever the value of b. In this case, the (EA) strategy has to be favored. In the opposite case, when

$\theta^2_{a_E}$ takes relatively large values, the interval on which $P(b)$ will be positive is of small magnitude. It is then possible that for relatively large values of b, the (NA) strategy delivers a smaller (aggregate) volatility of unemployment than the (EA) procedure.

6.2 Annex B: correlated Phillips curve slopes

Suppose that the distribution of the $\widetilde{a}_i$ has the following properties:

$$\begin{aligned} E_a(\widetilde{a}_i) &= a_i, \quad \forall i = 1, ..., N \\ cov_a(\widetilde{a}_i, \widetilde{a}_j) &= \begin{cases} \rho_{ij} & \text{if } i \neq j \\ \sigma_a^2 & \text{if } i = j \end{cases} \quad i, j = 1, ..., N \end{aligned}$$

It ensues that the variance of $\widetilde{a}_E$ is now given by:

$$\begin{aligned} var_a(\widetilde{a}_E) &= \sigma_a^2 \cdot \left(\sum_{i=1}^{i=N} \mu_i^2 \right) + 2 \cdot \sum_{i \neq j} \mu_i \mu_j \rho_{ij} \\ &\equiv \sigma^{*2}_{a_E} \end{aligned}$$

The results obtained in the paper would be modified (qualitatively) by these new assumptions if $\sigma^{*2}_{a_E} > \sigma_a^2$. But, as we will see, this is not the case.

Proof: let rewrite ρ_{ij} in terms of the correlation coefficient r_{ij}: $\rho_{ij} = r_{ij}.\sqrt{var(\widetilde{a}_i).var(\widetilde{a}_j)}$, that is, $\rho_{ij} = r_{ij} \cdot \sigma_a^2$. Moreover, we know that: $-1 \leq r_{ij} \leq 1$. Thus we may write:

$$\sigma^{*2}_{a_E} \leq \sigma_a^2 \cdot \left[\sum_{i=1}^{i=N} \mu_i^2 + 2 \cdot \sum_{i \neq j} \mu_i \mu_j \right]$$

which is equivalent to:

$$\sigma^{*2}_{a_E} \leq \sigma_a^2 \cdot \left(\sum_{i=1}^{i=N} \mu_i \right)^2$$

But $\sum_{i=1}^{i=N} \mu_i = 1$. Therefore,

$$\sigma^{*2}_{a_E} \leq \sigma_a^2$$

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