Monetary Policy in a Monetary Union: What Role for Regional Information?*

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Can the central bank of a monetary union, whose objectives are exclusively defined in terms of union-wide variables, improve its performance by reacting to regional variables rather than to union-wide variables only? Our answer is not clear-cut. We find the improvement to be large when we use a backward-looking model of the economy and negligible when we use a hybrid model. The main determinant of this finding seems to be the different degree of inertia (or its opposite, the forward-lookingness) characterizing the two models, rather than other model features.

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1. Introduction

The launch of the euro in January 1999 has rekindled an interest in monetary unions. Several papers have focused on the issue of regional heterogeneity and its implications for monetary policy. For the euro area, relevant differences have often been detected in the reactivity of key national macro variables to monetary policy (Angeloni, Kashyap, and Mojon 2003). Even in long-established

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monetary unions such as the United States, significant regional heterogeneity in the transmission of monetary policy has been documented (see, e.g., Carlino and DeFina 1998, 1999; Meade and Sheets 2002; and Owyang and Wall 2003).

In spite of this, little attention has thus far been devoted to the implications of regional heterogeneity for the conduct of monetary policy. The recent literature on monetary policy rules has focused on a large number of factors potentially affecting the design of policy, including the uncertainty on the structure or the parameters of the model, the presence of measurement errors in variables, the impact of data revisions, and the features of the reaction function (should simple rules be preferred to fully optimal ones? should the central bank react to current or expected inflation? should it react to the exchange rate?). A necessarily incomplete list of recent contributions dealing with these themes includes Peersman and Smets (1999), Taylor (1999a, 1999b), Orphanides (2001), Rudebusch (2001, 2002), Levin, Wieland, and Williams (2003), and Lubik and Schorfheide (2007). However, with a few notable exceptions, which we discuss below, the potential role of regional disaggregation is neglected.

Thus, the typical policy rule includes only union-wide variables among its arguments. Yet the presence of heterogeneity in a monetary union implies that indicators pertaining to the constituent regions should appear among the state variables of the model representing the economy of the union, and hence in the policy rule, by standard optimal control arguments, even when the central bank is exclusively interested in union-wide developments. In other words, the fact that the *objectives* of policy (the loss function) are defined exclusively in terms of union-wide variables does not imply that the *decision-making process* (the policy rule) should also rely exclusively on union-wide variables. While obvious, this distinction is often overlooked.[1]

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[1]The European Central Bank (ECB) has repeatedly argued in the past that to pursue area-wide objectives—as unambiguously required by the Maastricht Treaty and the ECB Statute—only area-wide economic developments mattered (see, e.g., President Duisenberg's statement during the press conference of September 9, 1999: "Our decisions today, again and as always, were based on a euro area-wide analysis of economic and financial developments—and nothing else"). More recently, however, ECB officials have increasingly stressed that national

There is, thus, a surprising gap between the widespread recognition of significant heterogeneities within important monetary unions and their virtual neglect in the design of monetary policy. The present paper addresses this issue. Specifically, we ask whether and to what extent the monetary authority of a currency union, exclusively interested in union-wide variables, should react to regional economic developments within the union.

We address this issue, adopting the linear quadratic framework commonly used in the literature on policy rules, and provide some answers for the euro area. We first estimate a simple multicountry model of the three main national economies of the area—France, Germany, and Italy. The model, in line with much of the existing literature, suggests that statistically significant differences among these economies do exist. Next, to assess whether these differences are of practical relevance to the policymaker, we compute optimal Taylor-type simple rules that minimize the policymaker's loss function under the constraint provided by the model. We focus on two classes of simple rules: one allows the policy rate to react to region-specific variables; in the other, the arguments are union-wide variables only. We compare the minimized loss under the two alternative rules, interpreting the difference as the cost of neglecting the heterogeneities inside the union. As the loss function depends on the unconditional variances of union-wide inflation and output gap, this difference can be viewed as a clear, policy-oriented metric to decide whether regional heterogeneities deserve practical consideration. This metric can usefully complement a statistical approach at assessing the relevance of heterogeneities, such as that proposed in the literature on aggregation (see, e.g., Pesaran, Pierse, and Kumar 1989 and Marcellino, Stock, and Watson 2003).

We focus on the euro area and on its component countries mainly because national differences in the economic structures (as well as in language, culture, institutional features, and legal systems) are at present pronounced, and idiosyncratic shocks are still likely to have a relatively important role. One may therefore conjecture that the

information is instrumental in gaining a better assessment of euro-area developments (see, e.g., the remarks by Otmar Issing, former member of the Executive Board, at the ECB workshop "Monetary Policy Implications of Heterogeneity in a Currency Area," Frankfurt, December 13–14, 2004).

potential loss associated with the neglect of country-specific information might be large. However, our approach has a wider methodological import. The above questions seem relevant, at least in principle, for the United States and for other monetary unions, such as Canada and China, where regional differences appear to be major.

Our main result is twofold. On the one hand, the loss reduction that can be attained when policy is allowed to react to regional variables can be large, and therefore the issue is potentially relevant. On the other hand, the size of the loss reduction is heavily dependent on the model of the area adopted. Specifically, using an estimated backward-looking model, we find that the loss reduction typically exceeds 30 percent, reflecting a similarly sized decline in inflation and output-gap variability. By contrast, when we replicate the analysis using an estimated hybrid model, featuring backward- as well as forward-looking components, we find that the gain associated with the use of regional information is almost negligible. A sensitivity analysis suggests that most of the difference in the results can be traced back to the degree of forward-lookingness of the model. Unfortunately, this is precisely the feature that seems most difficult to pin down empirically with a reasonable degree of confidence (see the papers collected in the September 2005 issue of the *Journal of Monetary Economics*, which we briefly discuss below).

A few recent papers deal with the role of regional variables in a monetary union. Using a two-region dynamic stochastic general equilibrium (DSGE) model, Benigno (2004) shows that the central bank should target an average price indicator in which the weight assigned to each region is proportional to its degree of price stickiness. Lombardo (2006) extends this analysis to the role of unequal degrees of competition. Our paper can be viewed as complementary to these studies, as it explores a similar issue using a completely different approach. The methodology in De Grauwe (2000), De Grauwe and Piskorski (2001), Aksoy, De Grauwe, and Dewachter (2002), and, to some extent, Wyplosz (1999) is similar to ours. However, these works associate the use of information on the individual countries with the (undue) nationalistic attitude of the Governing Council members, which implies loss functions defined over national variables. Their primary focus is therefore on the decision procedures within the ECB Governing Council rather than on the optimal use of regional information. Monteforte and Siviero (2008) define both the central bank's objective and policy rule over area-wide aggregates, and compute two alternative optimal rules under the constraint provided by either an area-wide or a multicountry model. Their main focus is on the consequences of following aggregate and disaggregate modeling strategies. Jondeau and Sahuc (2008) analyze the same issue but also address our main question using a DSGE model. Brissimis and Skotida (2007) compare the results achieved by the monetary policymaker using a disaggregate model and policy rule versus those attainable with an aggregate model and rule.

The organization of the paper is as follows. Section 2 describes the basic setup of our exercises. Section 3 illustrates the simple euro-area multicountry models used in the analysis—a fully backward-looking and a hybrid backward-forward-looking version. Section 4 reports the main results. Section 5 concludes.

2. Design of Experiments

In the standard optimal control of a linear system under a quadratic loss function, the solution of a matrix Riccati equation yields an optimal policy rule whose arguments are all the state variables of the system. Most of the recent literature on optimal monetary policy focuses instead on simple optimal policy rules, obtained by imposing some constraint on the functional form of the optimal rule, e.g., reducing the number of (lagged) variables appearing among its arguments. The underlying idea is to weigh the underperformance of the simple rules against their simplicity, which can make them easier to use for the monetary authorities and a more useful tool for communication with the public. Furthermore, simple rules may be more robust, as compared with more model-dependent optimal rules, thus implying a trade-off between performance in the context of a specific model and robustness.

The analytical framework adopted in the present paper is borrowed from that literature. However, we are not interested in the functional form of the policy rules, nor in their robustness as such. Rather, we focus on comparing the performance of rules that include national variables among their arguments *vis-à-vis* rules that only react to area-wide variables. We restrict our attention to Taylor-type rules, in which only contemporaneous inflation and output gap appear among the arguments, along with a lagged interest rate term.[2] The first rule we consider, which we dub the multicountry information-based rule (MCIBR), has the following form:

$$i_t = \alpha_M^G \pi_t^G + \alpha_M^F \pi_t^F + \alpha_M^I \pi_t^I + \beta_M^G y_t^G + \beta_M^F y_t^F + \beta_M^I y_t^I + \rho_M i_{t-1}, \quad (1)$$

where y denotes the output gap, π denotes annualized quarter-on-quarter inflation, i denotes a policy interest rate, and α_M^j, β_M^j, and ρ_M are coefficients to be determined. Superscripts $j = G, F, I$ stand, respectively, for Germany, France, and Italy, the three economies in the simple multicountry models of the euro area presented in section 3. The second rule, dubbed the area-wide information-based rule (AWIBR), is of the type

$$i_t = \alpha_A \pi_t + \beta_A y_t + \rho_A i_{t-1}, \quad (2)$$

where π_t and y_t are area-wide variables and α_A, β_A, and ρ_A are coefficients to be determined. Following the methodology adopted by Eurostat, we compute area-wide variables as $\pi_t = \sum_j w_\pi^j \pi_t^j$ and $y_t = \sum_j w_y^j y_t^j$, $j = G, F, I$, where w_x^j, $x = \pi, y$ represent the appropriate country weights.[3] In the case of the AWIBR, the policymaker is assumed to react to area-wide inflation and output gap only; in other words, the AWIBR constrains policy to depend on national variables with coefficients proportional to country weights. In the case of the MCIBR, instead, the parameters on the individual countries' inflation and output gap do not obey any proportionality constraint. The restriction imposed on the area-wide rule could be interpreted as a "political economy" constraint: to avoid the suspicion that country-specific concerns may affect its choices for the area, the monetary authority ties its own hands and decides not to react to country variables separately, but only to their aggregation.

[2] One advantage of reaction functions of this family, besides their simplicity, is that they have been shown to have good global stabilization properties (Benhabib, Schmitt-Grohé, and Uribe 2003).

[3] Specifically, w_y^j are 1999 GDP weights and w_π^j are 1999 consumer spending weights (under purchasing power parity). The weights are as follows: Germany: 0.43, 0.44; France: 0.29, 0.27; Italy: 0.28, 0.29.

To assess the performance of these rules, we adopt a standard quadratic, time-separable specification for the policymaker's loss function:

$$L_t = (1-\delta)E_t \sum_{\tau=0}^{\infty} \delta^{\tau} \left[\pi_{t+\tau}^2 + \lambda y_{t+\tau}^2 + \mu(\Delta i_{t+\tau})^2\right], \qquad (3)$$

where δ is a discount factor, and λ and μ are parameters that reflect the weights attached by the policymaker to the variability of the output gap and of the policy interest rate changes relative to the variability of inflation around a target, assumed to be zero for simplicity. Note that both inflation and the output gap are area-wide variables, in line with the basic tenet that the monetary policy authority is solely interested in area-wide developments.

For $\delta \longrightarrow 1$ the intertemporal loss function can be interpreted as the unconditional mean of the period loss functions, which in turn is given by the weighted sum of the unconditional variances of the target variables (see Rudebusch and Svensson 1999):

$$L_t = \text{var}(\pi_t) + \lambda \text{var}(y_t) + \mu \text{var}(\Delta i_t). \qquad (4)$$

The optimal AWIBR (MCIBR) is found by searching for values of the three parameters in (2) (the seven parameters in (1)) that minimize the loss function (4) subject to the constraints given by the estimated multicountry models described in the next section. As a benchmark, we also compute the fully optimal rule (FOR), i.e., the rule derived from the unconstrained solution to the dynamic problem of minimizing (4) subject to the model economy, which depends on all state variables of the models.

3. Two Simple Models

In this section we present the two main models that we use throughout the paper. Both consist of an aggregate supply (AS) equation or Phillips curve and an aggregate demand (AD) equation or IS curve for each of the three main economies in the euro area—Germany, France, and Italy—which jointly account for over 70 percent of the area GDP. The first is a backward-looking model, popularized by Rudebusch and Svensson (1999) and Rudebusch (2002). It displays remarkable parameter stability and tracks the data well; furthermore, it is simple to estimate and use. However, its theoretical grounding is weak. The second model, presented in section 3.2, features backward- as well as forward-looking right-hand-side variables. It belongs to a class of models that has become increasingly popular, as the models tend to fit the data better than the purely forward-looking version initially suggested by the theoretical New Keynesian literature (see Goodfriend and King 1997, Rotemberg and Woodford 1997, and Clarida, Galí, and Gertler 1999) and can at the same time be reconciled with theory.[4] However, these models have two main drawbacks. First, the estimated parameters tend to be fragile: as we document below, our model is very sensitive to the choice of the sample period. Second, the quantitative importance of forward-looking elements, which turns out to be crucial for our results, is particularly hard to pin down with precision. Indeed, this issue is the subject of an ongoing debate. Among the latest contributions, Galí, Gertler, and López-Salido (2005) and Sbordone (2005) argue that forward-looking behavior is dominant, whereas others, including Lindé (2005) and Rudd and Whelan (2005a, 2005b), criticize this viewpoint. All these authors concur that the estimation of the degree of forward-lookingness of the economy is fraught with econometric difficulties, especially in the context of a relatively large system of equations.

In our view, these reasons warrant an assessment of the sensitivity of our results to the model choice.

The models were estimated with quarterly data over the period 1978:Q1–2004:Q4. Inflation is measured as the quarter-on-quarter rate of change of the households' consumption deflator. Potential output was estimated by applying the band-pass filter (Baxter and King 1999) to the (log) real GDP for each country.

[4] Galí and Gertler (1999) show that a hybrid model for inflation can be derived under the assumption that a fraction of firms act as backward-looking price setters. Smets and Wouters (2003) and Christiano, Eichenbaum, and Evans (2005) show that lagged inflation and output terms may appear in the model as the result of Calvo-pricing firms with indexation to last-period inflation and habit persistence in consumers' behavior.

3.1 Backward-Looking Model

We started from a general specification involving up to six lags of each variable on the right-hand side of each equation. After eliminating statistically insignificant terms, the following specification was selected (standard errors are given in parentheses below each coefficient):[5]

$$
\begin{aligned}
\pi_t^G &= \underset{(.086)}{0.29}\,\pi_{t-1}^G + \underset{(.066)}{0.58}\,\pi_{t-4}^G + \underset{(.132)}{0.36}\,y_{t-1}^G + \underset{(restr.)}{0.13}\,\pi_t^F + \varepsilon_{\pi t}^G \\
y_t^G &= \underset{(.058)}{0.77}\,y_{t-1}^G - \underset{(.034)}{0.08}\,(i_{t-2} - \pi_{t-2}^G) + \varepsilon_{yt}^G \\
\pi_t^F &= \underset{(.049)}{0.92}\,\pi_{t-1}^F + \underset{(.168)}{0.32}\,\frac{1}{4}\sum_{i=2}^{5} y_{t-i}^F + \underset{(restr.)}{0.08}\,\pi_t^G + \varepsilon_{\pi t}^F \qquad (5)\\
y_t^F &= \underset{(.047)}{0.86}\,y_{t-1}^F - \underset{(.015)}{0.04}\,(i_{t-2} - \pi_{t-2}^F) + \varepsilon_{yt}^F \\
\pi_t^I &= \underset{(.010)}{0.96}\,\pi_{t-1}^I + \underset{(.108)}{0.24}\,y_t^I + \underset{(restr.)}{0.04}\,\pi_t^G + \varepsilon_{\pi t}^I \\
y_t^I &= \underset{(.065)}{0.70}\,y_{t-1}^I + \underset{(.067)}{0.11}\,y_t^G - \underset{(.014)}{0.03}\,(i_{t-1} - \pi_{t-i}^I) + \varepsilon_{yt}^I,
\end{aligned}
$$

where ε_k^j $(j = G, F, I; k = \pi, y)$ are serially uncorrelated disturbances. Due to the presence of simultaneous terms, the model was estimated with 3SLS.[6]

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[5] The values of some coefficients were restricted so as to impose long-run verticality of the national Phillips curves. The restriction was tested and accepted in all cases (see Monteforte and Siviero 2008). The adjusted R^2 for the equations are, respectively, 0.49, 0.64, 0.89, 0.78, 0.96, and 0.73.

[6] Constant terms were used in estimation but are not displayed in equations (5), which we use in the optimization exercises. This is in line with the approach followed in similar literature and amounts to interpreting equation systems such as (5) as a description of small deviations from the equilibrium. Since for most of the estimation period the exchange rates among the German, French, and Italian currencies were not fixed, though constrained by the Exchange Rate Mechanism of the European Monetary System, in estimation the inflation "imported" in country j from country i was constructed as the sum of the inflation rate in country i and the percentage variation of the exchange rate between the two countries (lagged values of all variables were used as instruments for the latter). In equations (5), to be used for the experiments presented below, the percentage change of the exchange rate was set identically equal to zero, consistent with the introduction of the single currency as of January 1, 1999.

The main nonstandard ingredient of model (5) is represented by the interactions among the various countries: to capture trade links, we let the inflation and output gap of each country have an effect on the corresponding variables in the other two countries. From a theoretical viewpoint, this choice is grounded in the two-country model of a monetary union in Benigno (2004). He shows that each country's Phillips curve depends, inter alia, on the terms of trade but that, via repeated substitutions, a specification can be obtained in which inflation in one country depends on its own lagged values and on the other country's current and lagged inflation.

The main properties of specification (5), as summarized by the impulse responses obtained by simulating the model augmented with a Taylor-type stabilizing policy rule, are roughly in line with well-established stylized facts about the euro-area economy.[7] The model estimates support the view that a significant degree of heterogeneity exists among the three economies analyzed. This result is in line with some of the most recent literature, although the issue is far from settled.[8] Further, heterogeneities within the euro area do not seem to have faded in recent times. Indeed, model (5) displays remarkable parameter stability: truncating the sample before the start of the monetary union (1978:Q1–1998:Q4) yields negligible changes in the parameter values (see the estimates in Angelini et al. 2002); also, we failed to detect appreciable signs of convergence in the shocks hitting the three economies considered.[9]

[7]In particular, the shocks hitting the AS and AD equations in France tend to have more persistent effects on area-wide inflation than the corresponding shocks hitting the Italian or the German economies; the effects of an AD shock are smallest and less volatile if they originate in Italy, while the effects on the output gap of an AS shock originating in the same country are largest and most volatile. Monetary policy takes longer to affect inflation in France than in either Italy or Germany; the time pattern in the latter two countries is similar, but the effect is markedly more pronounced in Italy.

[8]A large research effort devoted by the Eurosystem to the understanding of the monetary transmission mechanism in the euro area (see Angeloni, Kashyap, and Mojon 2003) shows that significant cross-country differences in the transmission mechanism exist but that alternative methods, data sets, and sample periods yield different, sometimes conflicting results.

[9]We compared the variance-covariance matrix of the model estimated with data up to 1998:Q4 with that of the model estimated with data up to 2004:Q4. The correlation of the shocks rises somewhat in the more recent period. However,

3.2 Hybrid Model

The model was estimated with GMM, using three lags of the variables as instruments. As in the case of the backward-looking model, we started from a general specification, featuring several leads and lags of the variables on the right-hand side, and gradually eliminated nonsignificant terms. The final version of the model is the following:

$$
\begin{aligned}
\pi_t^G &= \underset{(0.140)}{0.59}\, E_t\pi_{t+4}^G + \underset{(0.140)}{0.36}\, \pi_{t-4}^G + \underset{(restr.)}{0.05}\, \pi_t^F + \underset{(0.096)}{0.28}\, y_{t-1}^G + e_{\pi t}^G \\
y_t^G &= \underset{(0.039)}{0.69}\, y_{t-1}^G - \underset{(0.015)}{0.03}\left(i_{t-1} - E_{t-1}\widetilde{\pi}_{t+3}^G\right) + e_{yt}^G \\
\pi_t^F &= \underset{(0.131)}{0.69}\, E_t\pi_{t+3}^F + \underset{(0.125)}{0.27}\, \pi_{t-1}^F + \underset{(restr.)}{0.04}\, \pi_t^G \\
&\quad + \underset{(0.14)}{0.16}\left(\frac{1}{2}\left(y_{t-4}^F + y_{t-5}^F\right)\right) + e_{\pi t}^F \qquad (6) \\
y_t^F &= \underset{(0.036)}{0.83}\, y_{t-1}^F - \underset{(0.012)}{0.03}\left(i_{t-1} - E_{t-1}\widetilde{\pi}_{t+3}^F\right) + e_{yt}^F \\
\pi_t^I &= \underset{(0.196)}{0.49}\, E_t\pi_{t+2}^I + \underset{(0.200)}{0.46}\, \pi_{t-1}^I + \underset{(restr.)}{0.05}\, \pi_t^G \\
&\quad + \underset{(0.14)}{0.28}\left(\frac{1}{2}\left(y_{t-2}^I + y_{t-3}^I\right)\right) + e_{\pi t}^I \\
y_t^I &= \underset{(0.046)}{0.75}\, y_{t-1}^I + \underset{(0.047)}{0.11}\, y_t^G - \underset{(0.11)}{0.03}\left(i_t - E_t\widetilde{\pi}_{t+4}^I\right) + e_{yt}^I,
\end{aligned}
$$

where $\widetilde{\pi}_t^j = (1/4)\sum_{i=0}^3 \pi_{t-i}^j$. Altogether, the model fits the data well.[10] However, whereas the backward-looking model (5) displays remarkable parameter stability over time, the hybrid model estimates turn out to be very sensitive to the choice of the sample period and of the instruments. For instance, if the first two years of data are dropped from the estimation sample, all the real interest rate terms in the aggregate demand equations become insignificant, whereas the size of the output-gap coefficients in the aggregate supply equations declines dramatically (as much as halving for both

using the model estimated on the shorter data set to replicate the experiments conducted in section 4 below yields very similar results.

[10]The adjusted R^2 for the equations are, respectively, 0.48, 0.57, 0.87, 0.70, 0.94, and 0.72. As for model (5), long-run verticality of the national Phillips curves was imposed.

Germany and Italy). We also attempted measuring the output gap with a proxy for real marginal cost (arguably a better measure from a theoretical viewpoint), as proposed by Clarida, Galí, and Gertler (1999). However, such alternative proxy was not found to improve the fit of the model nor the robustness of the estimates.

From a methodological viewpoint, the only difference when using this model instead of model (5) is that the iteration process needed to compute the optimal coefficients of the AWIBR and MCIBR requires an additional step to solve the model (augmented with the policy rule) for the rational-expectation equilibrium.[11]

4. How Large Are the Costs of Overlooking National Information?

In this section we assess the importance of national information using the two models estimated in the previous section.

4.1 Exercises Using the Backward-Looking Model

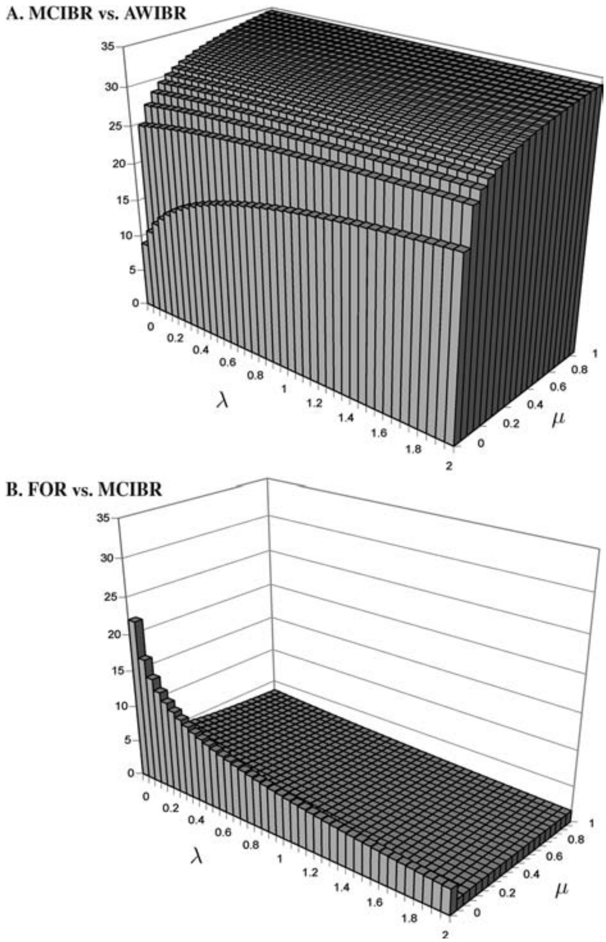
Using model (5), we computed the optimal losses under the optimized AWIBR (equation (2)), the optimized MCIBR (equation (1)), and the fully optimal rule (FOR) for different choices of the weights λ and μ assigned to output-gap and interest rate variability in the loss function (4). Since (2) is a restricted version of (1), the loss under the former is by construction at least as large as under the latter. The issue is, are the welfare gains under the MCIBR large enough to conclude that national information is important?

The results are reported in figure 1. Panel A shows that the answer is positive. Relative to the AWIBR, the MCIBR yields a loss reduction in the 25 to 35 percent range for most combinations of the preference parameters. Only when $\mu = 0$ (i.e., when there is no concern for interest rate variability) does the loss reduction shrink

[11] The solution found corresponds to what Clarida, Galí, and Gertler (1999) call "constrained commitment." It involves a form of commitment, since the central bank follows a rule decided in advance, rather than reoptimizing every period. It is, however, constrained to a class of rules that does not include the "full commitment" solution, which would also require the central bank to react to lagged values of the state variables.

Figure 1. Loss Reduction in the Backward-Looking Model

(in percent)



Note: The figure reports the percentage reduction in the value of the loss function attained under the multicountry information-based rule (MCIBR) relative to the area-wide information-based rule (AWIBR) under the constraint represented by the backward-looking model in section 3.1. The parameters λ and μ reflect the weight attached by the policymaker to the output gap and the interest rate variability, respectively (see equation (3) in the text). Panel A reports the percentage reduction in the value of the loss function attained under the MCIBR relative to the AWIBR. Panel B reports the percentage reduction in the value of the loss function attained under the fully optimal rule (FOR) relative to the MCIBR.

to 10–20 percent, and only when both λ and μ are zero, corresponding to an extreme form of inflation targeting, does it reduce to just below 10 percent. Clearly, in terms of "welfare units" the size of this improvement is arbitrary, as the central bank loss function is only identified up to a positive linear transformation. However, the improvement can be directly interpreted as a summary measure of the reductions of the unconditional variances of inflation, output gap, and interest rate changes. The variance reduction is between 10 and 30 percent for inflation, 20 and 35 percent for the output gap, and 20 and 45 percent for interest rate changes. Summing up, under model (5) the welfare gains associated with the use of national information are undisputedly large. Panel B of the figure shows that the MCIBR does a good job relative to the fully optimal rule. The latter improves upon the former by less than 4 percent on average across the various combinations of the preference parameters (the only sizable improvement occurring when no weight is assigned to interest rate variability).

To check the sensitivity of these results to parameter uncertainty, we ran one-tailed tests of the hypothesis that the average loss associated with the MCIBR and the AWIBR are the same.[12] The tests allow for rejection of the null hypothesis for most combinations of preference parameters, suggesting that the results in figure 1 are fairly robust to parameter uncertainty.

A second issue we explore is, what are the consequences of the adoption of the MCIBR at the country level? Since policy is by construction aimed at minimizing the aggregate loss (4), the adoption of the MCIBR need not yield a Pareto improvement for the three economies comprising our model. Indeed, in our exercises the optimal MCIBR systematically entails, vis-à-vis the optimal AWIBR, a reduction in the national loss function for Germany and

[12] To this end, for each combination of (λ, μ) we extracted one realization from the empirical distribution of the estimated model coefficients and, without recomputing the AWIBR and MCIBR, we simulated the model for 800 periods under either one or the other of the two competing rules. The process was repeated 5,000 times. We then computed (using the last 400 simulated values) the average loss associated with each rule, as well as the corresponding variances and covariances, and applied the standard test for equality of means of normal distributions.

France.[13] By contrast, Italy always fares better under the AWIBR. For instance, when $\lambda = \mu = 1$, Germany and France experience a loss reduction of roughly 40 percent, as opposed to an increase of almost 30 percent for Italy (see panel A of figure 4 in the appendix). We tried to assess how these results are affected by country size, but failed to detect clear patterns, as country size interacts with the specific features of the estimated country structures and shocks.[14] The comparison of the two rules, reported in table 1, also fails to display clear patterns. Overall, the MCIBR seems less aggressive with respect to inflation: the impact coefficient is 0.93, as opposed to 1.24 in the case of the AWIBR. This reflects reactivity that is lower for Italy and for Germany, and equal for France. In the case of the output gap, the MCIBR still underweighs Italy but overweighs France and leaves the German weight unchanged.

Finally, we analyze the issue of convergence. Clearly, if the national economies were identical, the different performance of the two rules would vanish. Therefore, it seems reasonable to conjecture that the potential relevance of regional information for monetary policy would gradually disappear were the regional asymmetries to fade away. As argued in section 3.1, no clear signs of recent convergence among the euro-area economies can yet be detected. However, the possibility of a gradual reduction in asymmetries in the future clearly cannot be ruled out. Therefore, we assess how our results would be affected should more symmetry among the regional economies gradually prevail in the future. Our counterfactual exercises, described in the appendix, provide two main results. First,

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[13] For each of the three economies, the national loss function is defined as in equation (4), except that the inflation and output-gap terms are replaced by their respective national counterparts.

[14] Specifically, we performed the following counterfactual exercises. We gradually increased the size of each country w^j, one at a time, from 1 to 99 percent; correspondingly, the size of the other two countries was reduced from 49.5 to 0.5 percent. Every time, the optimization exercise was rerun and the national and area-wide losses were recomputed. When the weight of Italy is increased, the area-wide benefits of the MCIBR (versus the AWIBR) monotonically increase (to above 60 percent), as do those for France and Germany, whereas the outcome for Italy initially worsens and then improves. However, when the same exercise is run for either Germany or France, the area-wide as well as their national benefits decline (to about 20 percent), while the benefits for Italy go from negative to positive.

Table 1. Optimal Rule Coefficients ($\lambda = 1, \mu = 0.5$)

	Inflation				Output Gap				Lagged Interest Rate
	Area	Fra	Ger	Ita	Area	Fra	Ger	Ita	
Backward-Looking Model									
Area-Wide Rule	1.24	**0.34**	**0.55**	**0.35**	1.23	**0.36**	**0.56**	**0.31**	0.78
Multicountry Rule	**0.93**	0.34	0.43	0.16	**1.23**	0.51	0.55	0.16	0.76
Hybrid Model									
Area-Wide Rule	0.25	**0.07**	**0.11**	**0.07**	0.42	**0.19**	**0.12**	**0.11**	0.95
Multicountry Rule	**0.23**	0.05	0.12	0.06	**0.44**	0.11	0.17	0.16	0.95

Note: The coefficients in bold are obtained by aggregating (in the case of the multicountry rule) or disaggregating (for the area-wide rule) the computed coefficients, using country weights.

heterogeneity of *both* country models and country shocks is needed for national information to be valuable. Under full convergence of either type, the relative gain associated with the MCIBR is negligible. Second, convergence of shocks or models has a different effect on the usefulness of national information. A moderate degree of convergence of models alone is sufficient for the welfare gains associated with the MCIBR to fall below 10 percent. By contrast, almost perfect convergence of shocks is needed for national information to become irrelevant.

4.2 Exercises Using the Hybrid Model

In this section we replicate the basic exercise underlying figure 1 using the hybrid model (6). The optimization exercise was run for the two rules (1) and (2) and various (λ, μ) combinations, and the percentage loss reduction was computed. Figure 2—the analogue of figure 1, panel A—reports the results. The magnitude of the loss reduction is now negligible, reaching a maximum of 3 percent for the pure inflation-targeting case.

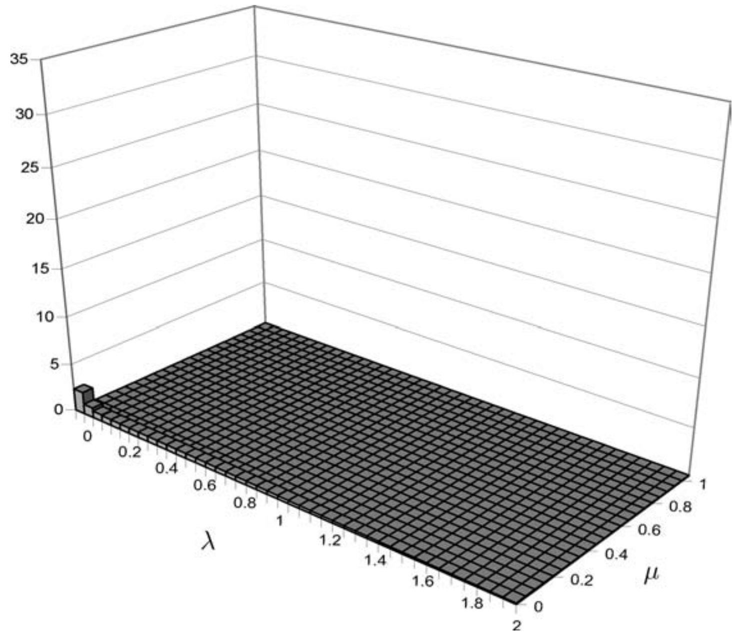
This clearly raises the question, what drives this change in the results? We first checked whether the change can be attributed to any particular parameter of the hybrid model (6). Setting $\lambda = 1$ and $\mu = 0.5$ (similar conclusions hold for all combinations of preference parameters) we perturbed, one at a time, each of the following groups of coefficients, starting from their respective estimated values: (i) the sensitivity of inflation to the output gap (AS equations); (ii) the sensitivity of the output gap to its lagged value or (iii) to the real interest rate (AD equations); and (iv) the degree of forward-lookingness (AS and AD equations). After each perturbation, we recomputed the loss reduction.[15]

The results are shown in figure 3. The horizontal axis reports the percentage perturbation applied to each group of coefficients, up to 60 percent. The vertical axis measures the loss reduction. Small

[15] Specifically, for groups (i) through (iii) we reduced the coefficients' value; for group (iv) we reduced the coefficient on expected variables and increased those of the corresponding lagged variables, so as to leave constant the sum of the two, hence preserving the long-run verticality of the Phillips curve.

Figure 2. Loss Reduction in the Hybrid Model

(in percent; MCIBR vs. AWIBR)

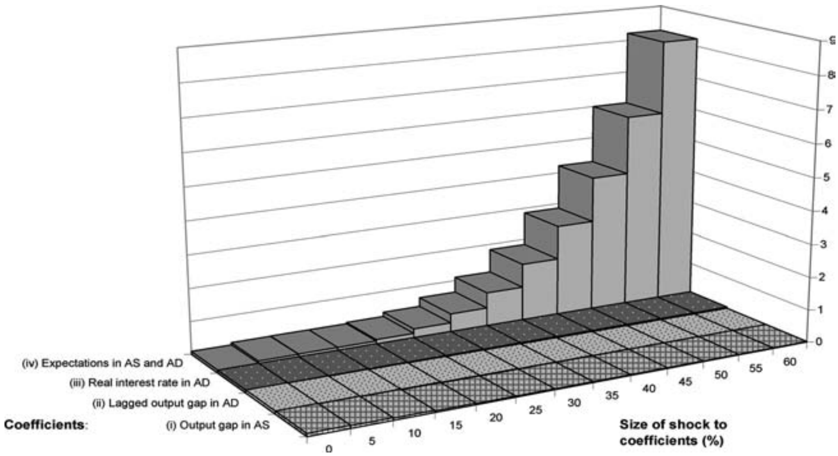


Note: The figure reports the percentage reduction in the value of the loss function attained under the multicountry information-based rule (MCIBR) relative to the area-wide information-based rule (AWIBR) under the constraint represented by the hybrid backward-forward-looking model in section 3.2. The parameters λ and μ reflect the weight attached by the policymaker to the output gap and the interest rate variability, respectively (see equation (3) in the text).

shocks—up to 15–20 percent of the estimated coefficient value—have no appreciable effect on the results, regardless of the coefficient group: the MCIBR still delivers negligible gains. For families of coefficients (i) to (iii), this also holds true for large shocks. However, the loss reduction is sensibly affected when the degree of forward-lookingness is modified. Namely, as the model becomes predominantly backward looking, the loss reduction goes back toward the high values documented in the previous section: applying a 60 percent shock to this family of parameters, the loss reduction increases

Figure 3. Sensitivity of the Loss Reduction in the Hybrid Model

(in percent; MCIBR vs. AWIBR; $\lambda = 1$, $\mu = 0.5$)



Note: The figure reports the sensitivity of the loss reduction in figure 2 to shocks to the coefficients of the hybrid model. Shocks are defined as a percentage reduction in the estimated coefficient value. See section 4.2 for a detailed description of the exercise.

to around 8 percent.[16] The pattern is highly nonlinear: a 40 percent shock yields a loss reduction of only 2 percent.

As an additional check that the change in results relative to those of section 4.1 is mainly driven by the forward-looking nature of model (6), we constructed an artificial hybrid model using the estimated backward equations (5). We parameterized the degree of forward-lookingness by $\phi \in [0, 1]$ so that $\phi = 0$ would yield model (5), whereas $\phi = 1$ would yield a fully forward-looking model with no autoregressive terms.[17] We replicated our optimization exercises using this model, letting ϕ gradually increase from zero to one. The

[16] Using shocks as large as 60 percent of the coefficient size clearly raises doubts about the validity of the approximation. However, we believe the experiment is still helpful in understanding what drives the difference in the results observed with the two models.

[17] For instance, we adopted the following version of the AS equation for Italy: $\pi_t^I = \phi 0.96 E_t \pi_{t+1}^I + (1 - \phi) 0.96 \pi_{t-1}^I + 0.24 y_t^I + 0.04 \pi_t^G + \varepsilon_{\pi t}^I$.

results of the exercises, not reported, confirm the importance of the degree of inertia of the economy: for values of $\phi < 0.4$ the results of section 4.1 are replicated; as ϕ approaches 0.5 the importance of national information declines, becoming negligible for $\phi > 0.7$.

These results are in line with those obtained in studies using dynamic stochastic general equilibrium models incorporating forward-looking terms. Jondeau and Sahuc (2008) show that significant welfare improvements can be obtained using a multicountry model, while those stemming from a multicountry rule are limited.

The near irrelevance of national information under the hybrid economy (6) seems to reflect a general reduced sensitivity of the loss to the precise specification of the policy in a forward-looking environment, as suggested by the following experiment. Setting $\lambda = 1$ and $\mu = 0.5$ we shocked, one at a time, the six country-specific coefficients of the optimized MCIBR and computed the increase in the loss function. The results obtained using the two models are dramatically different. For instance, using the hybrid model, a 50 percent reduction in any of the three coefficients of inflation yields a negligible loss deterioration, always below 1 percent; in the backward-looking model, by contrast, the deterioration ranges between 20 and 40 percent.

This feature of the forward-looking model need not be surprising, since the economy is less heavily dependent on its past and the behavior of the endogenous variables is more directly driven by that of the exogenous shocks. Policy, in these circumstances, can do relatively little. In particular, as noted by Clarida, Galí, and Gertler (1999), in the pure forward-looking case even the fully optimal policy (under discretion or "constrained commitment") cannot affect the rate at which inflation converges back to its target value, when displaced by a cost-push shock. This is not true in a model with inflation inertia. Therefore, in a model exhibiting non-negligible inertial behavior, policy appears to be more important. Results with a similar flavor are obtained by Adalid et al. (2005).

5. Concluding Remarks

In this paper we address an important question for the design of monetary policy for a monetary union: what is the cost of neglecting regional information in the decision-making process? Our answer is not clear-cut. We find that the cost is large using a backward-looking model of the economy; it is negligible using a hybrid model, featuring expected variables on the right-hand side. The main determinant of this finding seems to be the different degree of inertia (or its opposite, the forward-lookingness) characterizing our two models. Ideally, one should be able to identify the "best" model and pick one of the two answers. However, as we discussed above, both models have pros and cons: the backward-looking estimates are econometrically more reliable but theoretically unappealing, whereas the opposite holds true for the hybrid model. Indeed, the issue of the quantitative importance of forward-looking elements in New Keynesian Phillips curves, which turns out to be crucial for our results, is the subject of an ongoing debate. In this paper we do not take a stand in this debate, and therefore we remain somewhat agnostic about the answer to our key question. However, we believe that our results warrant a close scrutiny of the potential benefits of regional information for monetary policy purposes, certainly closer than the virtual neglect this issue has received so far.

The exercises performed in the paper yield several other interesting insights. For instance, in the backward-looking framework, the reduction of area-wide inflation and output variability associated with the use of national information does not reflect similar improvements in all participating countries; indeed, some countries may experience an increase in the variability of their economies. In the hybrid framework, the near irrelevance of national information seems to reflect a general reduced sensitivity of the loss function to the precise specification of the policy in a forward-looking environment: halving any of the three inflation coefficients of the optimal policy rule yields a negligible loss increase, always less than 1 percent; replicating the exercise in the backward-looking economy yields a loss increase of 20 to 40 percent.

Our concluding caveat is that none of our results should be interpreted as providing precise indications on the appropriate reaction of monetary policy to the actual asymmetries prevailing in the euro area, as the models we use are much too simple. Rather, we would stress the methodological case for paying attention to the potential costs of neglecting regional information in the design of the monetary policy in a monetary union, and for pursuing a disaggregate modeling strategy. Obvious extensions of this line of research would include further checking the robustness of the results to alternative modeling choices, exploring the monetary policy implications of the well-documented heterogeneities at the sector level within the monetary union (Dedola and Lippi 2005), and looking at other monetary unions.

Appendix. Relevance of Regional Information as the Economies Converge

In this appendix we assess in detail how the comparison between the AWIBR and the MCIBR reported in section 4.1 would be affected should more symmetry among the regional economies gradually prevail in the future.

We consider the two cases of convergence in shocks and structures separately. Regarding the convergence of stochastic disturbances, we take full AD (or AS) convergence to mean that the shocks in the corresponding equation become exactly the same in all countries (hence, the cross-country correlations equal 1—unlike fully optimal rules, optimal simple rules are affected by changes in the covariance matrix of the stochastic disturbances; see Currie and Levine 1985, 1987). As in De Grauwe and Piskorski (2001), we define the variance of the common AD shock under full convergence as

$$\overline{\sigma}_y^2 \equiv \left(w_y^G \sigma_y^G + w_y^F \sigma_y^F + w_y^I \sigma_y^I\right)^2, \tag{7}$$

where σ_y^i is the estimated standard deviation of ε_y^i in country $i(i = G, F, I)$, and w_y^i is the corresponding GDP weight.

We also consider the possibility of partial convergence, which we parameterize by $\xi_{AD}^s \in [0, 1]$ (with the extrema of the interval corresponding to zero and full convergence, respectively). The elements of the variance-covariance matrix of the shocks under partial convergence are defined as

$$\left(\widetilde{\sigma}_y^i\right)^2 \equiv \xi_{AD}^s \overline{\sigma}_y^2 + \left(1 - \xi_{AD}^s\right)\left(\sigma_y^i\right)^2 \tag{8}$$

$$\widetilde{\sigma}_y^{ij} \equiv \xi_{AD}^s \widetilde{\sigma}_y^i \widetilde{\sigma}_y^j \tag{9}$$

for all countries i, j, so that the correlation of shocks among countries is given by ξ_{AD}^s itself. Convergence of AS shocks is defined in an analogous way and parameterized by ξ_{AS}^s.

Full and partial convergence of economic structures (i.e., the parameters of the model) is modeled in a similar fashion. In particular, it is assumed that, under full convergence, inflation and output gap in each country respond to their determinants in the same way, except for the effects of country size. For each AS and AD equations, the coefficients under full convergence are defined as a weighted average of the original coefficients in all countries. The average cross-country effects at full convergence are computed as a weighted average of the original ones in equations (5), so that each country is influenced by the other two. Partial convergence is modeled as in the case of disturbances, with the parameters controlling the degree of convergence for the AD and AS equations denoted ξ^m_{AD} and ξ^m_{AS}, respectively.

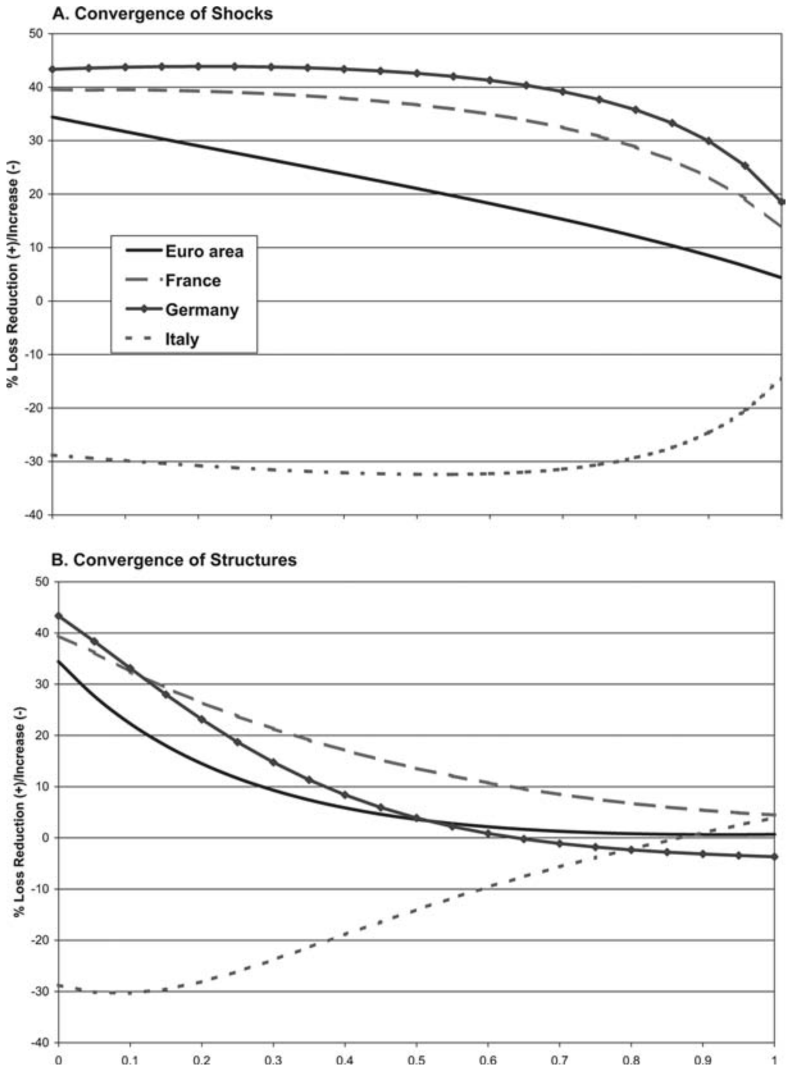
Figure 4 plots the reduction of the loss attained with the MCIBR, relative to that achievable with the AWIBR, as a function of the degree of convergence, for the case $\lambda = \mu = 1$ (similar results are obtained with alternative (λ, μ) combinations). In panel A we assume symmetric convergence in the shocks (i.e., $\xi^s_{AS} = \xi^s_{AD} \in [0, 1]$) and no convergence in the parameters of the models (i.e., $\xi^m_{AS} = \xi^m_{AD} = 0$). Conversely, in panel B the lines refer to the case of symmetric convergence of the economic structures, keeping the shocks unchanged. Two main results emerge from the figure.

First, heterogeneity of *both* country models and country shocks is needed for national information to be valuable. Under full convergence of either type, the relative gain associated with the MCIBR is negligible.

Second, convergence of shocks or models has a different effect on the relevance of national information. A moderate degree of (symmetric) convergence of models alone ($\xi^m_{AS} = \xi^m_{AD} > 0.3$) is sufficient for the welfare gains associated with the MCIBR to fall below 10 percent. By contrast, for $\xi^s_{AS} = \xi^s_{AD} = 0.7$ (without any convergence of models), such gains are still above 15 percent; almost perfect convergence of shocks is needed for national information to become irrelevant.

The figure also suggests that the country-specific implications of convergence of economic structures are roughly the same as for the area as a whole: a moderate degree of convergence of models suffices to reduce the difference in performance between the MCIBR and the AWIBR by a significant amount. By contrast, only with a

Figure 4. Usefulness of National Information as the Economies Converge
($\lambda = \mu = 1$)



Note: We simulate an increase in the symmetry of both AS and AD equations of the three countries in the estimated backward-looking model (5). On the vertical axis we measure the loss reduction (+) or increase (−) attained with the multi-country rule (MCIBR) relative to the area-wide rule (AWIBR). The horizontal axis measures the degree of convergence, increasing from left to right, so that zero corresponds to the case of no convergence.

rather high degree of shock convergence does the difference in performance between the two rules decline sensibly. For values of ξ^s_{AS} and ξ^s_{AD} below 0.7, in Germany, France, and Italy it is basically the same as in the case of no convergence, while it halves for the area as a whole.

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