MONETARY POLICY RULES FOR THE EURO AREA: WHAT ROLE FOR NATIONAL INFORMATION?[⊛]

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Abstract

Using a simple multi-country econometric model covering the three main countries of the euro area, the paper focuses on the role that can be played by information at the national level in defining the single monetary policy of the union. We find that the performance of a central bank that chooses the nominal interest rate to minimize a standard quadratic loss function of area-wide inflation and output gap significantly improves if the reaction function includes national variables — as opposed to the case in which the interest rate reacts to area-wide variables only. Our results suggest that asymmetries within the euro area are relevant to the central bank; overall, we interpret them as making a case for exploiting the available national information in the conduct of the single monetary policy.

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1. Introduction[1]

The role played by national information in the decision-making process of the Eurosystem has been rather controversial in the debate on the new-born institution. On the one hand, several elements lead to think that national developments do not play a significant role in shaping monetary policy decisions. To begin with, the monetary policy strategy is presented in ECB documents as focusing exclusively on area-wide developments and effects of the monetary action, neglecting events that occur in individual member countries. Other features of the Eurosystem' communication strategy also convey the same orientation,[2] which is well summarized by the following statement released by President Duisenberg at the press conference following the Governing Council meeting of 9 September 1999: "... our decisions today, again and as always, were based on a euro area-wide analysis of economic and financial developments — *and nothing else*" (italics added). On the other hand, some observers (see, e.g., De Grauwe, Dewachter and Aksoy, 1999; De Grauwe, 2000; De Grauwe and Piskorski, 2001) maintain that the prominent role played by NCB Governors within the Governing council of the Eurosystem is *de facto* likely to give national developments a higher weight in the decision making process than might be warranted. According to this view, while the ECB does every effort to convince the public that only area-wide developments are relevant for its policy stance, in practice monetary policy decisions are likely to be influenced by national interests.

This debate is centered around a positive issue: while both parties claim that only area-wide developments should be relevant, one of them argues that, as a matter of fact, national considerations loom (unduly) large. The discussion, however, begs the question as to whether the neglect of information pertaining to the national level is appropriate from

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[1] The views expressed are the authors' own and do not necessarily reflect those of the Banca d'Italia. We are indebted to Albert Ando, Pietro Catte, Luca Dedola, Riccardo Fiorito, Libero Monteforte, Fabio Panetta, Paolo Sestito and other participants in the Banca d'Italia-CIDE and BCI-Greta Conferences for their helpful comments, as well as to Lawrence Christiano and Richard Clarida for stimulating discussions on the subject of the paper. Any remaining errors are our own.

[2] According to the initial exposition of the ECB strategy "... policy decisions must be made in a manner that reflects conditions across the euro area in its entirety, rather than specific regional or national developments" (ECB 1999, p. 47). Also, monetary policy decisions are motivated in terms of economic developments in the area as a whole, both in the Bulletin and in the press releases following the Governing Council meetings. Furthermore, the statistical section of the ECB Monthly Bulletin shows only aggregate statistics for the area, with no national breakdown, except for fiscal positions.

a normative viewpoint. In our opinion, the seemingly widespread agreement that national information should, in principle, play no role in the single monetary policy stems from the failure to distinguish clearly between the objectives (in a formal model, the arguments of the monetary authorities' loss function) and the process through which policy decisions are made (the reaction function). It is far from clear that the process through which policy decisions are made should, from a normative viewpoint, completely disregard national developments. Indeed, the appropriate policy might require that the monetary authorities react to national developments, rather than (or in addition to) area-wide aggregates, even if their objectives are exclusively framed in area-wide terms. This may be the case if the economies of the area are characterized by significant structural differences, in particular concerning the monetary transmission mechanism. In these circumstances, a given shock may have different short and medium-term effects on the economy of the area depending on which country is initially or most prominently hit. The effects of the shock will reflect not only the relative weight of that country (as measured by the proportion of its GDP on the total for the area), but also the structural relations that characterize its economy, as well as its trade links with the rest of the Union.[3]

The present paper addresses this normative issue. Taking for granted that the NCB Governors' interpretation of their role in the Governing Council is consistent with their mandate and thus corresponds to the one recently reasserted by the ECB president,[4] we assess the usefulness of country-specific information in the conduct of monetary policy within a monetary union. In particular, we ask to what extent and how the Eurosystem should take into account information at the national level in making its monetary policy decisions; to answer this question, we provide an assessment of the cost of disregarding, or not using properly, this information.

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[3] An additional justification for the use of country-level information - of a logically different nature - is provided by cases in which the value of an economic variable of a specific country is a leading indicator for area-wide developments. For instance, in spite of the country small size, Belgium's manufacturing survey is considered a very good leading indicator for area-wide industrial production growth, due to the fact that Belgium is a large supplier of intermediate goods to the French and German manufacturing industry.

[4] "... in a monetary union, there is only one monetary policy, and this must be directed to a single objective. As laid down in the Treaty, each member of the Governing Council is therefore well aware that he or she is not a representative of a country or central bank but acts in a personal capacity in deciding the appropriate conduct of monetary policy for the euro area as a whole." (press conference following the Governing Council meeting of 30 March 2000).

To this end, we follow the standard approach to policy evaluation recently revived by a growing literature on monetary policy rules (see. e.g. the contributions in Taylor, 1999): we search for reaction functions that minimize the expected value of an intertemporal loss function, under the constraint provided by a simplified multi-country model of the euro area. Assuming that the monetary authority is exclusively interested in area-wide objectives (the arguments of the loss function are area-wide variables only), we compute and compare the performance of two classes of simple optimal reaction functions. ”Multi country information-based (MCIB) rules” allow the interest rate to be a function of country-specific variables (plus the lagged value of the interest rate to allow for some instrument smoothing). By contrast, rules in the second class, which we label ”area-wide information-based (AWIB) rules”, are restricted so that their arguments can only be area-wide variables; in other words, the monetary authority is assumed not to observe country variables separately, but only their aggregation. We then compare the minimized expected loss under the two alternative policy rules, interpreting the difference as the cost of neglecting country-specific information. As a benchmark, we also compute the fully optimal (FO) rule in our linear-quadratic framework (Chow, 1975), assuming no restrictions on the set of state variables to which the policy maker is allowed to react.

It must be emphasized that whereas the debate summarized above could lead to think that national developments should in principle play no role whatsoever in the Eurosystem’s strategy, there is reason to believe that this may partly reflect the Eurosystem’s effort to convey to the public the idea that its objectives are area-wide. Indeed, the process through which policy decisions are made (the reaction function) does — and, as we just argued, quite legitimately so — exploit national information: the Eurosystem currently uses a multi-country approach to the econometric modeling of the area (the ECB uses its own multi-country model, in addition to an area-wide one, and national econometric models developed and managed by the NCBs have a prominent role in the forecasting framework); national information is regularly exchanged and carefully analyzed within the Eurosystem; national statistics are available earlier than area statistics (which are prepared by Eurostat and by the ECB collecting the national information) and in many cases represent a more timely complement to the available area-wide indicators.[5] Thus, our main claim — that national-level information is relevant to the euro area policymaking process — is probably less controversial than it may appear.

It should be acknowledged that the claim of this paper — that the heterogeneity across euro area countries warrants consideration of national developments in the implementation of monetary policy — faces a natural objection. Why are similar concerns not raised for other monetary unions? The answer, we believe, is that the heterogeneity among the euro area countries is, a priori, likely to be larger. The differences in institutional features and economic structures (e.g. legal system, contract enforcement and corporate law, labor market arrangements, independent fiscal policies) are much more pronounced than in other monetary unions or federal States (the US being the most obvious comparison), and are likely to persist for some time in the future. In addition, convergence of fundamentals (such as the inflation rate, the level of interest rates, the budget deficits and the public debt) has been only a recent — and in some cases incomplete — achievement; language and cultural differences, tending to hinder labor mobility, may be a relevant obstacle for the foreseeable future. We therefore conjecture that the potential loss associated with the neglect of country-specific information might be large. At any rate, a measurement of such loss is precisely our goal in this paper.

The organization of the paper is as follows. Section 2 briefly describes some of the literature that has dealt with the issue of nation-wide vs. aggregate information in a monetary union. In particular, we briefly discuss the approach in De Grauwe (2000), De Grauwe and Piskorski (2001), Siviero and Monteforte (2002), whose focus is similar, and whose results are in some cases complementary, to ours. Section 3 illustrates the simple euro area multi-country model used in the analysis. We restrict our attention to the three main countries in the area — France, Germany and Italy. Whereas this choice is made primarily for practical reasons, these countries are broadly representative of the euro area, accounting for over 70 percent of its GDP. Each country is modeled separately (but trade links are allowed for) and the area-wide variables are obtained *ex-post*, via aggregation. Sections 4 and 5 describe the setup of the exercise and report the empirical results. The last section summarizes the preliminary conclusions and discusses the possible extensions of our research.

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[5] It is worth noting that this is not the case in the US, where aggregate data for the entire country are available before regional data. This aspect is highlighted in reports of Goldman Sachs (1999) and JPMorgan (1999), which describe how they ”create” area-wide statistics for the euro area from the more timely releases of national statistics.

2. Related literature

A few recent papers have dealt with the relevance of regional information in a monetary union.

De Grauwe, Dewachter and Aksoy (1999) concentrate on the possibility that the members of the ECB Governing Council (all of them or just the NCB Governors) care about national interests, as opposed to those of the area, and examine the implications of such a possibility for the welfare of the member countries under different hypotheses on the voting procedures of the Governing Council.

De Grauwe (2000) uses a simple two country theoretical model (one Phillips curve for each country) to analyse two cases. In the first, the policymaker chooses inflation to minimize a loss function constructed as a weighted average of the two national losses, under the constraint given by a multi-country model; in De Grauwe's terminology, in this case the central bank makes use of national information. In the second exercise, in which the loss function is defined over area-wide variables and the model is area-wide, the central bank is assumed to ignore national information. He finds that in the presence of asymmetries the central bank can improve monetary policy effectiveness by exploiting national information.

DeGrauwe and Piskorski (2001), sticking to policy rules that are always defined over national data (i.e., the monetary authority is assumed to react to national information), study the welfare implications of focusing on national vs. area-wide definitions of the loss function. Specifically, in one case they assume the preferences of the ECB to be a weighted average of the national loss functions and compute the optimal policy rule that is consistent with such preferences, under the constraint provided by a multi-country model. Alternatively, they assume preferences that are in line with the statutory provisions of the ECB, and are therefore based on area-wide aggregates, and again derive the optimal policy rule that is consistent with such preferences, under the same constraint. Finally, they compare, for each choice of the loss function, the performance of the two policy rules; they find that in all cases the welfare differences are relatively small, of the order of 5 to 10 per cent.

The three papers briefly described above are in different ways complementary to our analysis. In particular, De Grauwe, Dewachter and Aksoy (1999) associate the use of information about the individual countries with the nationalistic attitude of the Council members (and the voting procedure adopted in the Council), while in our paper the usefulness of this information is examined assuming an area-wide formulation of the Eurosystem strategy, unambiguously shared by the ECB Council in its entirety. De Grauwe and Piskorski (2000) always keep the policy rule defined in terms of country-specific variables, focusing on how the results are affected by changes in the definition of preferences.

By contrast, we explore the implications of using or not using country-specific variables in the design of the policy rule, always keeping the loss function defined over area-wide aggregates. We take their conclusion that only limited welfare differences are discernible in the cases considered to mean that, once one allows monetary policy to react to country-specific variables, the optimal policy is relatively insensitive to changes in the specification of the loss. This is fully consistent with our own findings, that the large improvement is achieved once country-specific elements are allowed for in the reaction function, even in a simplified and constrained form.

The exercise performed by Siviero and Monteforte (2002) is also complementary to ours. They rely on the same three-country model used in this paper and on its area-wide counterpart, estimated on aggregate data. Assuming a loss function defined over area-wide aggregates, simple optimal rules (whose arguments are solely aggregate variables) are computed under the constraint provided by either model. The performance of the rules is then assessed assuming the multi-country model to be the ”true” data generating process.[6] The results show significant welfare losses when the central bank relies on the area-wide model.

Wyplosz (1999) focuses on the problems posed to the ECB by the lack of synchronisation across EMU economies. He performs two exercises: in the first, the ECB is assumed to set its policy rate using a Taylor rule in which output growth and inflation are weighted averages of the corresponding time-series of the participating countries. In the second, the output variable is replaced with an index that assigns 50 per cent of the weight to the average output and 50 per cent to the output of the country that is experiencing a particularly strong deviation of output growth from the average. He finds that the resulting interest rate series differ little, both because the interest rate autoregressive coefficient is large and because the output coefficient in the rule is small.

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[6] In this framework, as in De Grauwe (2000) and in the present paper, the welfare effects of neglecting national information are therefore negative by definition.

Benigno (1999) analyses monetary policy in a monetary union using a two-region, general equilibrium model with monopolistic competition and price stickiness, showing that if the degrees of rigidity are different, policy should assign a higher weight to the region where rigidity is higher.

3. A small empirical model for the main euro area economies

The euro area economy is described by a simple two-equation model for each of the three main economies in the euro area (Germany, France and Italy, which jointly account for over 70 per cent of the area GDP). The model consists, for each of the three countries, of an aggregate supply equation (also referred to as Phillips curve) and an aggregate demand equation (also referred to as IS curve). The first equation determines inflation in each country as a function of lagged inflation and the output gap in the same country, as well as of inflation ”imported” from the other two. The sum of the coefficients on lagged and imported inflation is constrained to be one (a restriction accepted by the data), so that an accelerationist version of the Phillips curve holds for all countries. The second equation relates the output gap of each country to its own lagged values and the real interest rate, as well as to the output gap in the other two countries (a design meant to capture the trade links among euro area economies).[7] Euro area GDP and inflation are generated via identities, as weighted averages of the corresponding individual country variables. The output gaps are aggregated using 1999 GDP weights (under PPP); 1999 consumer spending weights (under PPP) are used to aggregate the inflation rates. The full set of weights is shown in Table 3.1 (for full details as to data construction, see Lippi and Monteforte (2002)).

As the model allows for simultaneous cross-country linkages, it was estimated with 3SLS. For most of the sample period (from 1978.Q1 to 1998.Q4, thus totalling 84 observations), 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. Accordingly, the measure of ”inflation imported in country i from country j” was constructed as the sum of the inflation rate in country j and the quarter-on-quarter percentage change of

[7] Inflation is given by 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 (1995)) to the (log) GDP for each country.

the exchange rate between the two countries (units of currency of country i needed for 1 unit of country j's currency).[8]

The general form of the two-equation sub-model for country j is the following:

$$(1)\quad \pi^j_{t+1} = \sum_{k=1}^{p} \alpha_{j,k}\pi^j_{t+1-k} + \sum_{i\neq j}\sum_{k=0}^{p} \beta_{j,i,k}(\pi^i_{t+1-k} + \dot{e}^{i,j}_{t+1-k}) + \sum_{k=0}^{p} \eta_{j,k} y^j_{t+1-k} + u^j_{t+1}$$

$$(2)\quad y^j_{t+1} = \sum_{k=1}^{p} \theta_{j,k} y^j_{t+1-k} + \sum_{i\neq j}\sum_{k=0}^{p} \varphi_{j,i,k} y^i_{t+1-k} + \sum_{k=1}^{p} \psi_{j,k}(i^j_{t+1-k} - 4\,\pi^j_{t+1-k}) + v^j_{t+1}$$

where π^j_{t+1} is the quarter-on-quarter consumer inflation rate in country j, $e^{i,j}_{t+1-k}$ is the quarter-on-quarter rate of change of the exchange rate between country i and country j (units of country j's currency for 1 unit of country i's currency, y^j_{t+1} is the utput gap in country j, i^j_{t+1} is the short-term interest rate in country j.

The starting specification included on the right-hand-side of each estimated equation the first 6 lags of all relevant variables. After dropping all insignificant lags the parsimonious specification presented in Table 3.1 was achieved. This framework is admittedly a very simple one, as it only models the three major economies in the area, and in a sketchy way. While this choice was made primarily for computational reasons, a full-fledged model for the euro area that were to include all twelve countries, paying a closer attention to country-specific institutional features (e.g., labour market arrangements, tax structures, fiscal policy mechanisms), would likely result in more pronounced asymmetries. As the existence of such asymmetries is the main factor on which our results rest, it can be conjectured that our results are likely to provide a lower bound estimate of the welfare gains that can be attained by properly exploiting all available national information.

Some insights into the main properties of the model can be obtained by looking at a few impulse responses (Figures 2.1-2.3).[9] Given our accelerationist version of the Phillips

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[8] Given the well-know difficulties to find satisfactory empirical specifications for the exchange rate, no attempt was made to augment the model with exchange rate equations. However, lagged values of all variables included in the model were used as instruments for the exchange rates. At any rate, in the experiments presented below, the percentage change of the exchange rate was set identically equal to zero, consistently with the introduction of the single currency as of 1 January 1999.

[9] In keeping with the approach followed in similar literature, the simulation model does not include any

curve, the model cannot be meaningfully simulated if it is not augmented with a stabilising monetary policy reaction function. Accordingly, the impulse responses were computed with an optimised AWIB rule, derived as described in Section 3 below.

For each equation, the size of the (one-period) shock is equal to one time the standard deviation of the corresponding estimation residuals. Thus, the differences in the responses of the model to aggregate supply and aggregate demand shocks in the various countries do not only reflect differences in the corresponding structural equations, but also the relative size of the stochastic terms. Monetary policy shocks correspond to a 100 basis points, one-period increase in the short-term interest rate.

A few prominent features emerge from the pattern of impulse responses:

– neither aggregate supply nor aggregate demand disturbances have permanent effects on output and inflation; however, the deviations from equilibrium tend to be remarkably persistent, at least in some cases;
– a positive shock to the Phillips curve induces a dampened oscillatory reaction of both inflation and the nominal interest rate, and results in a contraction of output that reaches its maximum in the course of the third year after the shock;
– a positive monetary policy shock results in a temporary contraction of output that reaches a maximum in the course of the second year after the shock; it also tends, initially, to affect output more pronouncedly than inflation, that shows the largest reduction three to four years after the shock.

The last two features of the model are consistent with well-established stylised facts about the timing of the impact of a monetary policy shock on output and inflation[10]. In

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constant terms, i.e., it may be taken to provide a description of the functioning of the euro area economy in the neighborhood of equilibrium. This amounts to implicitly assuming that the same equilibrium values apply to all countries, a condition that does not hold in the sample period, particularly regarding the (implied) equilibrium real interest rates. It is evident that, if we were to assume that the equilibrium interest rates of the individual country models differ from one another, then the welfare gains associated with paying due care to national developments would likely be even more pronounced. In this respect, our experimental set-up may be viewed as being, if anything, somewhat biased in favour of the AWIB rule. In the model used to compute the impulse responses and the optimal policy rules, moreover, the rate of change of the bilateral exchange rates is set to zero, consistently with the introduction of the single currency in January 1999. Similarly, while in estimation a measure of country-specific short-term interest rates where used, in the experiments below it was imposed that the interest rate be the same for all countries, i.e.: $i^j_{t+1} = i_{t+1}$, for all j's.

[10] See, e.g., the evidence presented at the Conference ”Monetary Policy Transmission in the Euro Area”, ECB, Frankfurt, 18-19 December 2001.

particular, the general features of the reaction of inflation and the output gap to a monetary policy shock is remarkably similar to the one estimated by van Els, Locarno, Morgan and Villetelle (2001), on the basis of the econometric models for the various euro area countries developed and used by the corresponding NCBs, and the ECB's Area-Wide Model (see Fagan, Henry and Mestre (2001)).[11] Our model seems therefore able to reproduce in a reasonably satisfactory way the main features of the monetary policy transmission mechanisms.

Looking now more closely at the responses of the model to the shocks, a number of interesting features emerge that can be related to individual countries:[12]

- the effects on area-wide inflation of shocks hitting the French Phillips curve tend to vanish less rapidly than the effects coming from a shock to either the Italian or the German Phillips curves;
- similarly for aggregate demand shocks: in the case of France, their effects are much more persistent, particularly as far as aggregate euro area inflation is concerned;
- for both aggregate supply and aggregate demand shocks, their effects are smallest, and least volatile, if the shocks originate in Italy;
- monetary policy takes longer to affect inflation in France than in either Italy or Germany; the time-pattern of the effects in the latter two countries is similar, but the effects are markedly more pronounced in Italy than elsewhere;
- the timing of the effects of monetary policy on the output gap are very similar across countries. The German output gap is the most reactive, followed by Italy.

[11] At a first glance, our results would seem to imply that our MCM results in a considerably slower reaction of the economy to the monetary policy shock, particularly for inflation, than estimated by van Els, Locarno, Morgan and Villetelle (2001); even more so since they examine the effects of a sustained shock (for 8 quarters) to the policy interest rate, while our shock is only for one period. However, one should bear in mind that the simulation experiments in van Els, Locarno, Morgan and Villetelle (2001) do not incorporate a monetary policy reaction function. In our experiments, given that the model is augmented with a monetary policy rule, the shock to the policy interest rate is in fact implicitly a sustained one. This goes in the direction of reconciling the two sets of results, though not entirely.

[12] While a case-by-case comparison with other empirical evidence is beyond the point, it may be worth emphasising that most of those individual country features are in accordance with the recent results in van Els, Locarno, Morgan and Villetelle (2001), which we take as further evidence that our simple MCM may be deemed to provide a reasonably satisfactory description, for our purposes, of the functioning of the euro area economy.

4. Design of experiments

The analytical framework adopted in this paper is borrowed from the time-honored Tinbergen-Theil approach to policy-making, recently revived by a strand of the literature on monetary policy rules that addresses the issue of whether the performance of simple rules,[13] obtained by imposing some constraint on the functional form of the optimal reaction function, is significantly inferior than the performance under the latter.[14] In this literature, the underperformance of the simple rules is weighted against their simplicity, that 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, there may be a trade-off between performance in the context of a specific model and robustness.[15]

While we share the same analytical approach used by this body of literature, the focus of our analysis is conceptually different. We are not interested in the functional form of the policy rules (e.g. number of lags, or forward vs. backward looking specification), nor in their robustness; rather, for a given functional form, 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 assume the policymaker's loss function to be quadratic and time-separable; its arguments include the deviation of inflation from its target value (assumed to be zero), the output gap, and a term accounting for the central bank's dislike for excessive interest rate volatility:

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[13] See the papers presented at the January 1998 NBER Conference on Monetary policy rules, recently published in Taylor (1999); in particular, see Rudebusch and Svensson (1999), who apply this approach to the United States.

[14] It has been shown that - unlike optimal rules - certainty equivalence does not hold for simple rules (the rule is not the same as that for the deterministic problem); in addition, the parameters of these rules depend on the covariance matrix of the error terms and on the initial conditions of the system (Currie and Levine, 1985, 1987).

[15] To test robustness of the ranking, the comparison is carried out changing one or more elements of the conceptual framework; in particular, different hypotheses are adopted concerning the preferences of the monetary authorities and the possible effects of uncertainty on the structure of the model, the estimation or calibration of the model parameters, and the presence of measurement errors (Rudebusch (1998); Orphanides (1998); Peersman and Smets (1999)). Other authors compare the performance of various rules across different models of the economy (Levine et al. (1999); Taylor (1999)).

(3) $$L = E_t \sum_{\tau=0}^{\infty} \delta^{\tau} [\pi_{t+\tau}^2 + \lambda \cdot y_{t+\tau}^2 + \mu \cdot (\Delta i_{t+\tau})^2]$$

where δ is a discount factor, and λ and μ are parameters that reflect the policymaker's preferences. Note that no country-specific variables appear in the loss function, implying that the monetary policy authority is solely interested in area-wide developments.

For $\delta = 1$ one can focus on the period loss functions, which is given by the weighted sum of the unconditional variances of the target variables (Rudebusch and Svensson, (1999)):

(4) $$L_{t+\tau} = \text{var}(\pi_{t+\tau}) + \lambda \cdot \text{var}(y_{t+\tau}) + \mu \cdot \text{var}(\Delta i_{t+\tau})$$

We restrict attention to Taylor-type rules augmented with a lagged interest rate term, i.e. rules in which only contemporaneous inflation and output gap appear among the arguments.[16] The difference between the AWIB and the MCIB rules is that in the former case the policymaker is assumed only to react to area-wide inflation and output gap aggregates (so that the rule implies that the reaction of the policy rate to a change in any country's inflation and output is given by the average impact, multiplied by the corresponding country weights). Thus, this rule includes three arguments (since it also comprises the lagged interest rate):

(5) $$i_t = \gamma_1^A \cdot \pi_t + \gamma_2^A \cdot y_t + \gamma_3^A \cdot i_{t-1}$$

In the case of the MCIB rule, instead, the parameters on the individual countries' inflation and output are not constrained to fullfil any proportionality constraint. This rule includes seven arguments:

(6) $$i_t = \gamma_{1D}^M \cdot \pi_t^D + \gamma_{1F}^M \cdot \pi_t^F + \gamma_{1I}^M \cdot \pi_t^I + \gamma_{2D}^M \cdot y_t^D + \gamma_{2F}^M \cdot y_t^F + \gamma_{2I}^M \cdot y_t^I + \gamma_3^M \cdot i_{t-1}$$

[16] As shown in Rudebusch and Svensson (1999), rules of this kind tend to produce an outcome that comes remarkably similar close to the one associated with the optimal instrument rule; this will be shown to be also the case for the experiments carried out below.

As a benchmark, we also compute the optimal instrument rule that depends on all state variables of the multi-country model (15 in all).

The two competing AWIB and MCIB rules stem from the solution of the following problems:

Optimization exercise based on AWIB rule

$$\min_{\gamma_1^A, \gamma_2^A, \gamma_3^A} E_t \sum_{\tau=0}^{\infty} [\pi_{t+\tau}^2 + \lambda \cdot y_{t+\tau}^2 + \mu \cdot (\Delta i_{t+\tau})^2]$$

s.to:
- Multi-country model, and
- eq. (5)

and:

Optimization exercise based on MCIB rule

$$\min_{\gamma_{1D}^M, \gamma_{1F}^M, \gamma_{1I}^M, \gamma_{2D}^M, \gamma_{2F}^M, \gamma_{2I}^M, \gamma_3^M} E_t \sum_{\tau=0}^{\infty} [\pi_{t+\tau}^2 + \lambda \cdot y_{t+\tau}^2 + \mu \cdot (\Delta i_{t+\tau})^2]$$

s.to:
- Multi-country model, and
- eq. (6)

It is clear from these panels that the performance of an optimal MCIB rule cannot be worse, by construction, than the corresponding AWIB one, as it boils down to being an unconstrained version of the latter. The issue then is: Given that using an MCIB approach must necessarily result in an optimised value of the loss function at least as desirable as the one granted by an AWIB approach, are the welfare gains at stake large enough to conclude that exploiting all available national information is worthwhile?

The variances of the goal variables are of course a function of both the choice of the parameters in the two rules above, as well as of the variance-covariance matrix of the stochastic terms in the estimated equation. The latter is given in Table 4.1. The historical variance-covariance matrix is rather sparse. Indeed, assuming that the off-diagonal block (i.e., the one that includes the covariances between the set of the three aggregate supply equations and the set of the three aggregate demand equations) is identically zero, did not perceivably modify our results.

In addition to minimising the loss function (3) subject to the variance-covariance matrix of Table 4.1, following De Grauwe and Piskorski (2001) we repeated the experiments with different assumptions regarding the correlation structure of residuals. Specifically, all experiments were repeated (and all results were evaluated) under two additional alternative assumptions regarding the variance-covariance matrix: (i) the correlation between stochastic terms that belong to the same diagonal block is exactly 1, that is to say: there exists only two stochastic processes in the area, one for the output gap and one for inflation; these processes are ”scaled” differently in the three countries, and are independent from one another; (ii) all stochastic processes that belong to the same diagonal block are exactly the same; their (common and identical) variance is obtained as an average of the three corresponding historical variances.[17]

Using a variance-covariance matrix as modified sub (i) or (ii) above may be justified on the ground of the argument that, in the estimation sample, one of the most relevant (if not the most relevant) source of stochastic shocks came from the exchange rate (which would be consistent with the fact that very little cross-country correlation is apparent in the estimated residuals). With the single currency, however, the exchange rate is the same for all countries. Hence, those alternative assumptions may be viewed as a very crude, and arguably extreme, way to take into account the possibility that euro area economies are now more similar to one another than they were in the estimation period.

5. The results

The main results of the exercise are reported in Table 5.1 and Figures 5.1 and 5.2. The table displays the (long-run values of the) coefficients of the three instrument rules described in the previous section (the fully optimal — labeled ”Optimal” — the AWIB — labeled ”Area-wide” — and the MCIB — labeled ”Multi-country”), for different choices of the weights λ and μ assigned to output gap and interest rate variability in the loss function.[18] To ease

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[17] More precisely, as in De Grauwe and Piskorski (2001), the average variances are calculated as squared weighted sums of the standard deviations of the country specific Phillips curve and aggregate demand shocks.

[18] Our choices of the values for λ and μ range from the case in which the monetary policymaker is virtualy only interested in inflation ($\lambda = 0, \mu = 0.05$) to the opposite extreme, in which the policymaker attaches a very high cost to deviations of the output gap from its equilibrium value (zero) and to the volatility of the policy-controlled interest rate ($\lambda = 3, \mu = 3.05$). Assuming $\mu = 0$ resulted in not entirely plausible parameter values in the optimal rule. It was found that, instead, even a very small weight on interest rate volatility suffices to make the results more sensible.

the comparison, for each rule the table presents the coefficients assigned to both area-wide and country-specific inflation and output-gap.[19] Clearly, depending on the rule, one or the other will be directly the result of the optimisation (in bold) and the complement will only be implicit. For instance, the implicit inflation coefficient for France in the third row (1.58) is obtained by multiplying the optimised area-wide inflation coefficient (5.75) by the relative weight of France out of the total three-country aggregate (0.27), while the implicit area-wide inflation coefficients in the first and second rows are obtained by summing the three national coefficients (respectively, 3.74=1.98+1.09+0.68 and 3.97=1.82+1.42+0.73). The table also shows the standard deviations of inflation, output-gap and interest rate change, as well as the loss function obtained for each rule. The top panel of Figure 5.1 shows the percentage reduction in the loss achieved with the MCIB rule relative to the AWIB, for wider grids of λ and μ than those reported in Table 5.1; the bottom panel expresses this reduction as a percentage of the difference between the AWIB and the FO losses. Figure 5.2 presents the optimal inflation/output gap frontiers (in terms of unconditional standard deviations) for both the AWIB and the MCIB rule, as well as for the fully optimal one; the frontiers have been computed, for given μ, by letting λ take a grid of values between 0 (north-west) and 3 (south-east).

A number of insights can be drawn from these results.

Focusing first on the final outcomes of the implemented policies, the key message is that neglecting the information contained in individual countries developments leads to a big worsening of the overall performance of monetary policy. Relative to the loss achievable with the AWIB rule, the MCIB rule yields a loss reduction between 25 and 50 per cent (see Figure 5.1). The loss reduction varies with the weights in the loss function, and increases when the relative weight of inflation and interest rate smoothness are increased; in particular, when inflation variability and interest rate smoothness are the only concerns of monetary policy the relative loss reduction associated with the MCIB rule ranges between 40 and 50 per cent. The gain is statistically significant: using parametric and nonparametric tests, equality of the two distributions or of their means was rejected at any significance level. While the loss reduction

[19] The optimal instrument rule depends on the complete set of the 15 state variables in the MCM: the latter set comprises inflation and output gap in the various countries for different lags. The coefficient on inflation reported in Table 4.1 is given, for the optimal instrument rule, by the sum of the value of all coefficients that the rule assigns to inflation in all countries and for all lags; similarly for the output gap.

would be influenced by an affine transformation of the loss function, the results can be directly appraised in terms of the (unconditional) standard deviation of inflation, output gap and interest rate changes. Table 5.1 shows that, relative to the standard deviation achieved under the AWIB rule, the MCIB rule delivers reductions of the order of 20-30 per cent for inflation and interest rate changes, of 10-20 per cent for the output gap. Figure 5.2 shows similar results, with the optimised combination of inflation and output gap variability (for varying relative weights) achieved under the AWIB rule well to the north-east of those associated with the MCIB rule.

A second insight, still concerning the overall performance of monetary policy, is that the MCIB rule does a very good job relative to the fully optimal (FO) rule. This can also be gauged from Figure 5.2, in which the frontiers associated with the two rules lie close together. This result is reminiscent of the conclusions reached in the literature concerning the performance of simple rules (see, e.g., Rudebusch and Svensson (1999)). Indeed, the MCIB rule only loads 6 variables, compared with the 15 of the FO rule, and yet delivers results that are relative close to those obtained under the latter.

This leads naturally to shift the attention to the nature of the rules. A number of noteworthy features emerge. First, the MCIB and FO rules are always remarkably similar, with few exceptions for the weights given to German output gap. Second, relative to the FO rule, the AWIB rule is too ”reactive”, both to inflation and output gap, as the implied (area-wide aggregated) coefficients of the former are considerably smaller than the coefficients of the latter (between 35 and 45 per cent for the inflation, between 10 and 50 per cent for the output gap). Also, the AWIB rule in general puts too much relative weight on (aggregate) inflation. Third, Italian inflation and output gap receive too much (implicit) weight in the AWIB rule relative to the weights in the FO and MCIB rules, in general 4 to 5 times (see Table 5.1). As to the variables of the other two countries, although their weights in the AWIB rule differ from the corresponding ones in the FO rule, the order of magnitude of the differences is much smaller (usually not exceeding 50 per cent). In particular German variables are both over-weighted; French inflation is over-weighted, and French output gap is under-weighted.

It would obviously be of considerable interest to trace back the various features of the rules to specific features of the individual economies, also to assess the robustness of the results here reported. In particular, it would be valuable to understand why the optimal monetary policy — as represented by the FO rule or, almost equivalently, by the MCIB rule — deviates so much from the relative weighting of the countries associated with the statistical procedure of aggregation. For example, why should the optimal monetary policy reaction to Italian inflation and output gap be so much more muted than what would be implied by the (GDP or consumption) weight that Italy has in the area?

While this issue is complex, in what follows we provide some pieces of evidence that allow a tentative assessment of the various factors at play in shaping the optimal monetary policy.

Table 5.2 provides a qualitative picture of the relationships between the structure of the economies, as captured by our simple model, and the coefficients of the FO rule. Specifically, a (small positive) shock was given to each of the 14 (independent) structural parameters of the model and the derivative of the coefficients of the FO rule was computed; the table indicates the sign of those derivatives (summarising a large set of numerical results obtained by varying the weights in the loss function). A few regularities are worth mentioning. First, if the inflation inertia of one country (the autoregressive coefficient of inflation in the inflation equation for that country) increases (keeping the vertical nature of the Phillips curve[20]), the weights that the FO rule assigns to inflation and the output gap in that country increase. Secondly, if the output gap inertia of one country (the autoregressive coefficient of the output gap in the output gap equation for that country) increases, the weights that the FO rule assigns to inflation and the output gap in that country increase. Thirdly, if the effectiveness of monetary policy in one country (measured by the interest rate coefficient in the output gap equation for that country) decreases, the weight that the FO rule assigns to inflation in that country increases (the evidence is less clear cut for the output gap). Finally, if the output gap effect on inflation in one country increases, the weight that the FO rule assigns to inflation in that country increases (the evidence is less clear cut for the output gap).

By and large, these responses obey to a common pattern: any change that reduces the monetary policy ”leverage” in one country (by increasing the inertial component of target variables or by reducing the direct effect of monetary policy) is associated with an increased reaction of the single monetary policy to the variables in that country. The only exception to this pattern is the effect of an increase of the output gap coefficient in the inflation equation, that

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[20] This implies that the coefficient of the cross-country effect (e.g. of French inflation in the German Phillips curve) is lowered by the same amount, to keep the sum of the coefficients on inflation terms equal to 1.

points to a stronger (indirect) effectiveness of monetary policy and yet results in increases of the weight given to inflation in the FO rule. This result stems from the following mechanism: on the one hand, a higher output gap coefficient in the aggregate supply equation implies that, *ceteris paribus*, monetary policy becomes more effective when it comes to curbing inflation; on the other, it also means that the variance of inflation is relatively more affected by aggregate demand shocks, thus calling for a more reactive policy. The observed results indicate that the second effect prevails.

On the basis of the latter remarks, the observed ”under-weighting” of Italian variables in the FO and MCIB rules can only be partially rationalised. Relative to other countries, the estimated Italian model features a lower coefficient of the output gap in the Phillips curve and a lower autoregressive term in the aggregate demand equation, both leading to a smaller weight being placed in the FO rule on Italian inflation and output gap. However, other features of the Italian model point to the opposite conclusion: the higher autoregressive term in the Phillips curve and the lower coefficient of the interest rate in the aggregate demand equation (note, however, that monetary policy is estimated to affect the Italian output gap more quickly than it does in the other two countries). At the present stage we can only observe that the former effects seem to dominate.

The weights assigned to the various variables by the FO rule can be expected to depend not only on the structural characteristics of the individual economies, but also on the causal structure of the overall euro area economy. In this respect, a result on the control of dynamic systems obtained by Ando, Simon and Fisher (1963) is worth recalling. They suggest that a more effective control of a dynamic system characterised by some form of block-recursiveness is obtained by reacting more strongly to those variables that occur earlier in the causal chain, since by affecting them one gets the extra bonus of affecting those that are ”downstream” in the causal chain. In the estimated model, there is a (country) causal structure that is in fact nearly block-recursive, with Germany at the root of the chain (affecting French and Italian inflation, as well as Italian output gap), then France, affecting (in a weaker form) German inflation, then Italy. This pattern would seem consistent with the relative over-weighting of Germany and the relative under-weighting of Italy. Table 5.2 confirms that increasing the coefficient of the German output gap in the Italian aggregate demand equation results in a rule that assigns larger parameter values to German inflation and output gap.

Indeed, putting close to zero[21] the ”cross-country” effects (the coefficient on German output gap and inflation in, respectively, the Italian aggregate demand and aggregate supply equations, the coefficient on German inflation in the French aggregate supply equation and the coefficient on French inflation in the German aggregate supply equation), the relative weights assigned by the FO rule to the various countries become very close to those implied by the aggregation weighting scheme.

It may be usefule to examine the response of the model to a number of different shocks if monetary policy-making is assumed to be set on the basis of the FO, AWIB and MCIB rules, alternatively. This is done in Figures 5.3, 5.4 and 5.5. The responses of the model under the MCIB and FO rules do not, in general, differ much from one another, while the AWIB rule results in a visibly more pronounced oscillatory behaviour.

So far, the attempts at understanding the basic result of this paper (the neglect of country specific information in the monetary policy reaction function has big welfare costs) relied on the benchmark provided by the FO rule: trying to understand why the FO rule weights country variables differently from the procedure of statistical aggregation helps to understand why the AWIB rule, that is constrained to adopt the latter relative weighting scheme, underperforms the MCIB rule, that can get closer to the fully optimal weighting scheme. A somewhat different tack in the attempt to understand the results would be to ask under which conditions the underperformance of the AWIB rule would be attenuated. Clearly, one would expect that the difference in the performance between the two rules shrinks when the single country (model) economies get more ”similar”, as the advantage of the MCIB rule lies precisely in exploiting (potential) differences in the working of the economies. It is however not obvious which metric should be used to measure this similarity. One possibility, following De Grauwe and Piskorski (2001) is to assume that the variance-covariance matrix of the structural disturbances converges to some common pattern, thus reducing the asymmetry of the shocks hitting the various countries (see Section 4 for a description of the experiments performed). One extreme case of this kind of ”similarity” amounts to assume that the shocks hitting, respectively, the aggregate demand and the aggregate supply equations are exactly the same in all countries. Figure 5.6 provides a summary of the results obtained under this extreme assumption: the

[21] Close, but not exactly equal to zero, since in the latter case the solution algorithm would become unreliable. We are still investigating the reason for this peculiar result.

relative loss reduction achieved by the optimal MCIB rule (relative to the loss under the optimal AWIB rule) is considerably smaller than in our baseline case, and in all cases lower than 10 per cent. All rules perform less satisfactorily than in the set of experiments where the historical variance-covariance matrix was assumed to hold, the worsening being of course much more pronounced in the FO and MCIB cases than in the AWIB one. A general worsening of the optimised losses should indeed be expected: in this latter experiment the shocks are perfectly correlated, while the historical ones are virtually independent, and hence do not tend to reinforce each other. We interpret this result as supportive of our basic finding, as it shows that our methodology is not hardwired to produce big gains from the use of country specific information.

While a full interpretation of the results is still not available, it seems that all the features of the economies (their internal mechanisms as well as their interrelationships) impinge upon the weights of the FO rule and presumably, though this still remains to be checked, on the weights of the MCIB rule and on the relative performance of the MCIB rule relative to that of the AWIB rule. Moreover, the nature of the correlation structure of the shocks hitting the single economies also has a bearing on that relative performance. This suggests the importance of a thorough empirical investigation of the properties of the euro area economy and of the monetary policy transmission mechanism, an investigation that, fortunately, has recently gained momentum both in the academia and in the central banking community.

6. Preliminary conclusions and possible extensions

This paper investigated to what extent the effectiveness of monetary policy in the euro area may be enhanced by paying attention to national information, as opposed to reacting exclusively to (target) aggregate area-wide variables, the starting conjecture being that this distinction should be of relevance because of the structural differences among participating countries. The exercise is based on a simple aggregate demand-aggregate supply multi-country model for the main three economies of the euro area (Germany, France and Italy) and a standard quadratic loss function of the central bank. While the objectives appearing in the loss function are expressed exclusively in terms of area-wide aggregates — so that the exercise is fully consistent with the area-wide orientation of the single monetary policy — the arguments of the reaction function of the Eurosystem (given by a Taylor-type rule) are assumed to be aggregate values of inflation and the output gap or, alternatively, the corresponding national values.

The main results can be summarised as follows:

– the rule that reacts to individual countries' information (labelled MCIB in the paper) provides results which are very close to those of the fully optimal (FO) rule;
– the MCIB rule delivers large welfare gains with respect to the rule based solely on area-wide information (AWIB), the loss reduction varying between 25 and 50 per cent, depending on the preference parameters;
– relative to the FO and MCIB rules, the AWIB rule is ”too reactive”, to both inflation and the output gap;
– the general overreaction of the AWIB rule is implicitly much too pronounced for Italy, for both inflation and the output gap, less so for Germany and France.

These results suggest that, from the viewpoint of the optimal monetary policy-making, the assessment of the euro area economic conditions must pay due care to national developments; neglecting the latter can be very costly.

The paper also provides a tentative assessment of the factors underlying the results, tracing the latter back to the structure of the three economies considered and the causal links among them.

Overall, the results should not be interpreted as providing specific indications on the appropriate reaction of monetary policy to the actual structural asymmetries prevailing in the euro area. Indeed, the preliminary character of the analysis, as well as potential shortcomings of the conceptual setup of our exercise, prevent at this stage any interpretation of this kind.[22] However, we see our results as making a clear case in favor of exploiting the available national information for the single monetary policy.

Several robustness checks need to be performed. In particular, we plan to check whether the gain deriving from the use of national information is sensitive to the class of rules one is

[22] For instance, throughout the simulation exercises the estimated model coefficients are taken as given, in particular those capturing the degree of inflation inertia and the slope of the Phillips curve. However, since in reality they are likely to be endogenous, it is not obvious that the policy maker would like to react to heterogeneity in these coefficients without closely monitoring their stability.

considering (for example, forward or backward looking, with a richer dynamics, with a larger conditioning set, etc).

A line of research that is also worth pursuing concerns the specification of the loss function. In place of the traditional quadratic loss function, with the deviation of inflation from the target and the output gap as arguments, it could be used a lexicographic approach, whereby the price stability objective is given the priority that the Statute of the ECB assigns to it (see Terlizzese, 1999). With a more radical departure from the basic tenet of this paper — only area-wide objectives are relevant — we could also consider the case in which the Eurosystem cares somehow about variance across countries in the euro area. Although at odds with the Eurosystem's description of its own strategy, such an attitude would not necessarily conflict with the provisions in the Treaty, which requires it to "support the general economic policies in the Community with a view to contributing to the objectives of the Community laid down in Article 2" without prejudice to the objective of price stability". Among these objectives, one finds: "to promote throughout the Community a harmonious and balanced development of economic activities, *a high degree of convergence of economic performance*, economic and social cohesion and solidarity among Member States" (Italics added). As general as they are, these objectives could in principle imply that a cost should be assigned to dispersion of economic developments across the area.

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Table 3.1

THE ESTIMATED MULTI-COUNTRY MODEL

		Equations for: Germany		Equations for: France		Equations for: Italy	
Input from:		π	y	π	y	π	y
Germany	π	0.292 [-1] (0.089) 0.600 [-4] (0.069)		0.063 [0] (restr.)		0.036 [0] (restr.)	
	y	0.095 [-1] (0.036)	0.785 [-1] (0.062)				0.173 [0] (0.058)
	r		-0.073 [-2] (0.038)				
France	π	0.108 [0] (restr.)		0.937 [-1] (0.044)			
	y			0.022 [-2] (0.012) 0.022 [-3] (0.012) 0.022 [-4] (0.012) 0.022 [-5] (0.012)	0.838 [-1] (0.052)		
	r				-0.036 [-2] (0.015)		
Italy	π					0.964 [-1] (0.010)	
	y					0.064 [0] (0.028)	0.657 [-1] (0.061)
	r						-0.038 [-1] (0.016)
	R^2	0.514	0.635	0.902	0.730	0.960	0.752
	$\overline{R}^2$	0.483	0.622	0.894	0.720	0.958	0.740
	σ	0.411	0.799	0.332	0.443	0.259	0.490
	DW	2.160	2.059	2.050	1.888	2.024	1.815

In parentheses: standard error of the coefficients.

In brackets: lag with which the variables enter the equations.

Table 4.1

CORRELATION MATRIX OF STOCHASTIC DISTURBANCES

		Aggregate supply			Aggregate demand		
		Germany	France	Italy	Germany	France	Italy
Aggregate supply	Germany	1	-0.024	0.035	-0.056	-0.009	0.167
	France		1	0.188	-0.013	-0.128	-0.058
	Italy			1	0.182	0.009	0.002
Aggregate demand	Germany				1	0.387	0.026
	France					1	0.328
	Italy						1

Table 5.1

Reaction function coefficients and loss values for the optimal, the area-wide, and the multi-country case

Parameter values in the loss function:		Type of rule	Long-run coefficients on:								Standard deviation of:			**Loss**
			Inflation				Output gap				Inflation	Output gap	Interest rate change	
			Area	Ger	Fra	Ita	Area	Ger	Fra	Ita				
$\lambda = 0$	μ=0.05	Optimal	3.74	1.98	1.09	0.68	3.85	1.28	2.24	0.33	0.53	1.31	1.32	0.37
		Multi-country	3.97	**1.82**	**1.42**	**0.73**	5.15	**2.44**	**2.22**	**0.49**	0.55	1.31	1.35	0.39
		Area-wide	**5.75**	2.56	1.58	1.62	**4.84**	2.06	1.41	1.37	0.68	1.59	1.91	0.65
	μ=1.05	Optimal	2.12	1.18	0.67	0.26	2.36	0.76	1.47	0.13	0.76	1.24	0.56	0.91
		Multi-country	2.24	**1.03**	**0.94**	**0.27**	3.31	**1.51**	**1.43**	**0.36**	0.77	1.24	0.58	0.96
		Area-wide	**3.78**	1.68	1.04	1.06	**4.74**	2.02	1.39	1.34	1.04	1.47	0.84	1.82
$\lambda = 1$	μ=0.05	Optimal	2.42	1.30	0.81	0.31	4.48	1.72	2.29	0.47	0.62	1.08	1.55	1.68
		Multi-country	2.31	**1.09**	**0.90**	**0.31**	4.36	**2.15**	**2.01**	**0.21**	0.64	1.09	1.63	1.72
		Area-wide	**4.13**	1.84	1.13	1.16	**4.90**	2.09	1.43	1.38	0.83	1.23	2.14	2.44
	μ=1.05	Optimal	1.82	1.02	0.62	0.18	2.57	0.90	1.50	0.17	0.80	1.15	0.58	2.31
		Multi-country	1.86	**0.87**	**0.80**	**0.19**	3.20	**1.52**	**1.45**	**0.23**	0.81	1.15	0.60	2.37
		Area-wide	**3.18**	1.41	0.87	0.89	**4.01**	1.71	1.17	1.13	1.11	1.32	0.85	3.72
$\lambda = 2$	μ=0.05	Optimal	2.14	1.15	0.77	0.23	4.84	1.90	2.39	0.55	0.68	1.04	1.82	2.81
		Multi-country	2.06	**0.99**	**0.84**	**0.24**	4.77	**2.28**	**2.19**	**0.30**	0.70	1.05	1.85	2.85
		Area-wide	**3.75**	1.67	1.03	1.06	**5.17**	2.20	1.51	1.46	0.92	1.17	2.42	3.87
	μ=1.05	Optimal	1.70	0.95	0.60	0.15	2.73	1.00	1.54	0.19	0.83	1.11	0.62	3.59
		Multi-country	1.72	**0.81**	**0.74**	**0.16**	3.24	**1.56**	**1.50**	**0.18**	0.85	1.12	0.64	3.66
		Area-wide	**2.95**	1.31	0.81	0.83	**3.89**	1.66	1.14	1.10	1.17	1.26	0.89	5.37

Note:
The optimal instrument rule depends on the complete set of the 15 state variables in the multi-country model, including inflation and the output gap in the various countries for different lags; the coefficients for both inflation and the output gap reported in the table are given by the sum of the coefficients for all lags and, in the case of area-wide variables, of the coefficients for all lags and countries. For the other two rules, the coefficients reported in bold are those directly resulting from the optimisation; the other coefficients are implicit and calculated as explained in Section 5 of the text.

Table 5.2

Derivatives of the reaction function coefficients with respect to the coefficients in the model equations(1)

Coefficients in the model equations(2)		Reaction function coefficients: Inflation in: Germany	Inflation in: France	Inflation in: Italy	Ouput gap in: Germany	Ouput gap in: France	Ouput gap in: Italy	Lagged interest rate
Aggregate supply equation for Germany	$\pi_{g(-1)}$	++	--	~ (+/-)	+	-	~ (+)	+
	$\pi_{g(-4)}$	++	--	~ (+/-)	+	--	~ (+)	~ (+)
	$y_{g(-1)}$	++	--	~ (+)	++	--	~ (-)	-
Aggregate demand equation for Germany	$y_{g(-1)}$	++	+/-	+/-	++	-	~ (+/-)	-
	$r_{g(-2)}$	++	--	--	~ (+/-)	--	~ (+/-)	--
Aggregate supply equation for France	$\pi_{f(-1)}$	--	++	~ (+/-)	--	++	~ (+/-)	~ (+/-)
	$y_{f(\text{various lags})}$	--	++	-	-	++	-	-
Aggregate demand equation for France	$y_{f(-1)}$	-	++	-	-	++	~ (-)	-
	$r_{f(-2)}$	--	++	--	--	++	-	--
Aggregate supply equation for Italy	$\pi_{i(-1)}$	--	--	++	+/-	--	++	~ (+/-)
	y_i	+/-	--	++	+	--	++	-
Aggregate demand equation for Italy	$y_{i(-1)}$	~ (+/-)	~ (+/-)	+	+	~ (+/-)	+	-
	y_g	+	~ (+/-)	~ (+/-)	++	~ (+/-)	~ (+/-)	-
	$r_{i(-1)}$	--	+/-	++	+/-	+/-	+	-

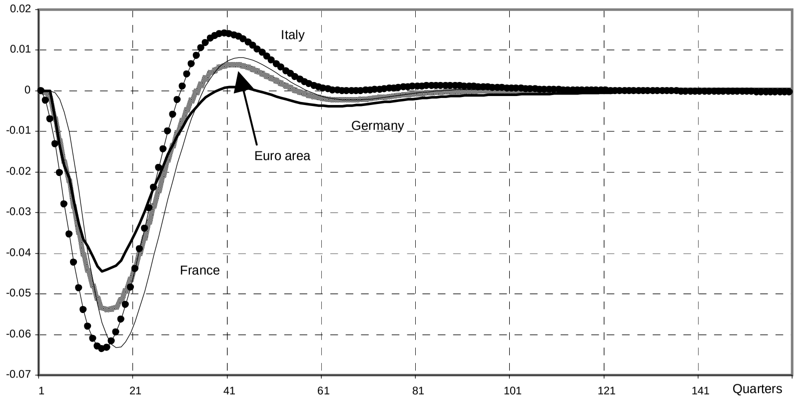
(1) "+" indicates that the dervivative is slightly positive; "++" indicates that it is positive and comparatively large; similarly for "-" and "--". "~" indicates derivatives consistently close to 0 for all λ's and μ's. "+/-" indicates that the sign of de

(2) Lags are indicated in parentheses.

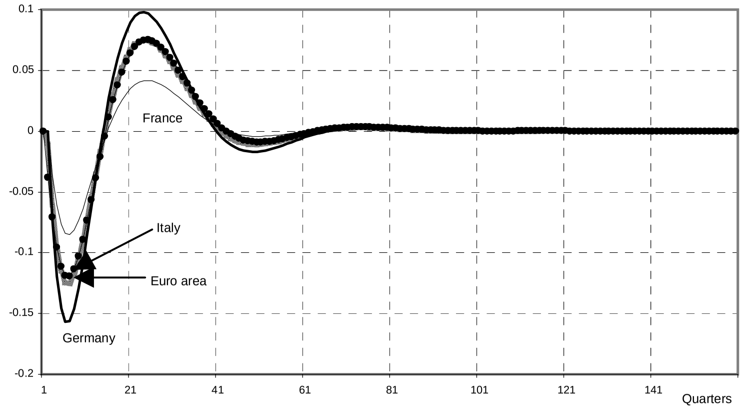
Fig. 3.1

Impulse responses to a temporary monetary policy shock (+100 b.p.)

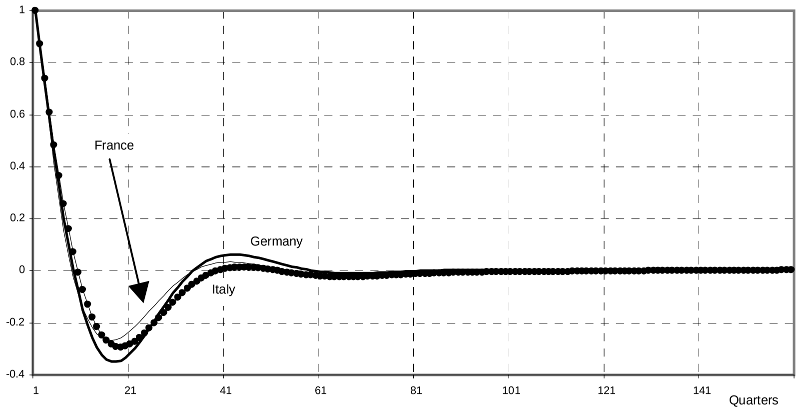
(a) Response of individual countries' and euro area inflation rate



(b) Response of individual countries' and euro area output gap



(a) Response of individual countries' real interest rate



(d) Response of euro area nominal interest rate

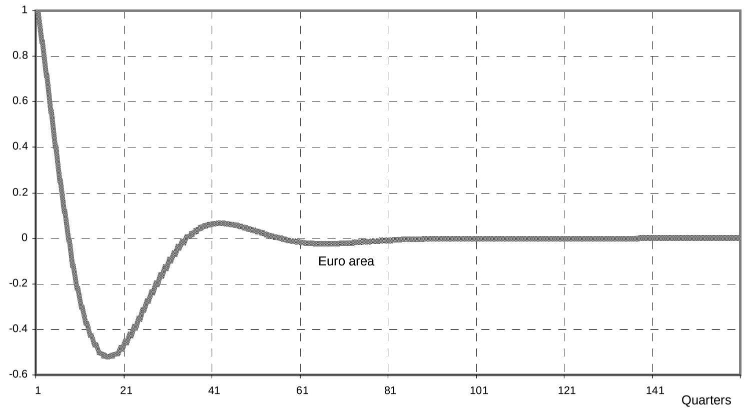
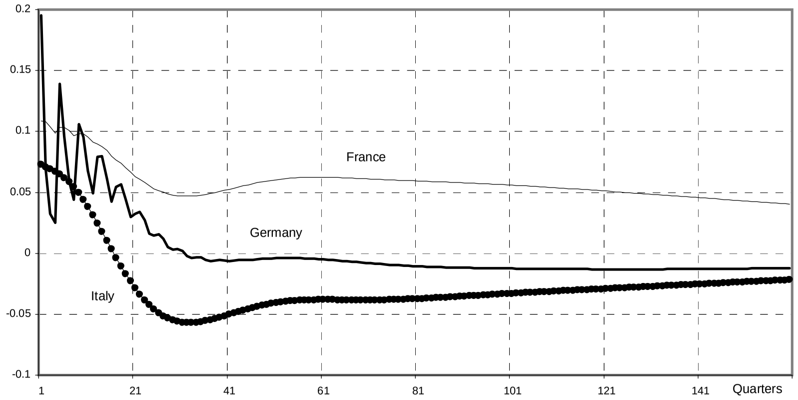


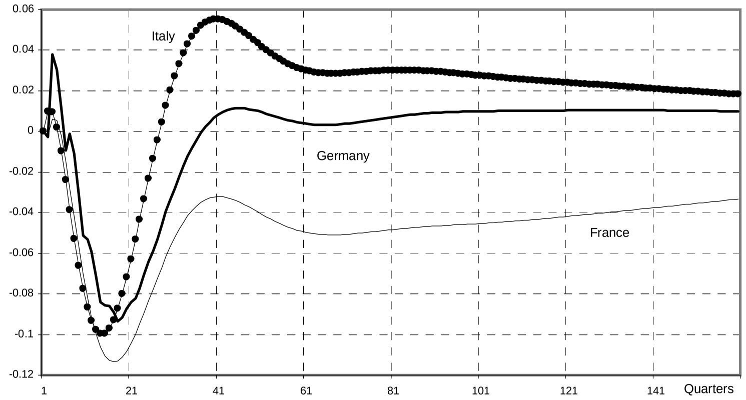
Fig. 3.2

Impulse responses to a temporary Phillips curve shock (+1 standard deviation of individual countries' stochastic terms)

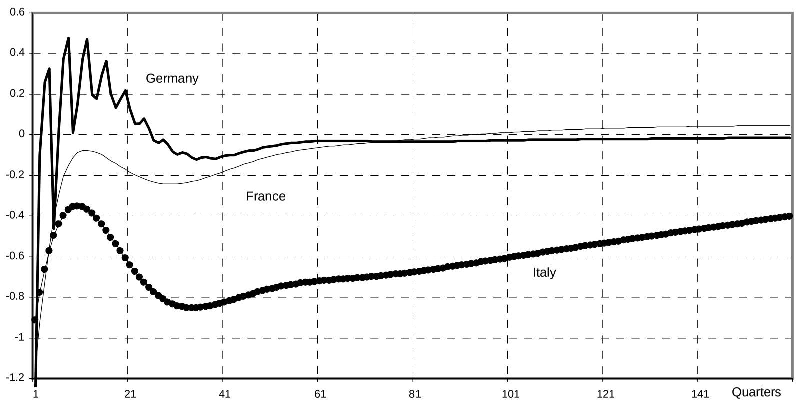
(a) Response of euro area inflation rate



(b) Response of euro area output gap



(a) Response of euro area real interest rate



(d) Response of euro area nominal interest rate

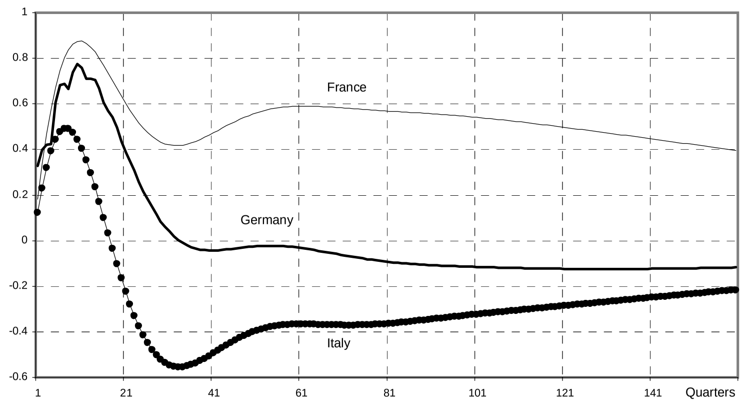
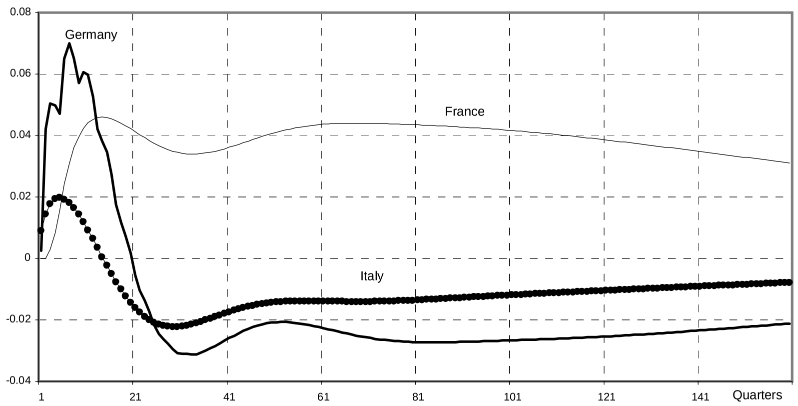


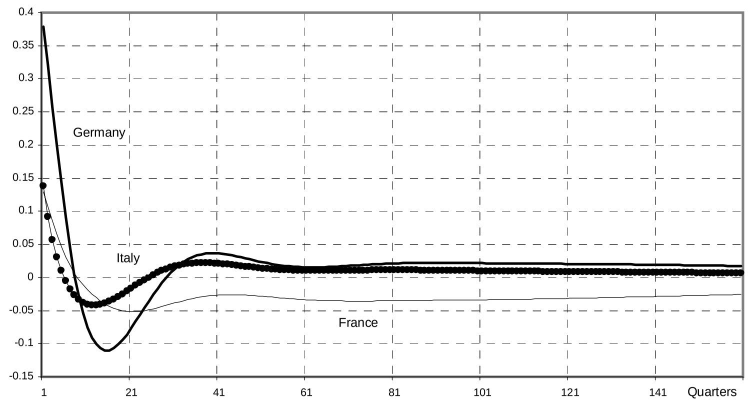
Fig. 3.3

Impulse responses to a temporary aggregate demand shock (+1 standard deviation of individual countries' stochastic terms)

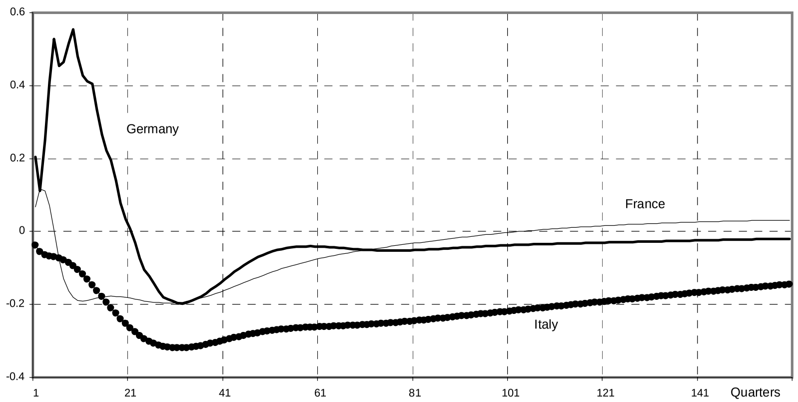
(a) Response of euro area inflation rate



(b) Response of euro area output gap



(a) Response of euro area real interest rate



(d) Response of euro area nominal interest rate

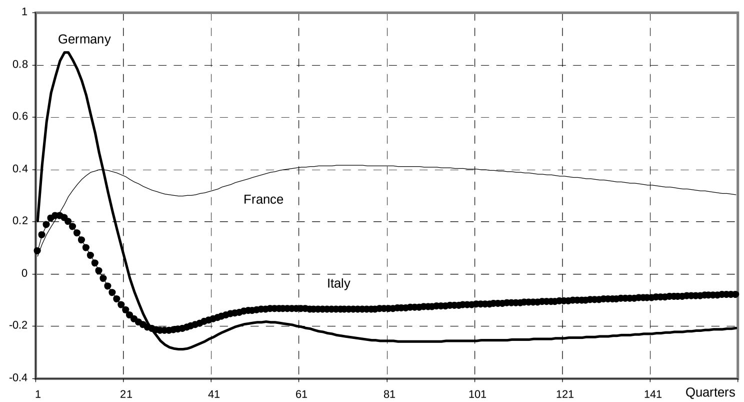
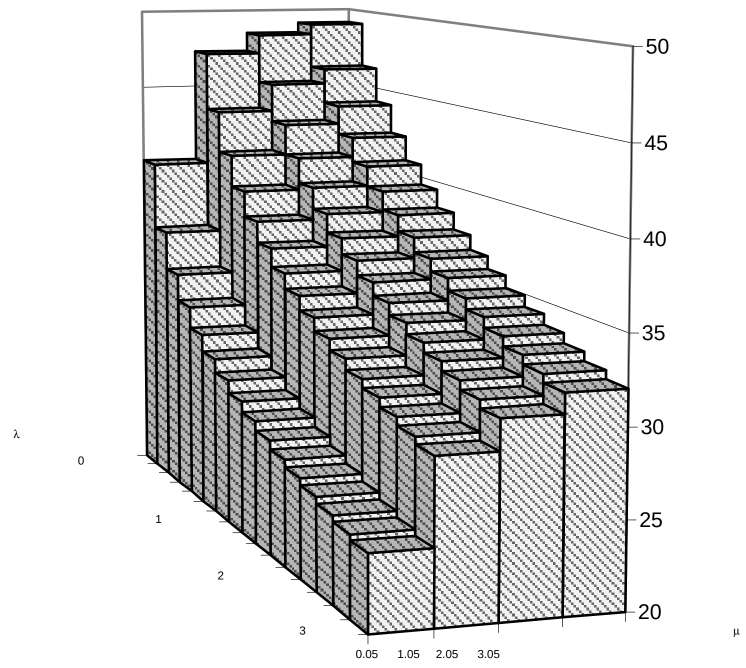


Fig. 5.1

Percentage reduction in the optimised loss function, MCIB rule vs. AWIB rule



Percentage reduction in the optimised loss function, MCIB rule vs. AWIB rule
(as a share of overall reduction -- Optimal instrument rule vs. AWIB rules)

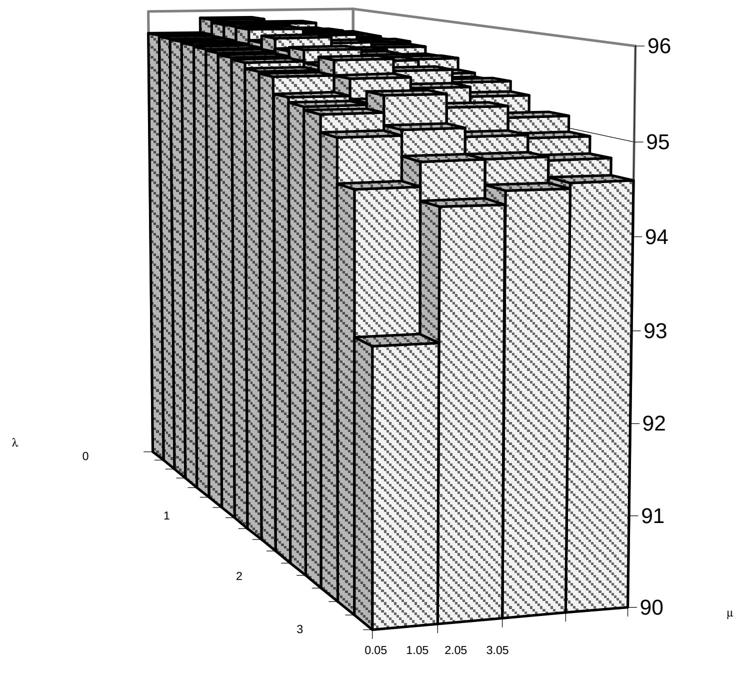
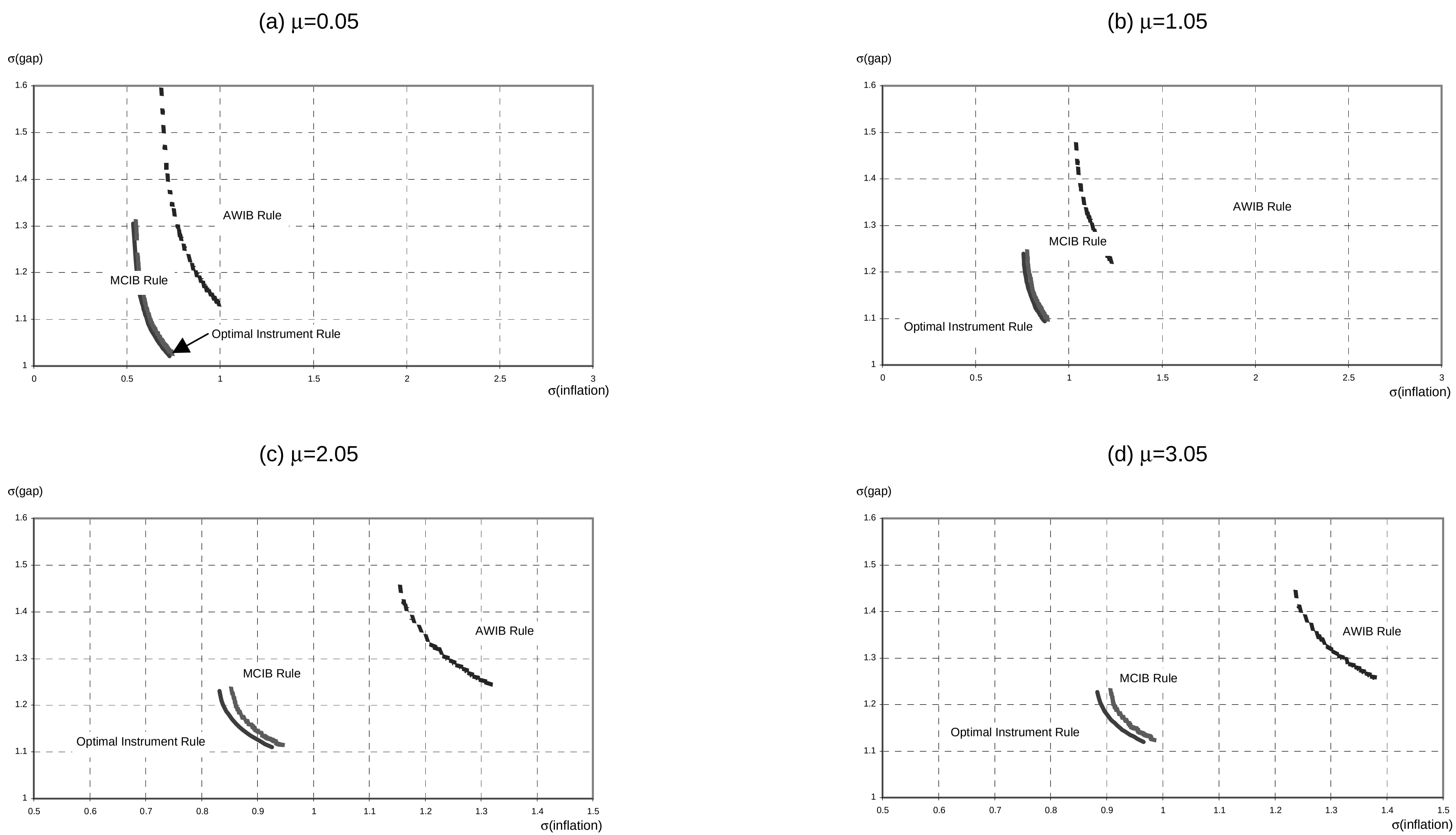


Fig. 5.2

Inflation - output gap optimal frontiers

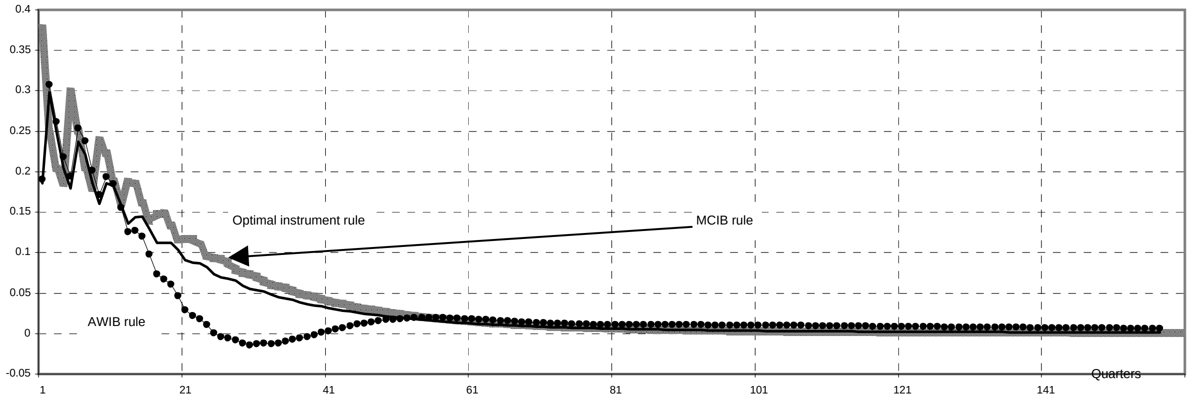


Note: in each panel, the frontiers have been computed, for given μ, by letting λ take a grid of values between 0 (north-west) and 3 (south-east).

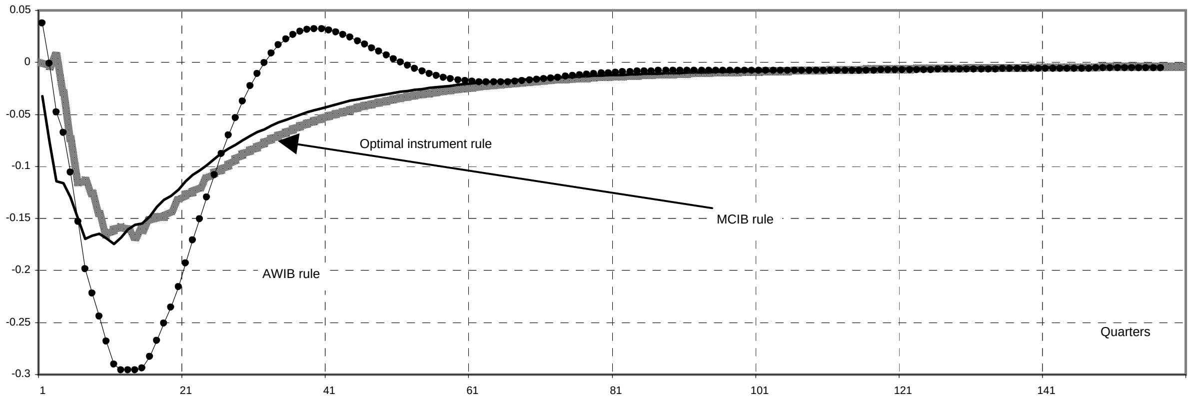
Fig. 5.3

Impulse responses to a temporary Phillips curve shock (+1 s.d. of stochastic terms) under AWIB, ICIB and optimal instrument rules

(a) Response of euro area inflation rate



(b) Response of euro area output gap



(c) Response of euro area nominal interest rate

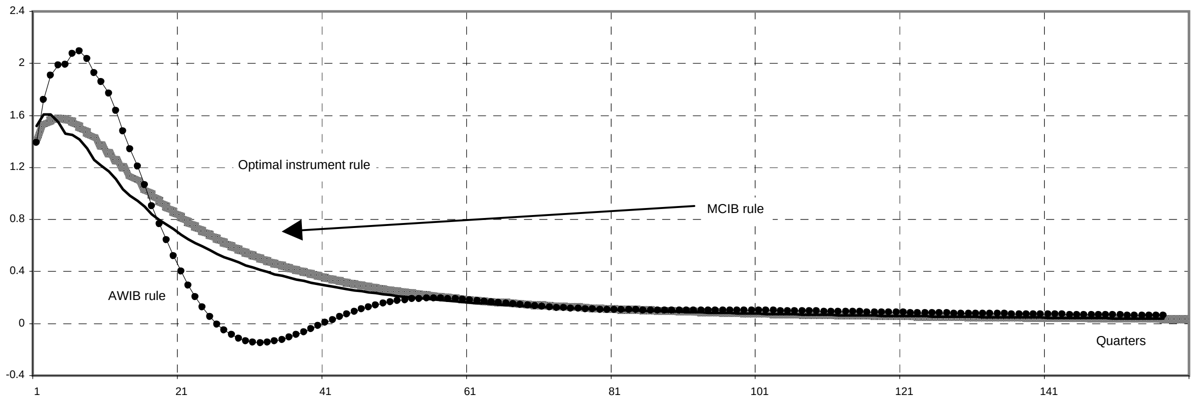
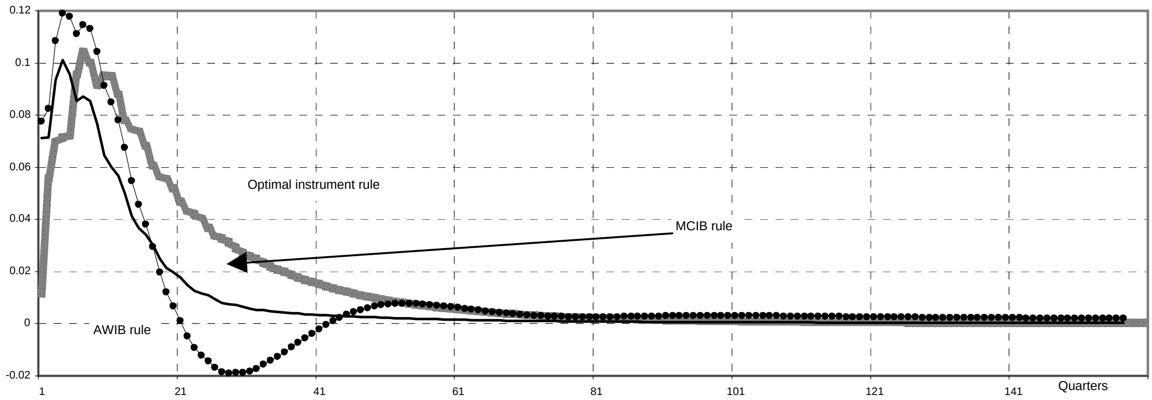


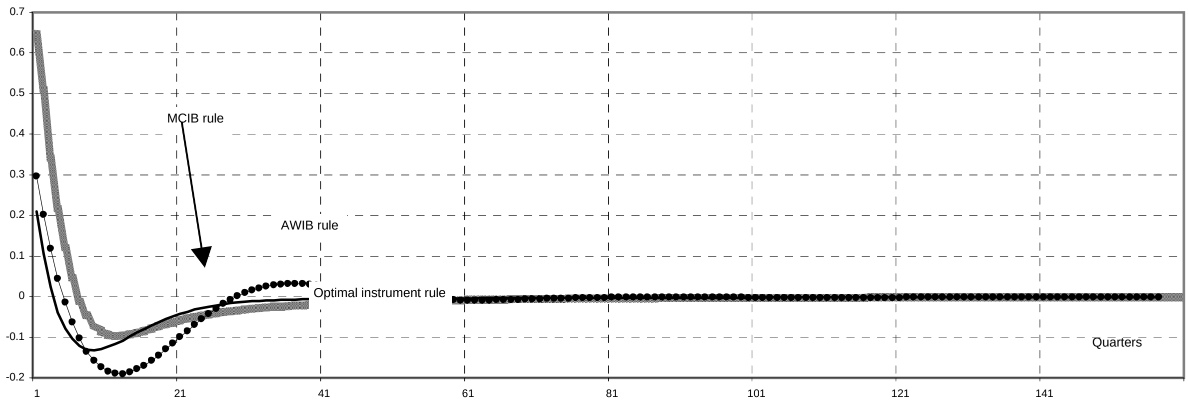
Fig. 5.4

Impulse responses to a temporary aggregate demand shock (+1 s.d. of stochastic terms) under AWIB, ICIB and optimal instrument rules

(a) Response of euro area inflation rate



(b) Response of euro area output gap



(c) Response of euro area nominal interest rate

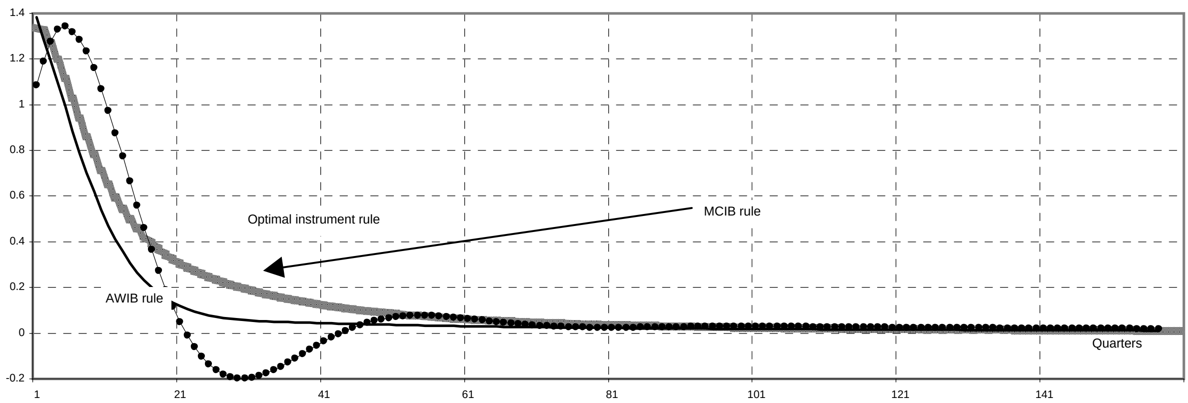
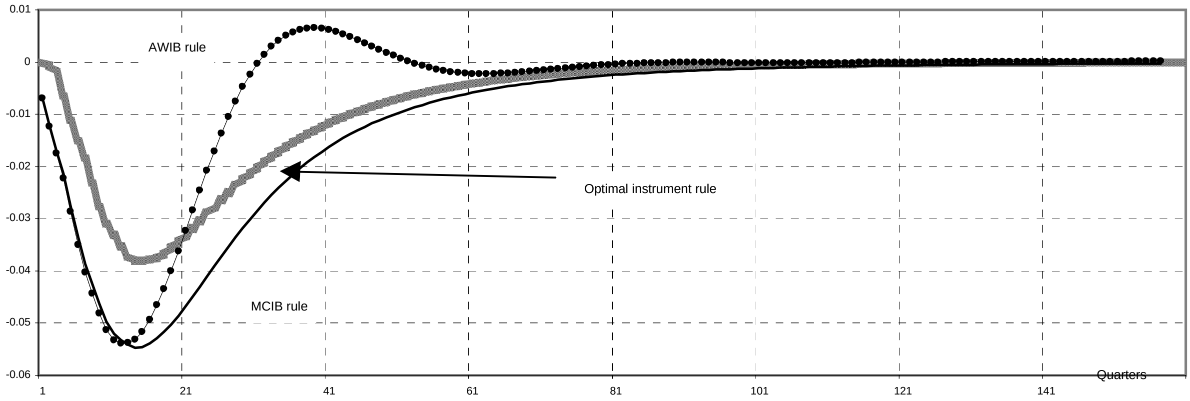


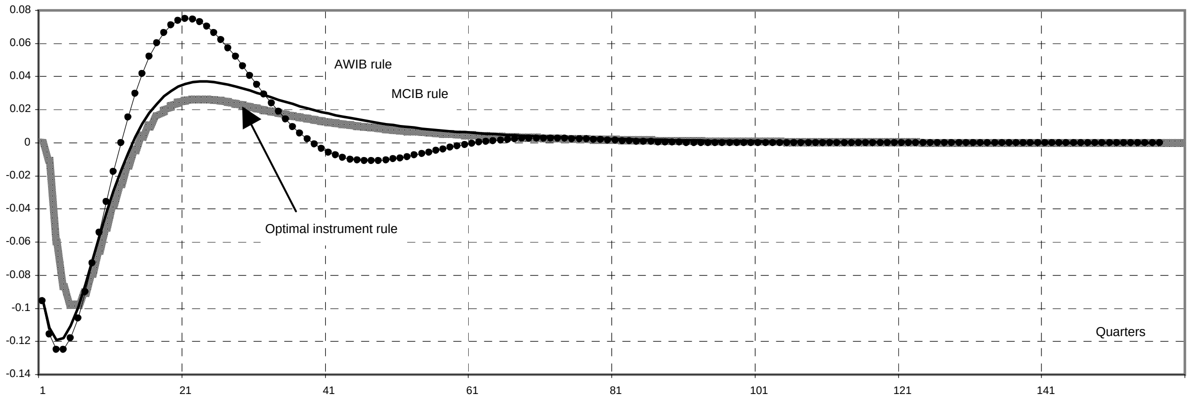
Fig. 5.5

Impulse responses to a temporary monetary policy shock (+1 s.d. of stochastic terms) under AWIB, ICIB and optimal instrument rules

(a) Response of euro area inflation rate



(b) Response of euro area output gap



(c) Response of euro area nominal interest rate

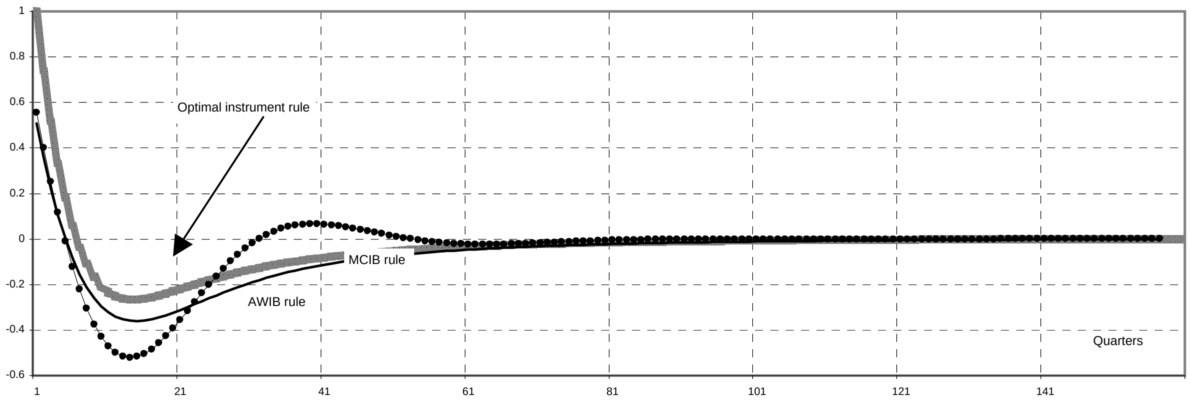


Fig. 5.6

Percentage reduction in the optimised loss function, MCIB rule vs. AWIB rule

(with identical stochastic processes in the Phillips curve and aggregate demand equation for all countries)