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Large Datasets, Small Models and Monetary Policy in Europe*

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Abstract

Nowadays a considerable amount of information on the behavior of the economy is readily available, in the form of large datasets of macroeconomic variables. Central bankers can be expected to base their decisions on this very large information set. Yet the academic profession has shown a clear preference for using small models to highlight stylized facts and to implement policy simulation exercises. Omitted information is then a potentially relevant problem. Recent time-series techniques for the analysis of large datasets have shown how a vast amount of information can be captured by few factors.In this paper we combine factors extracted from large datasets with more traditional small scale models to analyze monetary policy in Europe. In particular, we model hundreds of macroeconomic variables with a dynamic factor model, and summarize their informational content with a few estimated factors. These factors are then used as instruments in the estimation of forward looking Taylor rules, and as additional regressors in structural VARs. The latter are then used to evaluate the effects of unexpected and systematic monetary policy.

JEL Classification: E5, E52, E58

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1 Introduction

A recent strand of the econometric literature[1] has shown that very large macroeconomic datasets can be properly modelled using dynamic factor models, where the factors can be considered as an exhaustive summary of the information in the data. This approach has been successfully employed to forecast macroeconomic time series and in particular inflation. As a natural extension of the forecasting literature, Bernanke and Boivin (2000) proposed to exploit these factors in the estimation of forward looking Taylor rules for the US, in order to mimic more closely the behavior of central bankers, whose decisions are likely to be based on a substantial amount of information. In this paper we plan to extend the structural interpretation of dynamic factor models in two directions: first we try and provide an evaluation of the importance of factors for a better understanding of monetary policy; second we incorporate factors in small structural macro models to evaluate the implication of their use for the design of monetary policy and the evaluation of its effects.

We concentrate on European data and we provide an evaluation of the importance of the factors for a better understanding of monetary policy by using the same method adopted by Bernanke and Boivin(2000) for the US case: we compare the results of the estimation of forward-looking Taylor rules in a baseline model where factors are not included among the instruments used to forecast the future state of the economy with those obtained in an alternative scenario where factors are included among the instruments.

To evaluate the implication of the factors for the design of monetary policy and the evaluation of its effects we consider again two scenarios obtained

[1]Stock and Watson (1998, SW), Forni and Reichlin (1996, 1998) and Forni et al. (1999, 2000)

by building structural VAR models for all the instruments used in the forward looking Taylor rules. The baseline scenario is therefore a standard structural VAR model for the analysis of monetary policy, which we augment by including the factors in the alternative scenario. Within this framework, we assess the importance of the inclusion of the factors by analyzing the impact of both anticipated and unanticipated monetary policy. We consider anticipated monetary policy for two reasons. First, we show that the simulation of monetary policy in Europe within this framework is robust to some form of mis-specification of the VAR because of omitted variables; second the most remarkable deviations from Taylor rules in non-German European countries occurred in occasion of exchange rate crises. These are not the interesting shocks in the new EMU regime. Our results reinforce the arguments provided by Cochrane(1998) and Hoover and Jordà (2001) in favor of the analysis of systematic monetary policy.

The paper is organized as follows. In Section 2 we briefly review the econometrics of factor models, describe the dataset we use, and estimate Taylor rules with and without the estimated factors as instruments. In Section 3 we evaluate the effects of unexpected monetary shocks on the output gap and inflation, using structural VARs with and without the estimated factors as regressors. In Section 4 we adopt the same models to study the effects of systematic monetary policy. In Section 5 we summarize the main results and provide some concluding remarks.

2 Understanding monetary policy in Europe

In this section we evaluate the importance of the estimated factors from large datasets in understanding monetary policy in Europe. We compare the results of the estimation of standard forward-looking Taylor rules with those obtained when the factors are included in the information set relevant to the central bankers to determine their policy rates. We first briefly describe how the factors are constructed and can be used in Taylor rules; then we present results for the four largest countries in the monetary union.

Our dataset comes from Marcellino, Stock and Watson (2000a, 2000b), to whom we refer for additional information, details on data transformations, and a complete list of the variables. It includes the OECD main economic indicators, monthly, for the period 1982:1-1997:8, for all the countries in the EMU in the year 2000. There are about 50 variables for each country, that usually contain, among others, industrial production and sales (disaggregated by main sectors); new orders in the manufacturing sector; employment, unemployment, hours worked and unit labor costs; consumer, producer, and wholesale prices (disaggregated by type of goods); several monetary aggregates (M1, M2, M3), savings and credit to the economy; short term and long term interest rates, and a share price index; the effective exchange rate and the exchange rate with the US dollar; several components of the balance of payments; and other miscellanea variables.

To model these variables we use a factor model, whose standard formulation is

$$X_t = \Lambda F_t + e_t, \qquad (1)$$

where F_t is a $r \times 1$ vector of common factors, whose loadings are grouped in the $N \times r$ matrix Λ, e_t is an $N \times 1$ vector of idiosyncratic disturbances, N is the number of variables under analysis, much larger than r, and $t = 1, ..., T$. Note that this representation nests also models where X_t depends on lagged values of the factors, see SW for details.

SW showed that the factors can be consistently estimated by the first r principal components of X, even in the presence of moderate changes in the loading matrix Λ. For this result to hold it is important that the estimated number of factors, k, is larger or equal than the true number, r. Bai and Ng (2000) proposed a set of selection criteria to choose k. For the EMU dataset, just 4 or 5 factors are selected. We will assume $k = 6$ for safety. It is also worth noting that the factors are not uniquely identified, but this is not a problem in our context because we will not attempt a structural interpretation of the estimated factors.

We will consider two types of factors. The first one is obtained from a model where X_t includes all the variables in the dataset. The second one is specific for each country, i.e., X_t only includes the variables of a specific country. Marcellino et al (2000b) refer to the former as pooled factors and to the latter as country-specific factors. They show that the correlation between the pooled and the country specific factors is rather high, which suggests a substantial homogeneity of the EMU area. Yet, some differences still remain so that an evaluation of the relative merits of the alternative types of factors is required.

The estimated factors are particularly useful for forecasting inflation. Hence, they can be exploited to produce the inflation forecasts that appear in a forward looking Taylor rule. More precisely, following Clarida, Gali and Gertler (1998, CGG), we assume the Taylor rule for Germany takes the form

$$r_t^* = \overline{r} + \beta(\pi_{t+12}^e - \pi_t^*) + \gamma(y_t - y_t^*), \tag{2}$$

where r_t^* is the target nominal interest rate, $\overline{r}$ is the equilibrium rate, π_{t+12}^e is the forecast of the one year inflation rate made in period t, y_t is real output, and π_t^* and y_t^* are the desired levels of inflation and output. The parameter β indicates whether the target real rate adjusts to stabilize inflation ($\beta > 1$) or to accommodate it ($\beta < 1$), while γ measures the concern of the central bank for output stabilization.

Some modifications to (2) are required for France, Italy and Spain, in order to capture their commitments to remain in the ERM and, later on, to join the EMU. In particular, we assume that the target inflation rate coincides with the German one, and there is a willingness to follow the Bundesbank's monetary policy. Hence, the Taylor rules for these three countries can be written as

$$r^*_{it} = r_t + \beta(\pi^e_{it+12} - \pi^*_t) + \gamma(y_{it} - y^*_{it}), \quad (3)$$

where i indexes the country and r_t is the actual German rate.

We then suppose that in all countries the actual rate partially adjusts to the target rate r^*, so that

$$r_t = (1-\rho)r^*_t + \rho r_{t-1} + v_t, \quad (4)$$

where the smoothing parameter ρ satisfies $0 \leq \rho \leq 1$,and v_t is an interest rate shock.

Combining (2) and (4), and substituting the forecasts with their realized values, it follows for Germany that

$$r_t = \alpha + (1-\rho)\beta(\pi_{t+12} - \pi^*_t) + (1-\rho)\gamma(y_t - y^*_t) + \rho r_{t-1} + \epsilon_t, \quad (5)$$

where $\alpha = (1-\rho)\overline{r}$ and $\epsilon_t = (1-\rho)\beta(\pi^e_{t+12} - \pi_{t+12}) + v_t$. For the other countries

$$r_{it} = (1-\rho)r_t + (1-\rho)\beta(\pi_{it+12} - \pi^*_t) + (1-\rho)\gamma(y_{it} - y^*_{it}) + \rho r_{it-1} + \epsilon_{it}. \quad (6)$$

As a measure of π^*_t we use the official inflation target for Germany, while the potential output y^*_t is the Hodrick Prescott filtered version of the actual output series. For the interest rate, we use 3-month rates, in particular the

Fibor for Germany, the Pibor for France, and the interbank rate for Italy and Spain.

The parameters α, β, γ, and ρ in (5) and (6) are estimated by GMM, appropriately corrected for the presence of an MA component in the errors, over the sample 1983:1-1997:8 for all countries, except for Spain where the starting date is 1984:1.[2] The basic set of instruments mimics the choice in CGG and includes lagged values of the regressors, of the dependent variable, of a raw material price index, and of the real exchange rate with the US dollar. We then add the estimated factors to this set. Their use as instruments follows a suggestion in Bernanke and Boivin (2000) and, as noted before, is justified by their usefulness for forecasting inflation. Hence, the extended set of instruments should yield more precise estimates of the coefficients of the Taylor rule.[3]

We consider adding four sets of factors in turn. First, the country specific (CS) factors. Second, the pooled (PL4) factors that are extracted after merging the datasets for the four countries under analysis. Third, the pooled (PL) factors extracted from the dataset for all the 11 countries originally in the EMU. Fourth, CS and PL factors. These choices reflect the possible information used by the central bankers: either only national, or international but limited to the largest economies, or for the whole EMU area, or a combination of domestic and international. Note that if the countries in

[2] The choice of the starting date can affect the precision of the estimated coefficients. For example, we could reproduce CGG results for Germany starting the estimation in 1978, but not in 1982, which yielded substantially larger standard errors. This is likely due to the presence of extreme values at the beginning of the estimation period, reflected in very large residuals. Our choice of the sample period aims at avoiding these start-up effects. Our results are also different from those in Mihov (2001), because he uses quarterly data and an alternative specification for the reaction function.

[3] We have also experimented with the inclusion of contemporaraneous values of all instruments, which did not substantially alter our results.

the EMU were very homogenous, the choice of the type of factors would not matter because the CS and PL factors should be very similar.

The results are summarized in Table 1.

Insert Table 1 here

The most striking conclusion is that for virtually all countries and coefficients adding any set of factors to the set of instruments increases substantially the precision of the estimates, as measured by the t statistic. The set of factors that performs best is CS plus PL, but the differences are usually minor. We will comment upon this specification, but the estimated coefficients are rather similar for the other choices of factors.

First, the estimated value of β is larger than one for all countries, which suggests that the target real rate adjusts to stabilize inflation. The value of β is equal to 1.74 for Italy, 1.72 for Spain, 1.26 for France and 1.10 for Germany. The former two coefficients are also statistically different from one, while those for Germany and France are not.

Second, the estimated value of γ is larger than one for all countries, more so for Spain and Italy with values of 1.68 and 1.63, versus 1.06 for France and 1.30 for Germany. Yet, the standard errors around these point estimates are rather large, larger than those for β.

Third, the estimated values of ρ are very similar across countries, in the range $0.96-0.97$. These figures indicate a very sluggish adjustment of policy rates to their targets.

The values of the adjusted R^2 are in the range $0.96-0.98$, and the J-test for the validity of the instruments never rejects the null. It is interesting to note that the inclusion of afactors in the instrument sets does not alter substantially the standard errors of all the regressions. Given that the error terms in our estimated models are $\epsilon_{i,t} = (1-\rho_i)\beta_i(\pi^e_{i,t+12} - \pi_{i,t+12}) + v_{i,t}$, this evidence can be explained by the very high value of all the $\rho_i's$. However, it is important for us to determine whether the high value of the $\rho_i's$ is the only factor behind this evidence. In fact, another potential explanation is that the inclusion of factors in the information set has a very limited impact on the forecast for one-year ahead inflation. The explicit estimation of the model for twelve month-ahead inflation implicit in our GMM approach shows that the inclusion of factors leads to a reduction of the standard error inflation forecasts from 0.90 to .76 for Germany, from 0.43 to 0.37 for France, from 1.08 to 0.75 for Italy and from 1.03 to 0.76 for Spain.

These results highlight the importance of the information contained in large datasets for the estimation of Taylor rules, and indicate that the latter provide a good tracking of the behavior of European central banks over the period under consideration. In the next section we will compare their performance with that of small scale monetary VARs, and evaluate the role of the factors in this context.

3 The effects of different unexpected monetary policies

We have seen that the inclusion of factors in forward-looking Taylor rules reduces sizably the uncertainty on estimated parameters. However does it make any difference? In other words to what extent the inclusion of factors in small macro models changes our understanding of the effects of monetary policy? We try and provide an answer to this question by starting from the most standard approach used to evaluate monetary policy, i.e. VAR models. We estimate baseline VAR models for our four European countries with a specification consistent with the forward-looking Taylor rules estimated in the previous section:

$$\mathbf{A}\left[\begin{array}{c}\mathbf{X}_t\\ i_t\end{array}\right]=A\left(L\right)\left[\begin{array}{c}\mathbf{X}_{t-1}\\ i_{t-1}\end{array}\right]+\mathbf{B}\left[\begin{array}{c}\mathbf{u}_t\\ u_t^m\end{array}\right]$$

where the vector $\mathbf{X}_t$ contains domestic output gap, domestic inflation, commodities price inflation, and the US Dollar-Deutschemark exchange rate in the case of Germany, while for the other three European countries the US Dollar-Deutschemark exchange rate is substituted with the exchange rate of the local currency vis-a-vis the Deutschemark, and the German policy rates. The domestic policy rate is i_t. We then consider an alternative scenario based on the inclusion of the factors in $\mathbf{X}_t$. The specification of the lag length is chosen consistently with the specification of instruments in the forward looking Taylor rules estimated in the previous section. We are only interested in the identification of monetary policy shocks, and again we identify them consistently with the choice of instruments in the Taylor rules. Therefore given the ordering of variables specified above, the $\mathbf{A}$ is a lower triangular matrix with two exceptions: the German policy rate does not contemporaneously react to any variables, and all non-German policy rates contemporaneously react to the German policy rate only. We interpret our equations for policy rates as reduced form of the forward looking Taylor rules. Figure 1, which reports the residuals from the Taylor rules and the residuals from the VAR, for our four countries of interest, clearly validates our interpretation.

Insert Figure 1 here

We evaluate the importance of the inclusion of factors by looking at the response of main macro variables, output gap and inflation, to domestic monetary policy in the baseline and in the alternative scenario.

We report in Figure 2 the responses of the output gap and inflation to a monetary policy shock, in the four countries under analysis. The figures also contain the response of policy rates to an own shock. To help interpretation we report point estimates of the impulse responses alongwith their ninety-five confidence intervals computed analytically in the baseline scenario.

Insert Figure 2 here

The comparative analysis of the impulse responses shows that, in general, impulse responses generated by models including factors feature a stronger impact on the output gap, and more believable effects of monetary policy on inflation. For all countries the inclusion of the factors leads to the elimination of the price puzzle, similarly to what Bernanke and Boivin(2000) noted for the US case, except for Germany where nonetheless the response improves.[4] The persistence of the effects on the interest rate also in general decreases with the factors.

For all variables the precision of the estimated impulse responses increases. This last point is illustrated by Figure 3, which analyses the responses of German macroeconomic variables to German monetary policy. We report impulse responses and their confidence intervals by considering in turn VAR with and without factors.

Insert Figure 3 here

Lastly, we dare and consider[5] the response of the French, Italian and Spanish output gap and inflation to a German monetary policy shock. Given the leading role of the Bundesbank in the period under analysis, the German rate could be taken as a proxy for a common monetary policy.

[4] The responses for Germany are similar to those in Bernanke and Mihov (1997) using the call rate.

[5] Chris Sims suggested us to include a footnote with a word of caution related to the Lucas'critique. He also added "small" when referring to the size of the footnote.

Insert Figure 4 here

The responses are in general not significant, although the inclusion of factors determines an analogous pattern in the response of inflation to a shock in domestic rates, except for Spain. Output gaps respond very little to a German policy shock in all countries, while domestic interest rates feature a long-run unit elasticity to these shocks. No relevant asymmetries emerge across non German countries, although the low precision of the estimates suggests caution in interpreting these results.

3.1 Why is Germany so different?

The analysis of the responses of macro variables to monetary policy shocks in the Euro area singled out Germany as the only country featuring "perverse" responses of output to identified monetary policy shocks. In this section we provide a potential explanation for our findings and we propose to consider the responses of macro variables to expected monetary policy as a viable alternative.

Our specification of forward-looking Taylor rules is not derived explicitly from the optimization problem of the monetary policy maker. We follow a general structure in which Germany is the leader and the other European countries followed to keep the parity with the German currency. However, given that the leader has always professed a policy of monetary targeting, we argue that such behavior might cause some identification problems for the type of structural VAR we have employed. Consider the following simple stochastic representation for the German economy :

$$
\begin{aligned}
y_t - y_t^* &= b_0 + b_1\left(y_{t-1} - y_{t-1}^*\right) - b_2\left(R_{t-1} - \pi_{t-1}\right) + u_t^d && (7)\\
\pi_t &= \pi_{t-1} + c_1\left(y_{t-1} - y_{t-1}^*\right) + u_t^s && (8)\\
\Delta R_t &= a_1\left(y_t - y_{t-1} + \pi_t - \Delta m_t\right) + u_t^{md} && (9)\\
\Delta m_t &= \Delta m_t^* + u_t^{ms} && (10)\\
\Delta m_t^* &= \pi_t^* + \Delta y_t^* && (11)
\end{aligned}
$$

where equations$(7)-(8)$ are simple representations of the aggregate demand and supply, (9)is an inverted money demand equations which serves the purpose of determining interest rates as the central bank controls money supply, money supply is determined optimally by the money targeter. From equation (10)we have $E\left(\Delta m_t\right) = \Delta m_t^*$, where Δm_t^* is determined by (11) ,which is consistent with the well-known P-star model. The desired rate of growth of money is obtained by looking at the equilibrium money demand where policy rates are constant, inflation is at its target level and GDP grows at its potential rate. The system admits a structural three-dimensional VAR representation in the two macro variables and the policy rate.

$$
\begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ -a_1 & -a_1 & 1 \end{bmatrix}
\begin{bmatrix} y_t - y_t^* \\ \pi_t \\ R_t \end{bmatrix}
=
\begin{bmatrix} b_1 & b_2 & -b_2 \\ c_1 & 1 & 0 \\ -a_1 & 0 & 1 \end{bmatrix}
\begin{bmatrix} y_{t-1} - y_{t-1}^* \\ \pi_{t-1} \\ R_{t-1} \end{bmatrix}
+
+ \begin{bmatrix} b_0 \\ -a_1\pi_t^* \\ 0 \end{bmatrix}
+ \begin{bmatrix} u_t^d \\ u_t^s \\ u_t^{md} - a_1 u_t^{ms} \end{bmatrix}
$$

In particular, the third equation models policy rates as follows:

$$
\Delta R_t = a_1 \Delta\left(y_t - y_t^*\right) + a_1\left(\pi_t - \pi_t^*\right) + u_t^{md} - a_1 u_t^{ms}. \qquad (12)
$$

(12) illustrates clearly that a VAR model based on policy rates and macro variables can be still specified even if the monetary policy authority is a

money targeter. However,substituting money growth with its determinants results in an equation for the policy rates in which monetary policy shocks cannot be identified from money demand shocks. Therefore the derived impulse responses cannot be interpreted as the responses of the economy to monetary policy shocks, a point similar to that in Canova and Pina (1999). Our empirical evidence seems to sustain the above interpretation. Results are different for non-German countries where our specified Taylor rules are consistent with a scenario in which concerns for exchange-rate pegging have been the main determinant of policy-rates in the long-run. Interestingly, expected monetary policy is not affected by this potential mis-specification. In the next section we shall therefore consider how different are the responses of the economy to monetary policy rates when dynamic factors are explicitly included in the small macro model of interest.

4 The effect of different systematic monetary policies

To assess the impact of factors in the determination of systematic monetary policy and the evaluation of its effects we dynamically simulate the following model for each of our four countries of interest:

$$\begin{bmatrix} \mathbf{X}_t \\ i_t \end{bmatrix} = A(L) \begin{bmatrix} \mathbf{X}_{t-1} \\ i_{t-1} \end{bmatrix} + \begin{bmatrix} \mathbf{u}_t \end{bmatrix}.$$

The vector $\mathbf{X}_t$ contains all the variables included in the VAR for the baseline case and it is augmented with the factors in the alternative scenario. Note that, to the aim of simulating different expected monetary policies, we keep shocks to all variables in the vector $\mathbf{X}_t$ in the dynamic simulation but we exclude the shocks to the interest rate equations. The results are reported in Figure 5, which reports for each country the path of simulated policy rates, the output gap and inflation, alongwith the observed variables.

Insert Figure 5 here

The inclusion of the factors does not seem to generate a sizeable difference in the path of simulated policy rates in all countries, with the notable exception of Germany where the path of policy rates is much smoother when the model without factors is simulated. However, such smoothness is not a property of the observed data. Interestingly the comparison of actual and simulated data shows that the most relevant deviations between the two type of series occurred in occasion of currency crises, e.g. in 1992, when monetary policy had to be unexpectedly tight to deal with the crises. Differences among the baseline and the alternative scenarios are even less important in the simulation of macroeconomic variables, whose behavior is strongly dependent on non-monetary shocks and very weakly sensitive to different expected monetary policies. The largest differences are for inflation in Germany and Italy, where the actual figures are closest to the simulated ones when the CS-PL factors are included in the model.

The relevant moments of the inflation, output gap and policy rate are summarized in Table 2 for actual and simulated series.

Insert Table 2 here

The numbers reported in the Table show that it would be very hard to sustain that the inclusion of dynamic factors in small structural models has quantitatively relevant implications for the analysis of the effects of monetary policy. In other words, the factors seem to play a relevant role for understanding monetary policy, but their inclusion in small models does not lead to different effects of simulated monetary policy on inflation and the output gap. However the inclusion of factors does lead to a sizeable reduction in the uncertainty which affects the simulated series. We report in figure 6 the ninety-five per cent bounds of simulated series from the baseline model without factors and from the model augmented to include country-specific and pooled factors

Insert Figure 6 here .

Interestingly the more dramatic reduction in the uncertainty surrounding simulations is obtained when looking at the path of German policy rates. Such evidence is consistent with our explanation of the puzzling results obtained when analyzing German monetary policy with VAR models. Augmenting the model with factors greatly reduces the damage caused by the omission of money from the VAR information set when money is taken as a relavant intermediate target by the policy maker.

5 What have we learned?

The better way to summarize our results is probably a brief evaluation of what we have learned from the empirical investigation. Our first evidence is that forward-looking Taylor rules for European countries are more precisely estimated when factors are included. This evidence can be interpreted as a clear signal of the fact that central banks employ a much wider information set than that included in small macroeconometric models to forecast inflation and set their policy rates. Two questions arise naturally at this point:

a) Does this really matter? Are the effects of the mis-specification generated by under-parameterization statistically significant and economically important?

b) How far do we go in simply augmenting the small structural models with the information contained in the factors? In particular, is it possible within a framework which is still very simple to provide some indication to the monetary policy maker on how to react when the factors give an early warning of deviation of macroeconomic variables from their targets?

We have tried and provided an answer to these two questions by evaluating the differences in the analysis of the effects of monetary policy between simple models with and without factors. We have considered the effects of both shocks and expected monetary policy. The second type of simulation is justified by the peculiarity of the identification problem in the European context, and by the fact the deviation of monetary policy from the predominant rules occurred mainly on occasion of exchange rate crises.[6]

Our analysis of the effects of identified monetary policy shocks clearly showed that more precise and more credible responses are obtained when the factors are included in the specification. Again, we interpret this as evidence of the fact that central banks used a wider information set than that usually employed the econometrician. The inclusion of the factors can help in obtaining more precise stylized facts on the effects of monetary policy.

When we have instead considered the effects of systematic monetary policy, we have noted that the inclusion of the factors generated minor differences in the dynamic path of macroeconomic variables but it greatly reduced uncertainty ont the simulated series. The effects of systematic monetary policy on output and inflation in Europe are much more precisely estimated when the structural models are augmented with factors.

[6]Hopefully, these are not going to be the relevant shocks in the EMU.

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Table 1: Forward-looking Taylor rules fo Europe

		Germany	*France*	*Italy*	*Spain*
$\beta(s.e.)$	CGG	1.95 (0.705)	0.83 (0.188)	1.70 (0.142)	1.47 (0.162)
	CS	1.26 (0.202)	0.91 (0.196)	1.71 (0.148)	1.67 (0.138)
	PL4	2.35 (1.507)	1.24 (0.184)	1.73 (0.138)	1.46 (0.150)
	PL	1.14 (0.179)	1.16 (0.180)	1.67 (0.135)	1.52 (0.145)
	CS+PL	1.10 (0.159)	1.26 (0.156)	1.72 (0.127)	1.74 (0.132)
$\gamma(s.e.)$	CGG	2.42 (1.851)	1.20 (0.273)	1.61 (0.481)	1.69 (0.384)
	CS	1.30 (0.379)	1.24 (0.249)	1.69 (0.522)	1.60 (0.375)
	PL4	3.73 (4.312)	1.38 (0.285)	1.62 (0.485)	1.33 (0.378)
	PL	1.38 (0.388)	1.57 (0.278)	1.78 (0.503)	1.53 (0.368)
	CS+PL	1.30 (0.330)	1.06 (0.207)	1.63 (0.452)	1.68 (0.345)
$\rho(s.e.)$	CGG	0.99 (0.009)	0.95 (0.005)	0.97 (0.005)	0.97 (0.005)
	CS	0.97 (0.008)	0.96 (0.004)	0.98 (0.004)	0.97 (0.005)
	PL4	0.99 (0.008)	0.96 (0.004)	0.98 (0.004)	0.97 (0.004)
	PL	0.97 (0.007)	0.96 (0.005)	0.97 (0.004)	0.97 (0.004)
	CS+PL	0.97 (0.007)	0.96 (0.004)	0.97 (0.004)	0.97 (0.004)
R^2	CGG	0.986	0.972	0.966	0.961
	CS	0.985	0.972	0.966	0.960
	PL4	0.985	0.973	0.965	0.960
	PL	0.985	0.972	0.966	0.960
	CS+PL	0.985	0.972	0.965	0.960
S.E. of Regression	CGG	0.244	0.425	0.581	0.631
	CS	0.245	0.423	0.582	0.634
	PL4	0.244	0.422	0.582	0.630
	PL	0.245	0.424	0.582	0.631
	CS+PL	0.246	0.421	0.582	0.634
J-Stat (Prob)	CGG	22.94 (0.974)	27.43 (0.992)	27.60 (0.992)	25.83 (0.996)
	CS	26.85 (0.981)	30.19 (0.996)	29.45 (0.997)	26.36 (0.999)
	PL4	24.24 (0.993)	30.14 (0.996)	28.95 (0.998)	26.27 (0.999)
	PL	26.96 (0.979)	29.82 (0.997)	29.10 (0.998)	26.22 (0.999)
	CS+PL	27.35 (0.996)	31.42 (0.999)	29.99 (0.999)	26.89 (0.999)

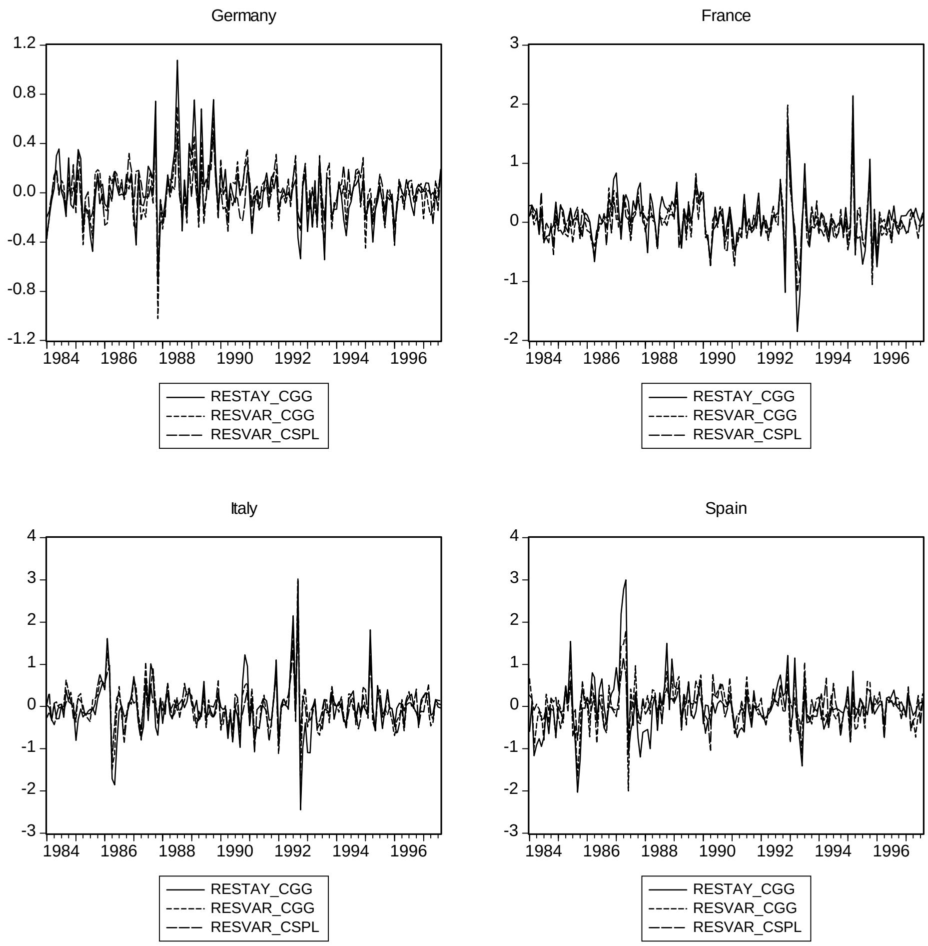
Notes: the estimated equations are $r_t = \alpha + (1-\rho)\beta(\pi_{t+12} - \pi_t^*) + (1-\rho)\gamma(y_t - y_t^*) + \rho r_{t-1} + \epsilon_t$ for Germany and $r_{it} = (1-\rho)r_t + (1-\rho)\beta(\pi_{it+12} - \pi_t^*) + (1-\rho)\gamma(y_{it} - y_{it}^*) + \rho r_{it-1} + \epsilon_{it}$ for France, Italy and Spain (see text for details). The parameters are estimated by GMM over 1983:1-1997:8 (except for Spain: 1984:1-1997:8). CGG is the set of instruments used in Clarida, Galì and Gertler (1998). In the other models, four sets of factors were used as additional instruments: country specific factors (CS), factors extracted from the 4-country merged dataset (PL4), factors extracted from the EMU pooled dataset (PL) and country specific plus pooled factors (CS+PL), respectively. The table entries are the coefficient estimates (robust standard errors in brackets), R-squared and standard error of the regressions, and the j-test (associated p-values in brackets) for the validity of the instruments.

Table 2: Actual and simulated macroeconomic variables

	Actual	CGG	CS Factors	PL Factors	CS+PL Factors
			Germany		
$Var(R_t)$	4.32	0.21	3.50	3.06	4.02
$E(\pi_t)$	2.34	2.15	2.32	2.37	2.34
$E(y_t - y_t^*)^2$	4.19	3.87	4.05	4.13	4.41
$E(\pi_t - \pi_t^*)^2$	2.40	1.06	2.23	1.74	2.29
			France		
$Var(R_t)$	5.69	4.94	4.68	4.95	5.02
$E(\pi_t)$	3.14	3.07	3.07	3.10	3.07
$E(y_t - y_t^*)^2$	1.82	1.76	1.56	1.25	1.42
$E(\pi_t - \pi_t^*)^2$	3.02	2.91	2.94	3.03	3.10
			Italy		
$Var(R_t)$	7.58	6.36	6.69	8.11	6.78
$E(\pi_t)$	5.71	5.85	5.77	5.55	5.76
$E(y_t - y_t^*)^2$	5.08	4.79	4.75	6.20	4.79
$E(\pi_t - \pi_t^*)^2$	14.10	15.11	14.56	12.44	14.55
			Spain		
$Var(R_t)$	10.01	6.54	8.59	8.78	8.22
$E(\pi_t)$	6.09	6.06	6.11	6.11	6.10
$E(y_t - y_t^*)^2$	4.96	5.03	4.34	4.50	4.11
$E(\pi_t - \pi_t^*)^2$	17.64	17.46	17.32	17.51	17.60

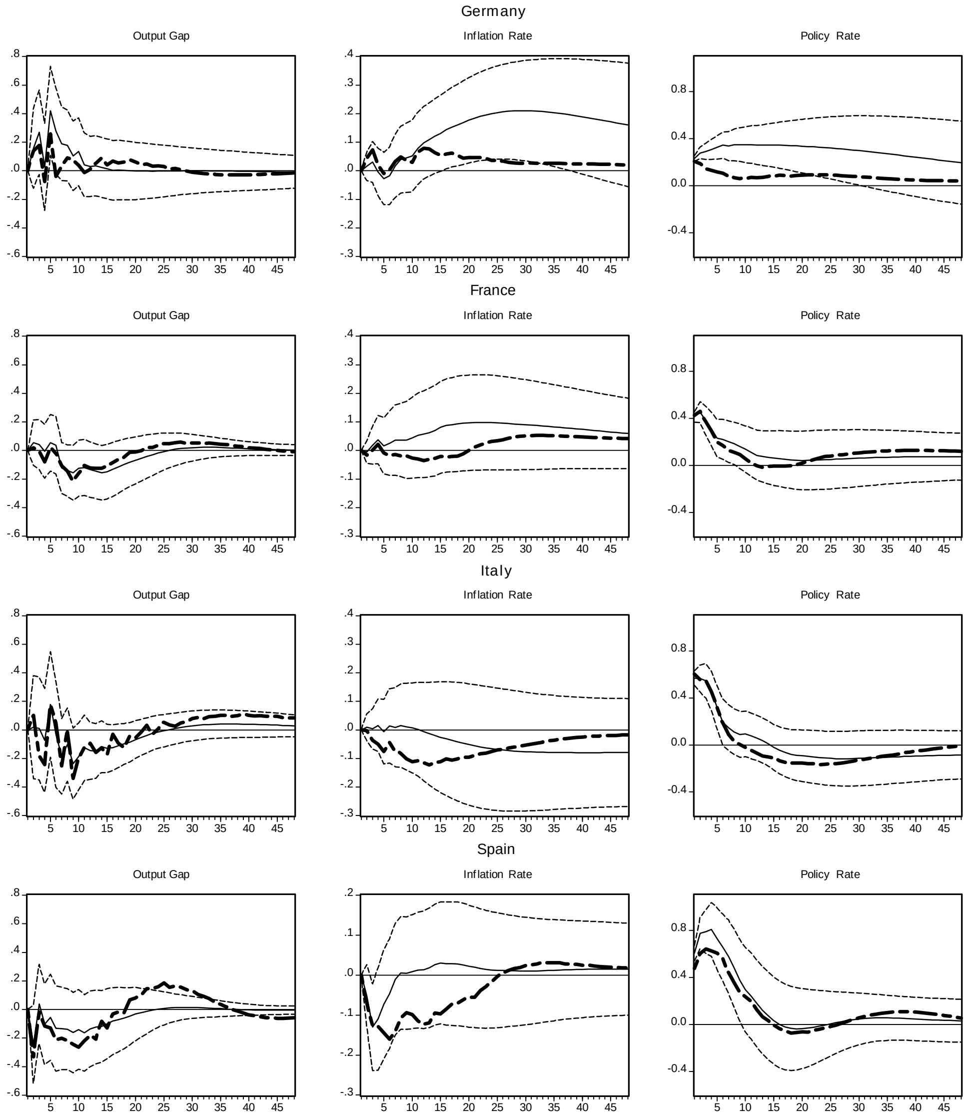
Notes: sample period is 1984:1-1997:8. R_t is domestic policy rate, y_t^* is potential output (computed as the Hodrick Prescott filtered version of actual output) and π_t^* is the official inflation target for Germany.

Figure 1: Residuals from Taylor rules, VARs without factors and VARs with factors



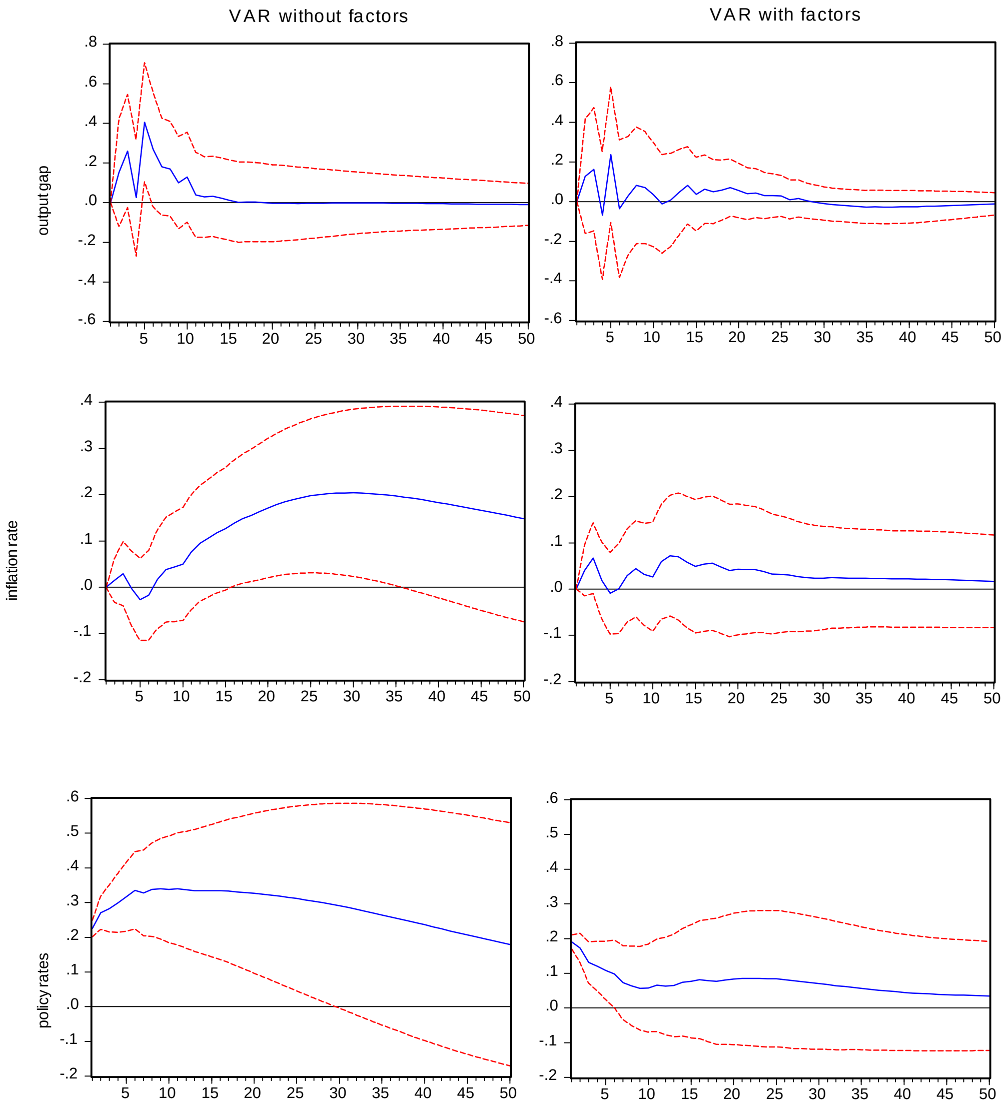
Notes: each graph reports three measures of monetary policy shocks - the residuals from the policy rate equations of the baseline VAR with the CGG set of variables (RESVAR_CGG), from an alternative VAR with country-specific and pooled factors (RESVAR_CSPL), and from the Taylor rule estimated with the CGG set of instruments (RESTAY_CGG) (the residual series from Taylor rules across different models are almost identical).

Figure 2: Responses to one S.D shock to domestic policy rate



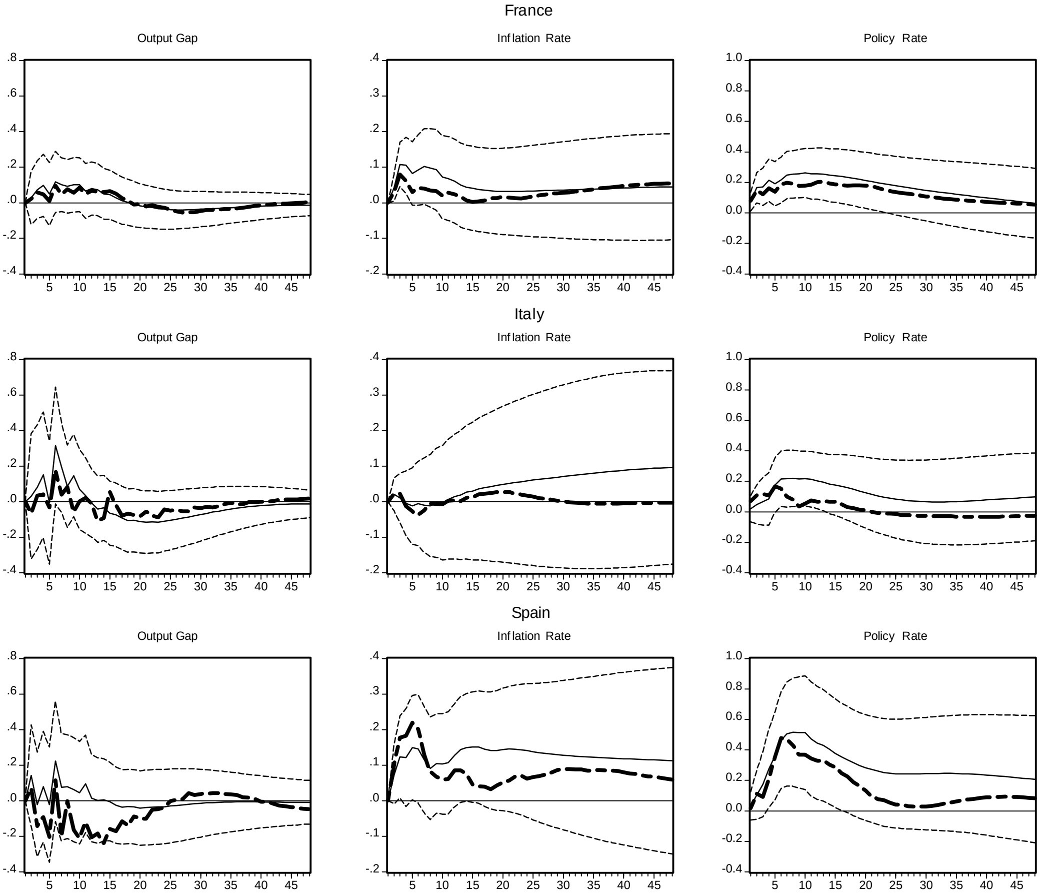
Notes: each graph reports point estimates of the impulse responses in the baseline VAR with the CGG set of variables (continous line) and in the alternative VAR with country-specific + pooled factors (thick dotted line), alongwith their 95% confidence intervals computed analitically in the baseline scenario.

Figure 3: Germany: a comparison of responses to one S.D. shock in policy



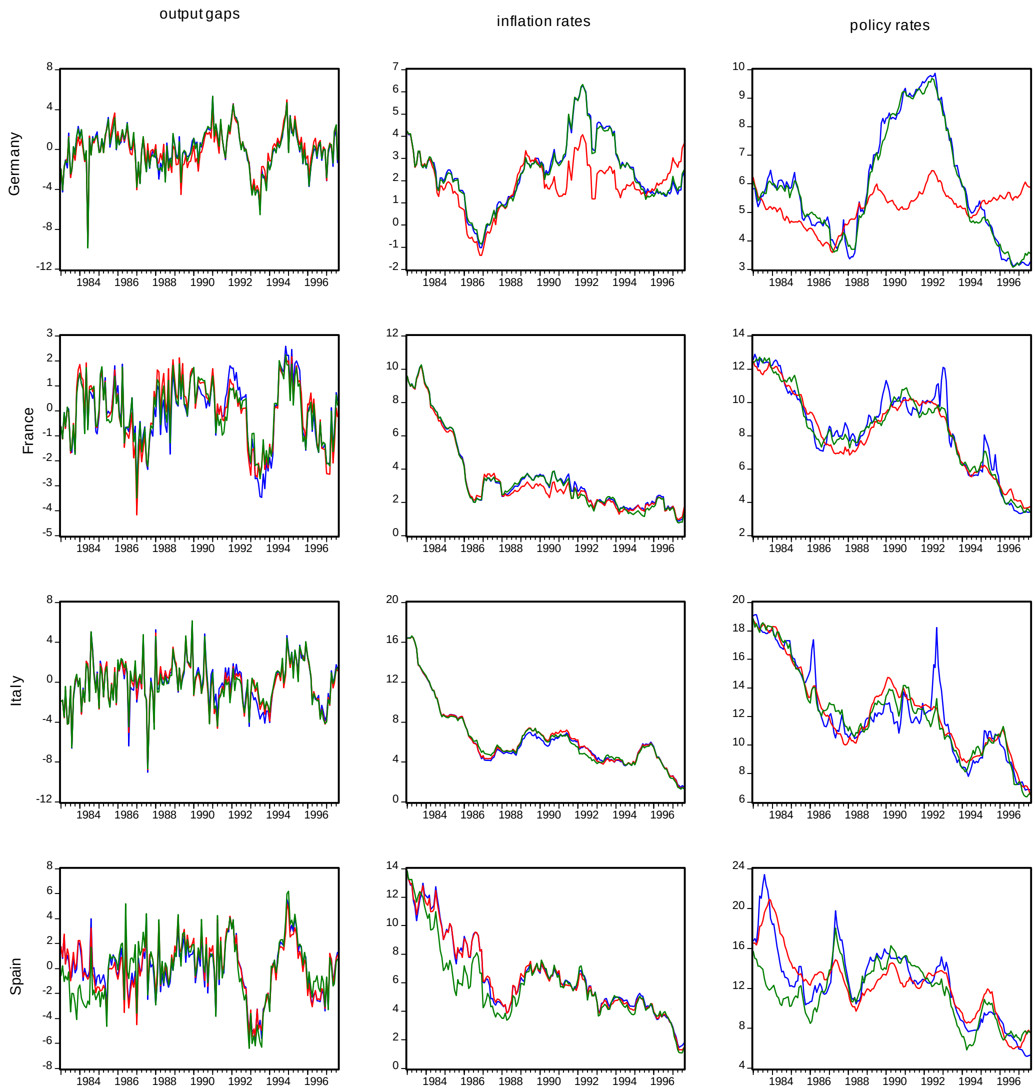
Notes: the graphs report point estimates and confidence intervals of the impulse responses in the baseline VAR with the CGG set of variables (continous line) and in the alternative VAR with country specific + pooled factors.

Figure 4: Responses to one S.D shock to German policy rate



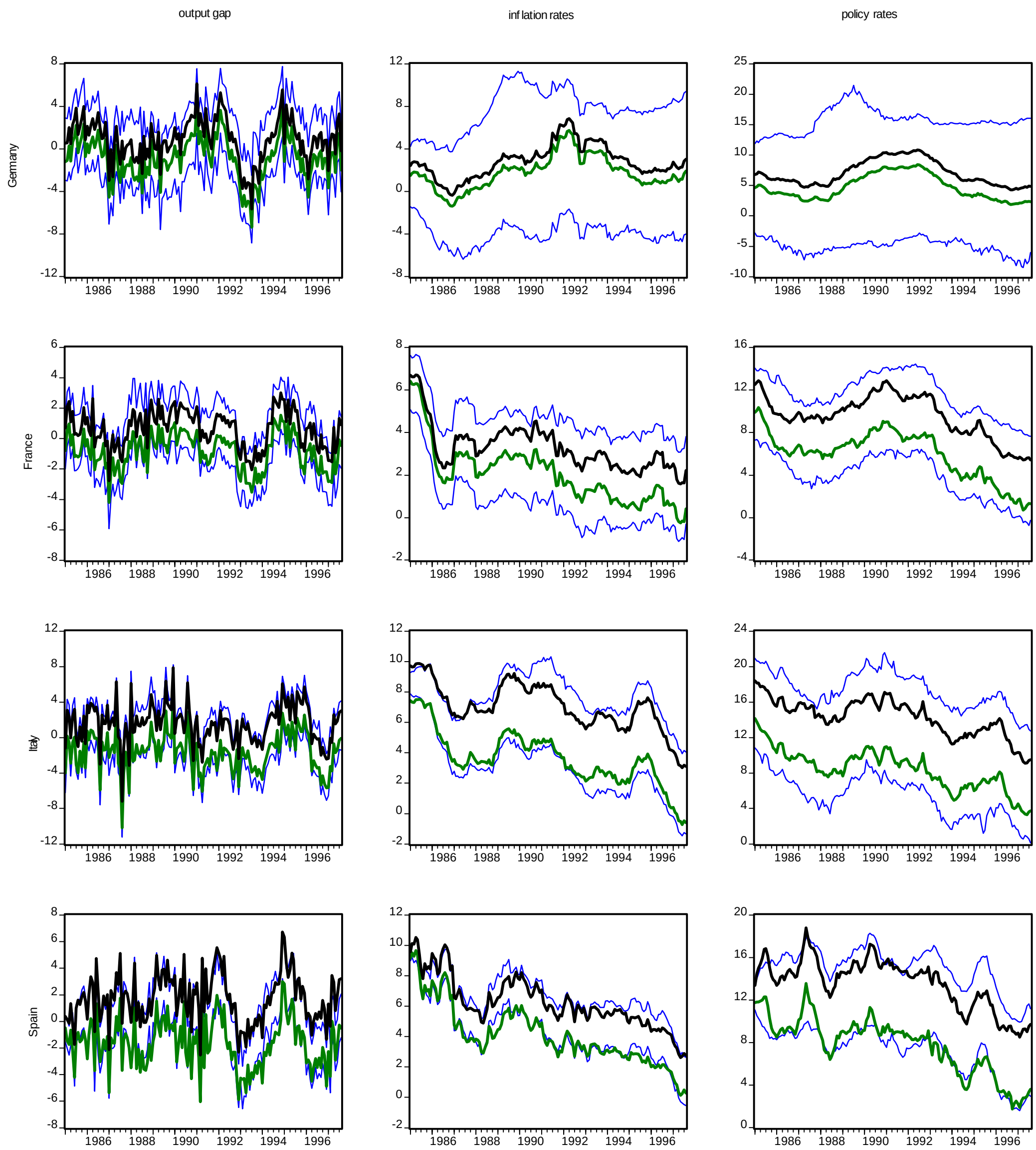
Notes: each graph reports point estimates of the impulse responses in the baseline VAR with the CGG set of variables (continous line) and in the alternative VAR with country specific + pooled factors (thick dotted line), alongwith their 95% confidence intervals computed analitically in the baseline scenario.

Figure 5: The effects of systematic monetary policy



Notes: each graph reports the simulated paths from the baseline model (CGG- dotted line) and from the alternative scenario with country-specific + pooled factors (dashed line), alongwith the actual variables (continous line)

Figure 6: The uncertainty on the effects of systematic monetary policy



Notes: each graph reports bounds for dynamically simulated variables in the baseline model with the CGG set of variables (thin lines) and in the alternative model with country specific + pooled factors (thick line).