

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, summarize the information with a few estimated factors, and use them as instruments in the estimation of forward looking Taylor rules and as additional regressors in structural VARs to evaluate, respectively, the determinants and effects of monetary policy. In all cases more precise estimates can be obtained, and in a few cases the point estimates also become more in line with theory.

JEL Classification: E5, E52, E58

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1 Introduction

A recent strand of the econometric literature 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, for example, Stock and Watson (2002a and 2002b, SW), Forni and Reichlin (1996, 1998) and Forni, Lippi, Hallin and Reichlin (2000, FHLR). 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 (2003) 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(2003) 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 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 monetary policy shocks using impulse response functions and dynamic simulations.

In this paper the factors are extracted using the static principal component based method of SW. In a companion paper, Favero, Marcellino and Neglia (2004), we compare this approach with the one suggested by FHLR, finding that for these particular applications the SW factors seem to perform better.

The paper is organized as follows. In Section 2 we briefly review the econometric methodology and describe the dataset we use. In section 3 we present empirical results for France, Germany, Italy and Spain. In Section 4 we analyze in more detail the case of Germany, since this country presents some peculiar characteristics. In Section 5 we summarize the main results and provide some concluding remarks.

2 Understanding monetary policy in Europe

In this section we explain how the estimated factors from large datasets can be helpful in understanding monetary policy in Europe. We first briefly describe the large dataset we use and discuss how the factors are constructed. Then we focus on the role of the estimated factors for the specification and estimation of Taylor rules and small scale structural VARs.

2.1 The data and the factors

The dataset we adopt comes from Marcellino, Stock and Watson (2000, 2003), 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

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

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 $t = 1, \dots, T$. 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 (2002) proposed a set of selection criteria to choose k that are generalizations

of the BIC and AIC criteria. 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 (2000) 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.

2.2 Taylor rules

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

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

where r_t^* is the target nominal interest rate, \bar{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 reaction of the central

bank to output fluctuations¹.

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

$$r_{it}^* = r_t + \beta(\pi_{it+12}^e - \pi_t^*) + \gamma(y_{it} - y_{it}^*), \quad (3)$$

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 $\alpha = (1 - \rho)\bar{r}$ and $\epsilon_t = (1 - \rho)\beta(\pi_{t+12}^e - \pi_{t+12}) + v_t$. 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 (one-sided) filtered version

¹In fact, γ is a convolution of those parameters describing the structure of the economy and of those parameters describing central bank preferences for output stabilization (see, for example, Favero-Rovelli, 2003)

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, which 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

The factors could play an even more important role in Taylor rules. The central banks could react not only to expected inflation and output gap but also to other variables in the economy, as summarized by the factors. If this is the case, the coefficients estimated in traditional Taylor rules are not only inefficient but also biased because of an omitted variable problem. The procedure Bernanke and Boivin (2003) propose to evaluate this potential omitted variable problem by testing for the significance in the Taylor rule of the fitted values of the interest rate recursively regressed on the factors.

Hence, we estimate the equations

²The 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.

³It is not clear whether the conditioning information set should contain contemporaneous values of the instruments or not. Our results are robust to this inclusion.

$$r_t = \alpha + (1 - \rho)\beta(\widehat{\pi}_{t+12} - \pi_t^*) + (1 - \rho)\gamma(y_t - y_t^*) + \rho r_{t-1} + \eta \widehat{r}_t + \epsilon_t, \quad (7)$$

for Germany, and

$$r_{it} = (1 - \rho)r_t + (1 - \rho)\beta(\widehat{\pi}_{it+12} - \pi_t^*) + (1 - \rho)\gamma(y_{it} - y_{it}^*) + \rho r_{it-1} + \eta \widehat{r}_t + \epsilon_{it}. \quad (8)$$

where $\widehat{\pi}_{t+12}$ is the estimated inflation from a regression of π_{t+12} on the instruments including the factors, while \widehat{r}_t is the estimated value from

$$r_t = \alpha F_{t-1} + u_t,$$

and test whether $\eta = 0$ using a robust t-test. Following Bernanke and Boivin (2003), $\eta \widehat{r}_t$ can be considered as an “excess policy response”.

2.3 Structural VARs

The most standard approach used to evaluate the effects of monetary policy is the computation of the dynamic response of key macroeconomic variables to monetary shocks using structural VAR models. We estimate baseline VAR models for the European countries with a specification consistent with the forward-looking Taylor rules described in the previous sub-section. Specifically, the basic model is

$$\mathbf{A} \begin{bmatrix} \mathbf{X}_t \\ i_t \end{bmatrix} = A(L) \begin{bmatrix} \mathbf{X}_{t-1} \\ i_{t-1} \end{bmatrix} + \begin{bmatrix} \mathbf{u}_t \\ u_t^m \end{bmatrix}, \quad (9)$$

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 as exogenous regressors in the VAR.⁴

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, \mathbf{A} is a lower triangular matrix.⁵ The equations for policy rates can be interpreted 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 can then evaluate the “economic” importance of the inclusion of factors in the VAR by looking at the response of the output gap and inflation to domestic monetary policy in the baseline and in the alternative scenario. As in the case of Taylor rules, we can expect a reduction in uncertainty, as measured by smaller confidence intervals around the estimated point responses, but also a different pattern for the point responses.

Finally, an alternative tool for the evaluation of the effects of monetary shocks on the economy is the dynamic simulation of the following model for each of our four countries of interest:

$$\mathbf{A} \begin{bmatrix} \mathbf{X}_t \\ i_t \end{bmatrix} = A(L) \begin{bmatrix} \mathbf{X}_{t-1} \\ i_{t-1} \end{bmatrix} + \begin{bmatrix} \mathbf{u}_t \end{bmatrix}. \quad (10)$$

⁴In the results reported in the paper we condition on contemporaneous factors but similar findings are obtained with their lagged values.

⁵The results are similar when 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.

The vector \mathbf{X}_t contains all the variables included in the VAR for the baseline case, and in the alternative scenario the variables can react to the factors. Note that 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 equation. The difference between the actual and the simulated output gap and inflation provides a measure of the effects of monetary shocks. The magnitude of this difference with and without factors in the VARs, and its standard deviation, represent another measure of the relevance of the factors.

3 Results

In this section we present the results from estimating Taylor rules and structural VARs with and without factors for Germany, France, Italy and Spain.

Starting with Taylor rules, we consider adding four sets of factors in turn to the standard set of instruments described in the previous Section. 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 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.⁶

⁶We have also experimented with the inclusion of contemporaneous values of all instruments, which did not substantially alter our results. We have also tried using an unrestricted constant in the Taylor rule, and the use of the German factors rather than the pooled factors for France, Italy and Spain, but the results did not improve.

The results are summarized in Table 1. In general the CS and PL factors yield the larger gains in terms of reduction of estimation uncertainty, which suggests that national information matters but the Euro area variables also play a role. For simplicity we will focus our comments on this set of factors.

Insert Table 1 here

The most striking conclusion is that for *all* countries and *all* coefficients adding the factors to the set of instruments increases substantially the precision of the estimates, as measured by their standard deviation. The gains are usually in the range 10-20%, larger for Germany.

About the estimated parameters, first, the value of β (the parameter on inflation) is larger than one for all countries except France, which suggests that the target real rate adjusts to stabilize inflation. The value of β is equal to 1.79 for Italy, 1.46 for Spain, 1.33 for Germany and 0.73 for France. The former three coefficients are also statistically different from one.

Second, the estimated values of γ are larger than one and of comparable size for all countries, with values of 1.68 for Italy, 1.56 for Germany, 1.44 for Spain and 1.35 for France. Yet, the standard errors around these point estimates are usually larger than those for β .

Third, the estimated values of ρ are also very similar across countries, in the range 0.96 – 0.98. 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 – 0.99, and the J -test for the validity of the instruments never rejects the null. It is interesting to note that the inclusion of factors 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 $\epsilon_{i,t} = (1 - \rho_i)\beta_i(\pi_{i,t+12}^e - \pi_{i,t+12}) + v_{i,t}$, this

evidence can be explained by the very high value of all the ρ'_i s. However, it is important for us to determine whether the high value of the ρ'_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 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 of inflation forecasts from 0.90 to 0.76 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.

In Table 2 we then report the results of the “excess policy response” analysis. It turns out that \hat{r}_t is significant only in the case of France and Germany, where the main consequences of its inclusion in the Taylor rule are that the output gap is no longer significant and the size of the coefficient of expected inflation is also affected, with a larger value for France and a smaller one for Germany. Yet, for all countries the improvement in the fit of the Taylor rules is only marginal.

Insert Table 2 here

The findings we have obtained so far 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. We now evaluate to what extent the inclusion of factors in small macro models changes our understanding of the effects of monetary policy. To provide an answer to this question we compute the impulse response function from structural VARs with and without (CS+PL) factors, following the methodology outlined in the previous Section.

Insert Figures 2-5 here

In Figures 2-5 we report for each country point estimates of the alternative impulse responses, alongwith their ninety-five confidence intervals computed analytically. The comparative analysis of the impulse responses shows first of all that for virtually *all* countries, variables and horizons there is a reduction in the standard errors of the estimated responses, which is particularly sizeable in the case of the response of inflation. Moreover, for all countries the inclusion of the factors leads to the elimination of the price puzzle, similarly to what Bernanke and Boivin(2003) noted for the US case.⁷ The response of output are instead rather similar, while in general there is a decrease in the persistence of the effects on the interest rate with the factors.

We now discuss the outcome of the dynamic simulation of the VARs. The results are presented in Figure 6, which reports for each country the path of simulated policy rates, the output gap and inflation with and without factors, alongwith the observed variables.

Insert Figure 6 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 for other countries shows that the most relevant deviations between the two types of series occurred in occasion of currency crises, e.g. in 1992, when monetary policy had to be unexpectedly tight to deal with the

⁷Notice that the basic responses for Germany are similar to those in Bernanke and Mihov (1997) using the call rate.

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 the monetary shocks, in line with the literature. The largest differences are for inflation in Germany, where the actual figures are closest to the simulated ones when the CS-PL factors are included in the model.

Insert Table 3 here

The relevant moments of inflation, output gap and the policy rate are summarized in Table 3 for actual and simulated series, using types of factors in the VARs. 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 shocks. However, the inclusion of factors does lead to a sizeable reduction in the uncertainty around the simulated series, as indicated by Figure 7 where we report 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 7 here

4 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 systematically more precisely estimated when factors are included in the instrument set. 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 macroeconomic models to forecast inflation and set their policy rates. Moreover, the information summarized by the factors could have a direct effect on the policy decisions.

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?

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 monetary shocks both using standard impulse response functions and by means of stochastic simulation.

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 by 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 monetary policy using stochastic simulations, we have noted that the inclusion of the factors generated minor differences in the dynamic path of macroeconomic variables, but it greatly reduced uncertainty on 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.

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Table 1: Forward-looking Taylor rules for Europe

| | | <i>Germany</i> | <i>France</i> | <i>Italy</i> | <i>Spain</i> |
|--------------------|-------|----------------|---------------|--------------|--------------|
| $\beta(s.e.)$ | CGG | 3.17 (1.409) | 0.75 (0.143) | 1.72 (0.073) | 1.02 (0.139) |
| | CS+PL | 1.33 (0.171) | 0.73 (0.127) | 1.79 (0.066) | 1.46 (0.080) |
| | CS | 3.04 (1.255) | 0.76 (0.138) | 1.78 (0.079) | 1.46 (0.098) |
| | PL | 1.53 (0.240) | 0.83 (0.133) | 1.79 (0.075) | 1.52 (0.082) |
| $\gamma(s.e.)$ | CGG | 4.43 (3.107) | 1.55 (0.212) | 1.57 (0.299) | 1.40 (0.248) |
| | CS+PL | 1.56 (0.392) | 1.35 (0.144) | 1.68 (0.277) | 1.44 (0.185) |
| | CS | 3.68 (2.313) | 1.47 (0.176) | 1.67 (0.346) | 1.62 (0.217) |
| | PL | 1.74 (0.604) | 1.39 (0.181) | 1.76 (0.343) | 0.30 (0.180) |
| $\rho(s.e.)$ | CGG | 0.99 (0.006) | 0.96 (0.003) | 0.97 (0.003) | 0.97 (0.003) |
| | CS+PL | 0.98 (0.004) | 0.96 (0.002) | 0.98 (0.003) | 0.97 (0.002) |
| | CS | 0.99 (0.005) | 0.96 (0.003) | 0.98 (0.003) | 0.97 (0.003) |
| | PL | 0.99 (0.005) | 0.96 (0.003) | 0.98 (0.003) | 0.96 (0.003) |
| R^2 | CGG | 0.985 | 0.972 | 0.966 | 0.961 |
| | CS+PL | 0.986 | 0.972 | 0.966 | 0.961 |
| | CS | 0.986 | 0.972 | 0.966 | 0.961 |
| | PL | 0.986 | 0.972 | 0.966 | 0.961 |
| S.E. of Regression | CGG | 0.246 | 0.426 | 0.581 | 0.625 |
| | CS+PL | 0.246 | 0.424 | 0.582 | 0.630 |
| | CS | 0.244 | 0.425 | 0.583 | 0.630 |
| | PL | 0.245 | 0.425 | 0.583 | 0.637 |
| J-Stat (Prob) | CGG | 14.18 (0.99) | 14.5 (0.99) | 14.26 (0.99) | 14.24 (0.99) |
| | CS+PL | 15.33 (0.99) | 14.99 (0.99) | 14.57 (0.99) | 14.54 (0.99) |
| | CS | 15.11 (0.99) | 14.78 (0.99) | 14.43 (0.99) | 14.41 (0.99) |
| | PL | 15.12 (0.99) | 14.78 (0.99) | 14.47 (0.99) | 14.37 (0.99) |

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: "Excess policy response" analysis

| | β (s.e.) | γ (s.e.) | ρ (s.e.) | η (s.e.) | R^2 | S.E. of Regr. |
|----------------|-------------------|--------------------|------------------|-------------------|-------|---------------|
| <i>Germany</i> | 0.43 (0.189) | 0.14 (0.102) | 0.89 (0.037) | 0.78 * (0.125) | 0.987 | 0.235 |
| <i>France</i> | 1.10 (0.192) | 0.24 (0.341) | 0.90 (0.027) | 0.18 * (0.050) | 0.974 | 0.414 |
| <i>Italy</i> | 1.44 (0.734) | 0.36 (0.434) | 0.95 (0.025) | 0.08 (0.261) | 0.967 | 0.572 |
| <i>Spain</i> | -1.13 (2.102) | 1.23 (1.392) | 0.96 (0.039) | 0.65 (0.490) | 0.963 | 0.612 |

* Significant at the 1% level

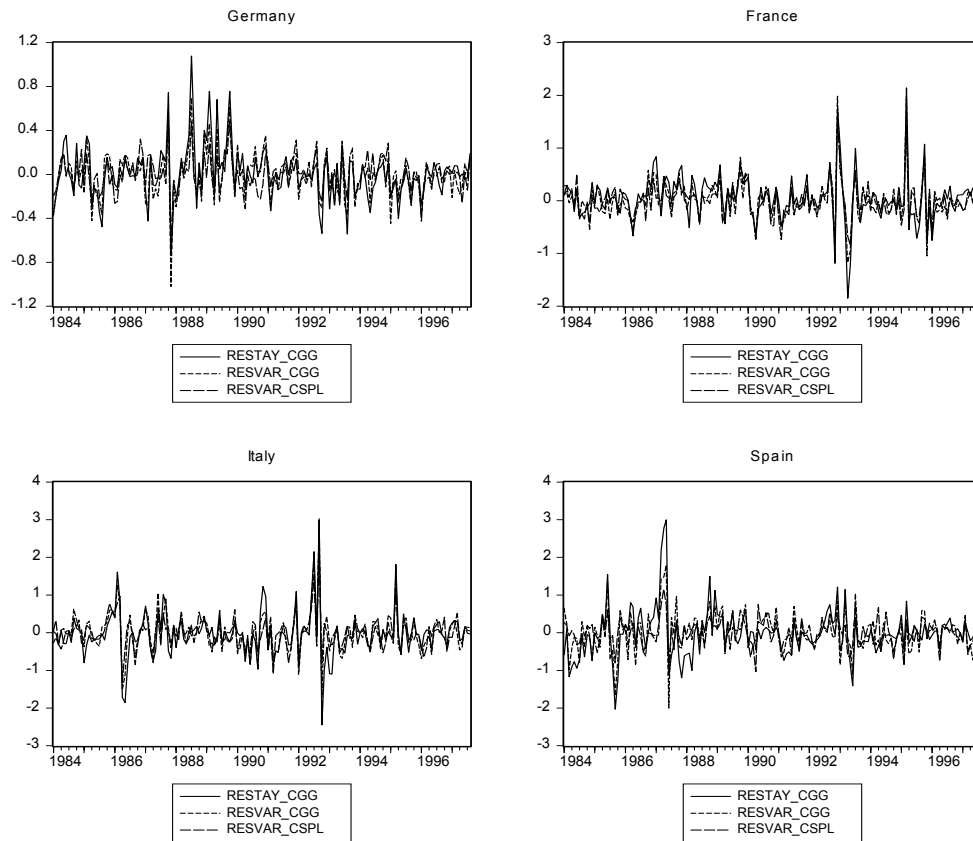
Notes: the estimated equations are $r_t = \alpha + (1 - \rho)\beta(\hat{\pi}_{t+12} - \pi_t^*) + (1 - \rho)\gamma(y_t - y_t^*) + \rho r_{t-1} + \eta \hat{r}_t + \epsilon_t$ for Germany and $r_{it} = (1 - \rho)r_t + (1 - \rho)\beta(\hat{\pi}_{it+12} - \pi_t^*) + (1 - \rho)\gamma(y_{it} - y_{it}^*) + \rho r_{it-1} + \eta \hat{r}_t + \epsilon_{it}$ France, Italy and Spain (see text for details). The parameters are estimated by OLS over 1983:1-1997:8 (except for Spain: 1984:1-1997:8). The table entries are the coefficient estimates (robust standard errors in brackets), R-squared, and standard error of the regression.

Table 3: Actual and simulated macroeconomic variables

| | Actual | CGG | CS+PL Factors | CS Factors | PL Factors |
|------------------------|--------|-------|---------------|------------|------------|
| Germany | | | | | |
| $Var(R_t)$ | 4.02 | 0.41 | 3.53 | 3.09 | 2.57 |
| $E(\pi_t)$ | 2.41 | 2.00 | 2.40 | 2.38 | 2.38 |
| $E(y_t - y_t^*)^2$ | 4.20 | 3.82 | 4.07 | 4.03 | 4.27 |
| $E(\pi_t - \pi_t^*)^2$ | 2.26 | 1.56 | 2.15 | 2.15 | 1.70 |
| France | | | | | |
| $Var(R_t)$ | 6.42 | 5.34 | 5.85 | 6.32 | 6.23 |
| $E(\pi_t)$ | 3.57 | 3.45 | 3.55 | 3.58 | 3.57 |
| $E(y_t - y_t^*)^2$ | 1.77 | 1.73 | 1.63 | 1.66 | 1.56 |
| $E(\pi_t - \pi_t^*)^2$ | 5.23 | 4.88 | 5.20 | 5.22 | 5.18 |
| Italy | | | | | |
| $Var(R_t)$ | 9.72 | 8.47 | 8.84 | 8.36 | 8.64 |
| $E(\pi_t)$ | 6.34 | 6.46 | 6.34 | 6.39 | 6.32 |
| $E(y_t - y_t^*)^2$ | 5.31 | 5.01 | 5.06 | 5.06 | 5.07 |
| $E(\pi_t - \pi_t^*)^2$ | 22.31 | 23.15 | 22.34 | 22.69 | 22.61 |
| Spain | | | | | |
| $Var(R_t)$ | 13.80 | 10.05 | 10.77 | 11.16 | 11.86 |
| $E(\pi_t)$ | 6.51 | 6.47 | 6.54 | 6.43 | 6.52 |
| $E(y_t - y_t^*)^2$ | 4.74 | 4.87 | 4.86 | 4.78 | 4.72 |
| $E(\pi_t - \pi_t^*)^2$ | 21.65 | 21.43 | 21.93 | 21.47 | 21.61 |

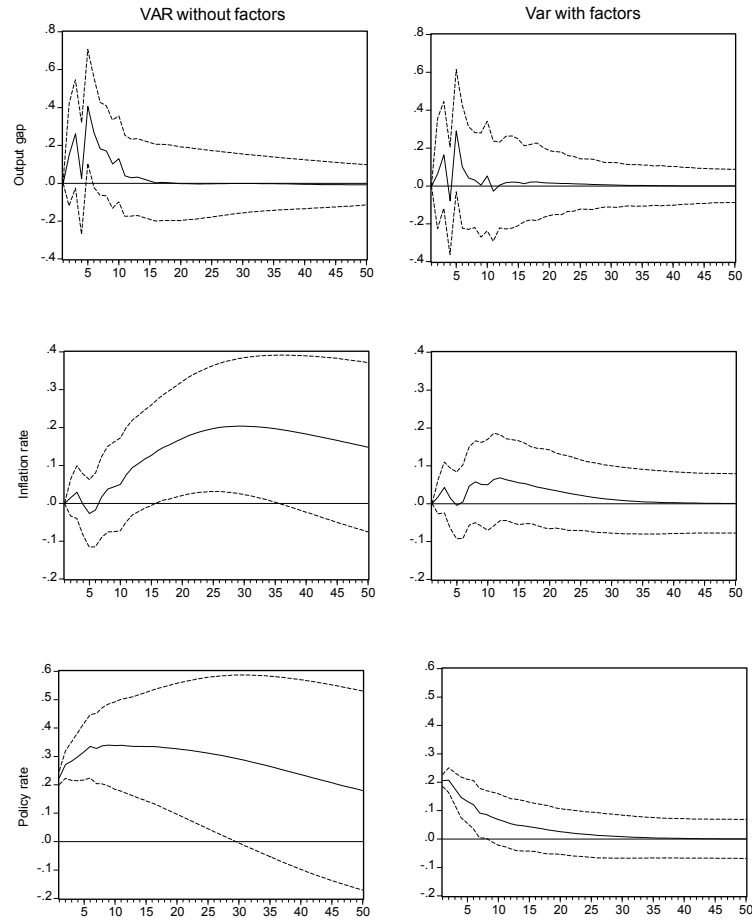
Notes: sample period is 1984:1-1997:8. R_t is domestic policy rate, y_t^* is potential output (computed as the Hodrick Prescott filtered version of actual output) and π_t^* is the official inflation target for Germany. [Domestic monetary shock set to zero]

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



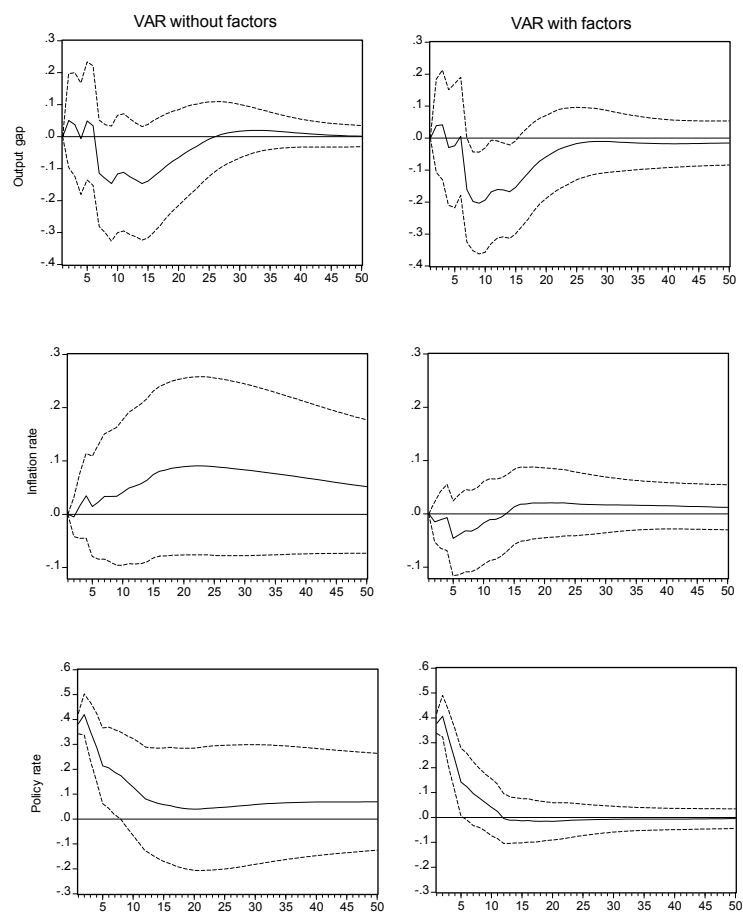
Notes: each graph reports three measures of monetary policy shocks - the residuals from the policy rate equations of the baseline VAR with the CGG set of variables (RESVAR_BL), from an alternative VAR with country-specific and pooled factors (RESVAR_CSPL), and from the Taylor rule estimated with the 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 - Germany



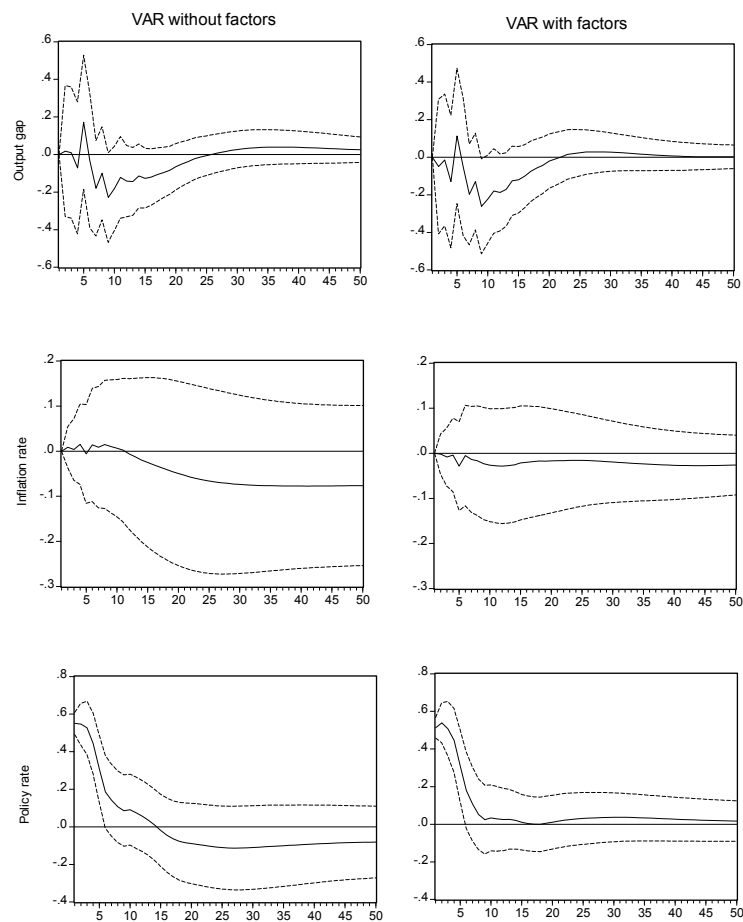
Notes: the graphs report point estimates and confidence intervals of the impulse responses in the baseline VAR with the CGG set of variables and in the alternative VAR with country specific + pooled factors .

Figure 3: Responses to one S.D shock to domestic policy rate - France



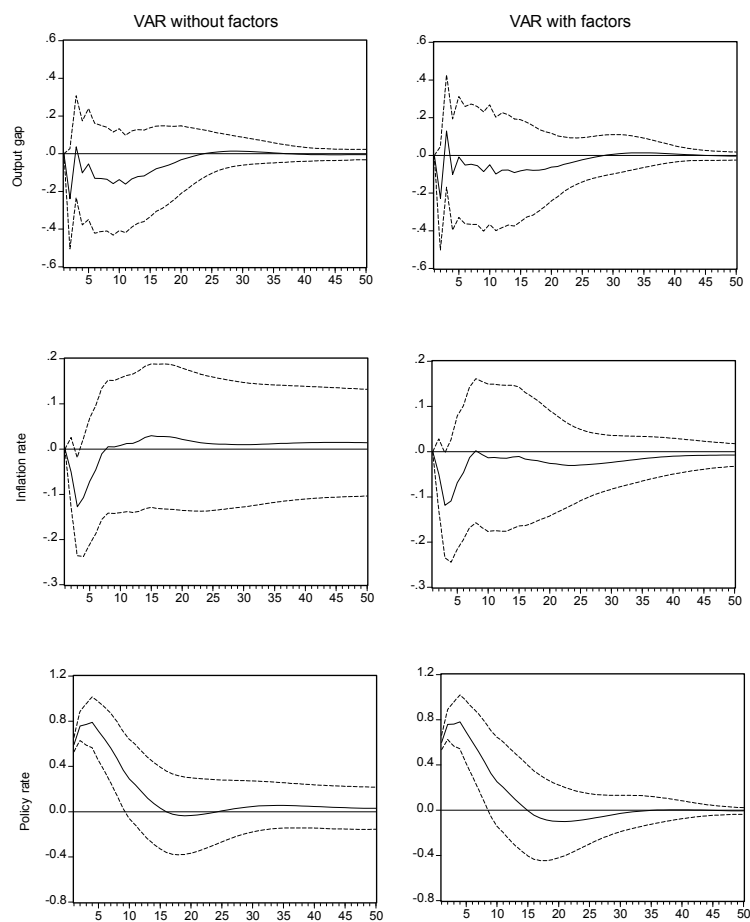
Notes: the graphs report point estimates and confidence intervals of the impulse responses in the baseline VAR with the CGG set of variables and in the alternative VAR with country specific + pooled factors.

Figure 4: Responses to one S.D shock to domestic policy rate - Italy



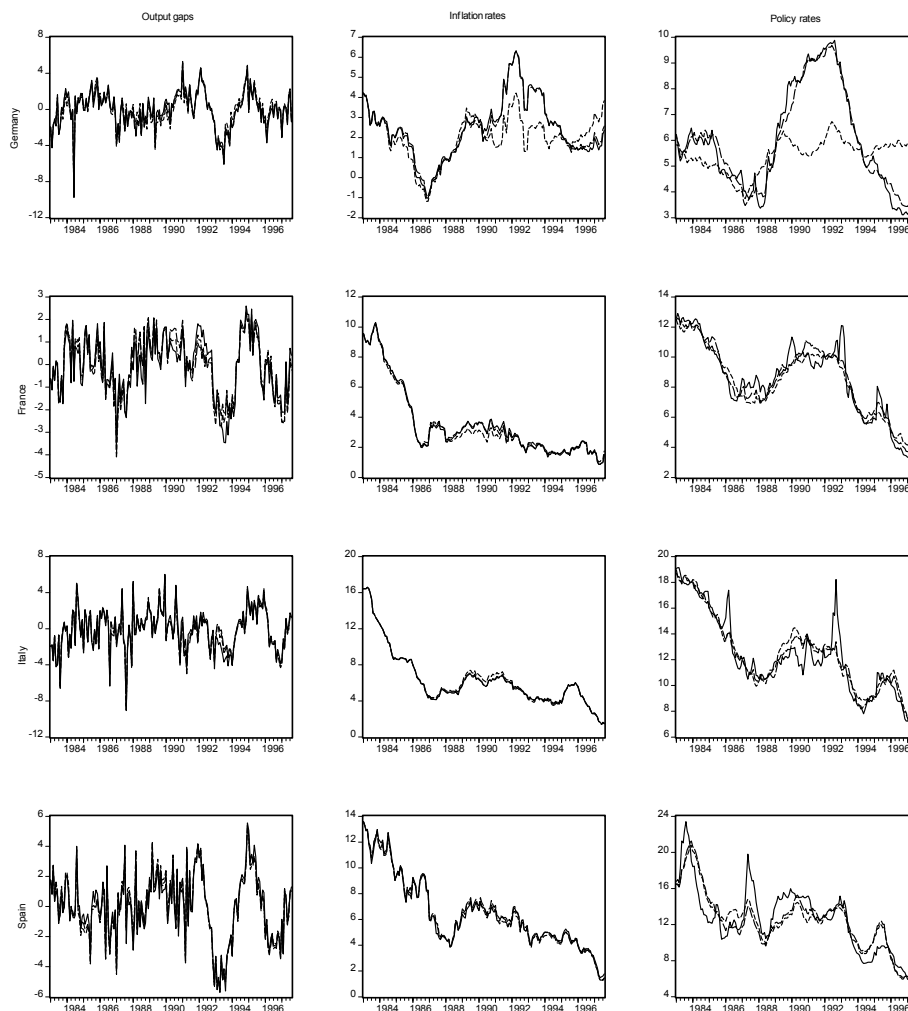
Notes: the graphs report point estimates and confidence intervals of the impulse responses in the baseline VAR with the CGG set of variables and in the alternative VAR with country specific + pooled factors.

Figure 5: Responses to one S.D shock to domestic policy rate - Spain



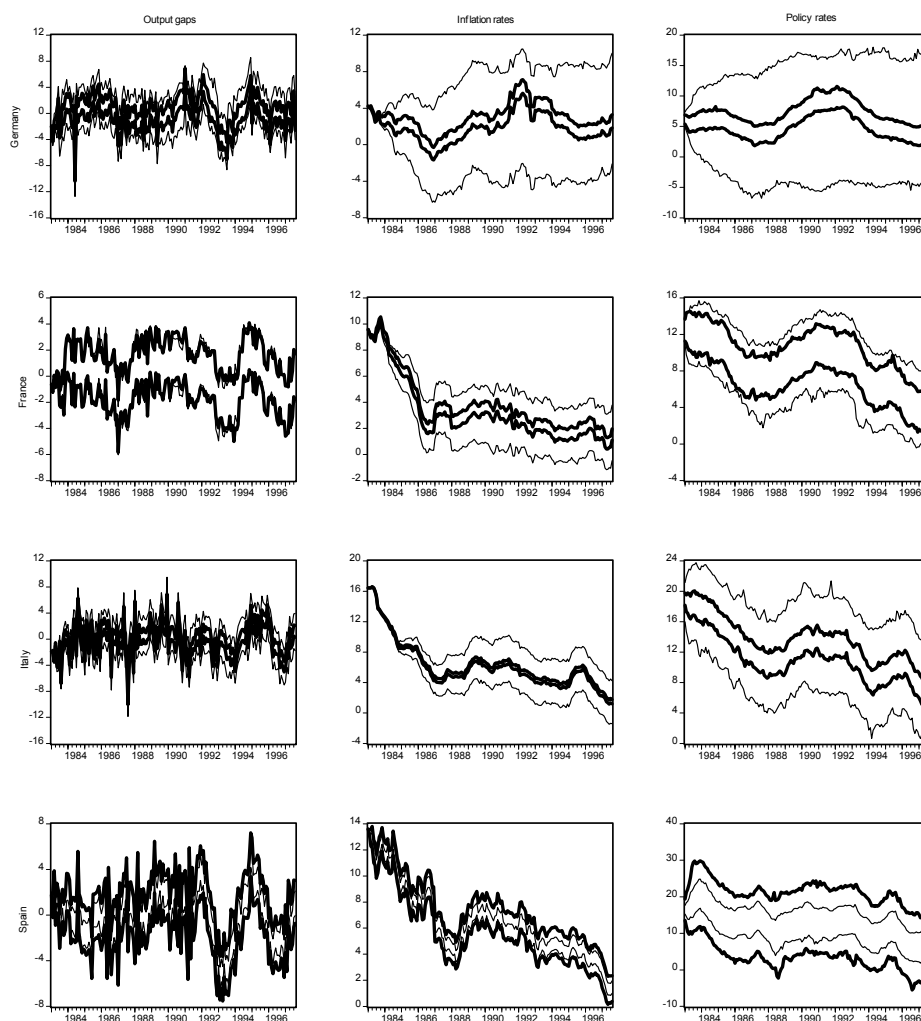
Notes: the graphs report point estimates and confidence intervals of the impulse responses in the baseline VAR with the CGG set of variables and in the alternative VAR with country specific + pooled factors

Figure 6: An alternative evaluation of the effects of monetary shocks



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), along with the actual variables (solid line).

Figure 7: The uncertainty on the effects of monetary shocks



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 lines).