RESEARCH SEMINAR IN INTERNATIONAL ECONOMICS

School of Public Policy
University of Michigan
Ann Arbor, Michigan 48109-1220

Discussion Paper No. 384

# Monetary Policies under the EMS: An Empirical VAR Approach.

Giuseppe De Arcangelis
Dip. di Economia Pubblica and CIDEI
University of Rome "La Sapienza"

July, 1996

# Monetary Policies under the EMS. An Empirical VAR Approach.

Giuseppe De Arcangelis
Dip. di Economia Pubblica and CIDEI
University of Rome "La Sapienza"

July 1996

**Abstract**

This paper proposes an empirical framework to analyse monetary policies in a small open economy under fixed exchange rates. First, the analysis proposes a semi–restricted VAR model with the lowest number of restrictions to focus on the effects of the center–country and the Rest–of–the–World monetary policies. Next, we use a fully structural VAR approach where the identifying restrictions are imposed on the short–run behavior of the variables.

The model is applied to the EMS experience of France, Italy and the Netherlands by considering Germany as the center country and the US as the Rest of the World. The presence of imperfect capital mobility allows us to attribute partial monetary independence to the domestic monetary authorities. Innovations in the German monetary policy are found to be highly important for the Dutch monetary policy, but much less for France and especially for Italy. Instead, the US shock plays a particularly relevant role for the French monetary policymaking. There is also evidence of stronger recessionary impact of restrictive German monetary policies on France and Italy rather than the Netherlands. This may explain why the former two countries devalued so many times.

**JEL Classification**: F33, F41, F42.

**Keywords**: Fixed Exchange Rates, Monetary Policy, European Monetary System, Structural VAR.

# Monetary Policies under the EMS. An Empirical VAR Approach.[1]

Giuseppe De Arcangelis[2]

## 1 Introduction

In this paper the main objective is to study empirically the relationship between fixed exchange–rates and monetary policy. In particular, given the recent European experience, the economies that are the objectives of this study are France, Italy and the Netherlands. These three countries joined the EMS since the beginning (in 1979), but their histories are quite different (see Table 1).

France started with a very independent economic policy, but after the realignments in 1982 and 1983 switched towards a more restrictive and anti–inflationary policy. Unlike the previous years, the stability of the exchange rate with the Deutsche Mark was one of the goals of its monetary policy (the so–called policy of the *Franc Fort*) in order to acquire anti–inflationary credibility from the Bundesbank.

Italy joined the ERM since its outset, but with a wider band than all the other members (±6 % instead of ± 2.25%). Only in 1990 did the Italian Lira start to fluctuate within the common band, while beforehand it had frequently taken advantage of the possibility of changing the parity with the DM.

Finally, the Netherlands represents probably the closest partner to Germany, which has been indicated as the center country of the EMS. The Dutch Guilder experienced only one realignment in 1983 and has been kept within even a narrower band (± 1%) than established by the exchange–rate agreements for a quite long period of time before the crisis in 1992–93.

Capital controls were also an important feature of the regime. France and Italy were the last countries to abolish all kinds of currency regulations in 1990. Some authors actually attribute the success of the EMS and the

[1] I wish to thank Matthew D. Shapiro for the numerous and valuable discussions on the model and for his comments on previous versions of this work. In addition Alan Deardorff and Phil Howrey provided me with useful suggestions. The responsability is entirely of the author. Usual disclaimers apply.

[2] Correspondence: Dipart. di Economia Pubblica, Via del Castro Laurenziano 9, I-00161 Rome (Italy), e-mail:gdearc@serifos.caspur.it

Table 1: Realignment Dates and Changes in the Parities with the German DM.

| *Country* | *Realignment Dates* | *Devaluation with the DM* |
|---|---|---|
| **France** | October 5, 1981 | 5.5% |
| | June 14, 1982 | 10% |
| | March 21, 1983 | 8% |
| | April 6, 1986 | 6% |
| | January 12, 1987 | 3% |
| **Italy** | March 23, 1981 | 6% |
| | October 5, 1981 | 5.5% |
| | June 14, 1982 | 7% |
| | March 21, 1983 | 8% |
| | April 6, 1986 | 3% |
| | January 12, 1987 | 3% |
| | January 8, 1990 | 3.7% |
| **Netherlands** | March 21, 1983 | 2% |

long–lasting period of stable exchange rates between 1987 and 1992 to the presence of capital controls.

In other words, both adjustments in the parities and obstacles to the free movement of financial funds assured the *possibility* of monetary–policy independence with respect to the center country, Germany.

The main task of this paper is then to evaluate to what extent each country has willingly taken advantage of this possibility offered by both imperfect capital mobility and the design of the EMS institutions.

More exactly, to what extent was the divergent behavior of France and Italy due to an explicit willingness to conduct their own independent monetary policies (i.e., differences in preferences across countries)? Or were the costs (in terms of "too much imported" recessionary policy from Germany) very different because of different economic structures?

For instance, when estimating the reaction functions of the three countries' monetary authorities, we could find different weights assigned to either domestic goals (i.e., full–emplyment output or price stability) and the center–country interest rate. In particular, a monetary policy that is highly consistent with the fixed exchange–rate agreement would change the domestic interest rate mainly because of variations in the foreign rate and would disregard domestic goals. This is the pattern that we expect to find for the Netherlands, for instance.

However, the present paper tries to go beyond this expected evidence. Although monetary policies have been set out differently for the three countries under analysis, is there any indication in their economic structures of why they behaved so differently with respect to the nominal exchange–rate constraint? For instance, if real (IS–type) shocks are correlated with Germany, a restrictive monetary policy in the center country would simply help smooth output variations and keep inflation low. But if real shocks are not correlated, a deflationary policy in German would cause even a stronger recession in the periphery country. Our results seem to provide some indirect evidence of this phenomenon. Furthermore, when keeping the nominal exchange rate fixed, countries renounce to a policy instrument. What is the cost of keeping the domestic nominal rate fixed in terms of foregone devaluations with respect to the Deutsche Mark? Would a devaluation with the German currency bring about a strong increase in output? If this is true, then the domestic country is giving up a powerful instrument to fight recessions and it would be reluctant to keep the nominal exchange rate always fixed.

We focus our empirical analysis on the typical economic variables of business–cycle studies (i.e., the price level, output, money and the interest rate), to which we add the real exchange rate. Influences from abroad are represented by the interest rates of Germany and the US.

The choice of the interest rate to represent influences from abroad is due to two main reasons. First, we are especially interested in the influence that monetary policymaking abroad has on domestic monetary policymaking and on all the other relevant economic variables. Some recent empirical studies (see, for the US, Bernanke and Blinder, 1992, and for other industrialized countries, Batten et al., 1990) have shown that the "true" indicator of monetary policy in the short run is the (call–money) interest rate, which is the rate that central banks can control very closely.[3]

Second, if the interest rate is a policy variable and if policy is performed according to feedback rules (i.e., reaction functions) of the authorities, then the interest rate is the most "endogenous" variable.[4]

This paper proposes two empirical frameworks (based on VAR analysis) to study the monetary policies of the three mentioned countries in order to shed some light on why they have been different. Two econometric dynamic models are estimated and identified with very few contemporaneous

[3]Kim and Roubini (1995) use a similar assumption when studying monetary policies of the major industrialized countries.

[4]In the VAR analysis with a Choleski decomposition, this is equivalent to the specification of the interest rate as the last variable of the VAR.

restrictions.

In the first approach, we take a more agnostic stand and present a model with the lowest number of constraints in order to identify only the transmission of monetary policies (we name this "a semi–structural VAR", or SSVAR, approach). The focus is on the transmission of restrictive monetary–policy measures in Germany to the three "small" countries, but without imposing any economic structure to the domestic variables of the small economies.

Next, in order to study more in depth some relevant structural aspects of the three small countries, we also constrain the VAR with restrictions that hinge on a traditional theoretical macroeconomic model for a small open economy. We perform the common structural VAR (or SVAR) analysis and so we are able to analyse some aspects of the domestic economic structures by identifying economically meaningful shocks. In particular, this second approach is expected to give some evidence on the reasons why the three countries behaved differently with respect to the fixed exchange–rate constraint.

The rest of the paper is divided in six sections. The next one presents the SSVAR analysis.

## 2 A Semi–Structural Approach

In this section we propose a semi–restricted VAR analysis on the variables introduced in the Section 1 (a semi–structural VAR, SSVAR).

More exactly, we want to make both the US and the German interest rates as representative as possible of the monetary policymaking of these two countries. Moreover, the domestic interest rates should identify innovations in domestic monetary policy. On the other hand we do not want to attach any structural meaning to the innovations in the other domestic variables, but we are interested in the responses of these same variables to the three policy shocks that we claim to identify. In a next section instead we present a complete structural model in which the shocks arising in the other equations can be interpreted and analysed.

The structural form of the model that we estimate for the present section is the following for country $c$:

$$
\begin{bmatrix} i_{US,t} \\ i_{GER,t} \\ p_{c,t} \\ y_{c,t} \\ q_{c,t} \\ m_{c,t} \\ i_{c,t} \end{bmatrix} = \mathbf{A}_c(L) \begin{bmatrix} i_{US,t-1} \\ i_{GER,t-1} \\ p_{c,t-1} \\ y_{c,t-1} \\ q_{c,t-1} \\ m_{c,t-1} \\ i_{c,t-1} \end{bmatrix} + \begin{bmatrix} \mathbf{A}_{US,1}(L) & \mathbf{A}_{US,2}(L) \\ \mathbf{A}_{GER,1}(L) & \mathbf{A}_{GER,2}(L) \\ \mathbf{0} & \mathbf{0} \\ \vdots & \vdots \\ \mathbf{0} & \mathbf{0} \end{bmatrix} \begin{bmatrix} \mathbf{X}_{US,t} \\ \mathbf{X}_{GER,t} \end{bmatrix} +
$$

$$
\begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ a_{21} & 0 & 0 & 0 & 0 & 0 & 0 \\ a_{31} & a_{32} & 0 & 0 & 0 & 0 & 0 \\ a_{41} & a_{42} & 0 & 0 & 0 & 0 & 0 \\ a_{51} & a_{52} & 0 & 0 & 0 & 0 & 0 \\ a_{61} & a_{62} & 0 & 0 & 0 & 0 & 0 \\ a_{71} & a_{72} & a_{73} & a_{74} & a_{75} & a_{76} & 0 \end{bmatrix} \begin{bmatrix} i_{US,t} \\ i_{GER,t} \\ p_{c,t} \\ y_{c,t} \\ q_{c,t} \\ m_{c,t} \\ i_{c,t} \end{bmatrix} + \begin{bmatrix} \epsilon_{W,t} \\ \epsilon_{GER,t} \\ e_{p,t} \\ e_{y,t} \\ e_{q,t} \\ e_{m,t} \\ \epsilon_{MS,t} \end{bmatrix}
$$

where $\mathbf{A}(L)$ is a full matrix of polynomials in the lag operator $L$, $i_x$ is the short–term interest rate of country $x$, $p$ is the (log of the) price level, $y$ is (the log of) output, $m$ is the (log of the) money supply and $q$ is the (log of the) real exchange rate between country $c$ and Germany.[5] Moreover

$$
\begin{aligned}
\mathbf{X}_{US,t} &\equiv [\ p_{US,t}\ y_{US,t}\ m_{US,t}\ ]' \\
\mathbf{X}_{GER,t} &\equiv [\ p_{GER,t}\ y_{GER,t}\ m_{GER,t}\ ]' \\
\mathbf{A}_{US,i}(L) &\equiv [\ a_{US,3(i-1)+1}(L)\ a_{US,3(i-1)+2}(L)\ a_{US,3(i-1)+3}(L)\ ] \\
\mathbf{A}_{GER,i}(L) &\equiv [\ a_{GER,3(i-1)+1}(L)\ a_{GER,3(i-1)+2}(L)\ a_{GER,3(i-1)+3}(L)\ ] \\
a_{ij}(L) &\equiv a_{ij0} + a_{ij1}L + a_{ij2}L^2 + \cdots + a_{ijk}L^k
\end{aligned}
$$

where $a_{ii0} = 1$ for normalization. The shocks $e_p$, $e_y$ and $e_q$ are all correlated among each other, but are orthogonal to all the others; $\epsilon_{US}$, $\epsilon_{GER}$ and $\epsilon_{MS}$ are all orthogonal with one another. All shocks are assumed to be normally distributed. All the variables are included in the levels.[6]

[5]The real exchange rate is defined as the relative price of foreign goods with respect to domestic goods. When $q$ rises there is a domestic real depreciation and domestic goods become cheaper.

[6]In this paper we neglect the issue of unit roots and focus on the variables in the levels. Basically we rely on the prior of stationarity of all the variables also recalling the very low power of the traditional unit–root tests (see also Campbell and Perron, 1991, for a related discussion). In other words we follow the first strategy that Hamilton (1994, p. 651-2) suggests and our work is close to the approach taken by Bernanke and Blinder (1992) and, more recently, by Kim and Roubini (1995) or Zha (1995) in an international context. Future work would consider other dynamic structures, like structural vector error–correction models by including cointegration constraints.

The model can be re–written in a more compact form as follows:

$$\mathbf{X}_{c,t} = \mathbf{A}(L)\mathbf{X}_{c,t-1} + \mathbf{C}(L)\mathbf{X}_{f,t} + \tilde{\mathbf{A}}\mathbf{X}_{c,t} + \nu_t$$

or

$$\mathbf{A}\mathbf{X}_{c,t} = \mathbf{A}(L)\mathbf{X}_{c,t-1} + \mathbf{C}(L)\mathbf{X}_{f,t} + \nu_t$$

where $\mathbf{A} \equiv \mathbf{I} - \tilde{\mathbf{A}}$, the $\mathbf{X}_{c,t}$ and $\mathbf{X}_{f,t}$ vectors contain respectively the seven left–hand–side endogenous variables and the predetermined (US and German) variables; the $\nu_t$ vector includes all the error terms.

The proposed structure then satisfies the following assumptions. First, the US and the German interest rates identify the foreign influences to the small open economy. These interest rates are unrestrictedly affected also by the domestic variables of the small open economy (i.e., the matrix $\mathbf{A}(L)$ is a full matrix), but in the structural form their equations also include current and lagged domestic US and German variables (price level, output, money) that are deemed relevant for monetary policy in both the US and Germany. Once the US and the German rates have been conditioned to these domestic variables, their equations are assumed to identify structural monetary–policy shocks (i.e., innovations orthogonal to all the other shocks of the system) in the US ($\epsilon_W$) and in Germany ($\epsilon_{GER}$). The only difference between the German–rate and US–rate equation is that the German rate is contemporaneously affected by the US rate (and not vice–versa), therefore indicating that the US rate is not Granger–caused by the German rate.

Next, in the domestic country the variables $p$, $y$, $q$ and $m$ are unconstrained: they depend contemporaneously on the US and German rate (i.e., the US and the German rate are not Granger–caused by these variables), but their innovations ($e_i$'s) are correlated and have no structural economic meaning.

Finally, the last equation considers the domestic interest rate as the policy variable; in fact, all the other variables in the model are not Granger–caused by the domestic rate and the domestic rate is the "most endogenous" variable of the system. Its innnovation ($\epsilon_{MS}$) represents the domestic monetary–policy innovation and is orthogonal to all the other shocks.

## 2.1 The Estimation Technique

The direct estimation of the structural model above cannot provide unbiased and consistent estimates of the contemporaneous coefficients isolated in the $\mathbf{A}$ matrix. Hence, we have to resort to the estimation of the reduced form:

$$\mathbf{X}_{c,t} = \mathbf{H}(L)\mathbf{X}_{c,t-1} + \mathbf{D}(L)\mathbf{X}_{f,t} + \mathbf{e}_t$$

where

$$\begin{aligned} \mathbf{H}(L) &\equiv \mathbf{A}^{-1}\mathbf{A}(L) \\ \mathbf{D}(L) &\equiv \mathbf{A}^{-1}\mathbf{C}(L) \\ \mathbf{e}_t &\equiv \mathbf{A}^{-1}\nu_t \end{aligned}$$

Besides the coefficients of the polynomials that are present in the unrestricted $\mathbf{H}(L)$ matrix, the estimation of the reduced form will give also the variance–covariance matrix for the residuals.[7] This latter one can be substituted in the log–likelihood function of the model, which can be maximized with respect to the unknown parameters of matrix $\mathbf{A}$ and the variance and covariances of the structural shocks.[8] The outcome will be FIML estimates of the unknown parameters, whose (asymptotic) variance–covariance matrix coincides with the inverse of the information matrix. Moreover, we also obtained the impulse response functions (IRF) and the forecast error variance decompositions (FEVD) at different steps ahead with relative standard errors.[9]

In the next section, we discuss the results obtained from the estimation of this model.

## 2.2 The Empirical Results of the SSVAR Model

The variables included in the VAR are: the US Federal Funds rate ($i_{US}$), the German call–money rate ($i_{GER}$), the consumer price index ($p$), the industrial production index ($y$), the real exchange rate (obtained by considering the nominal exchange rate and adjusting with the relative consumer price indexes of the two countries; $q$), M1 ($m$) and the domestic call–money rate ($i$). All variables (except for the interest rates) are considered in logarithmic terms[10]. All data are monthly. The estimation period is 1979:3–1993:7 for France and the Netherlands (i.e., the period of "small" target zones in the EMS before the widening to ±15%) and 1979:3–1992:9 for Italy (i.e., the whole EMS period for this country).

[7] Note that $\mathbf{H}(L)$ is a full matrix with nonzero terms. Hence, the SUR problem will not arise in this context.

[8] For further details, see the next section on the SVAR methodology.

[9] See Giannini (1992).

[10] Besides taking the log, M1 has also been transformed into an index by normalizing the value for January 1980 to 100.

Table 2: SSVAR Model: Estimated Short-Run Coefficients for the Interest-Rate Equation. (Standard errors in parenthesis)

| *Coefficient* | *Variable* | **France** | **Italy** | **Netherlands** |
|---|---|---|---|---|
| $a_{71}$ | $i_{US,t}$ | -0.049 | -0.030 | -0.148 |
| | | (0.009) | (0.004) | (0.005) |
| $a_{72}$ | $i_{GER,t}$ | 0.270 | 0.240 | 0.482 |
| | | (0.021) | (0.009) | (0.012) |

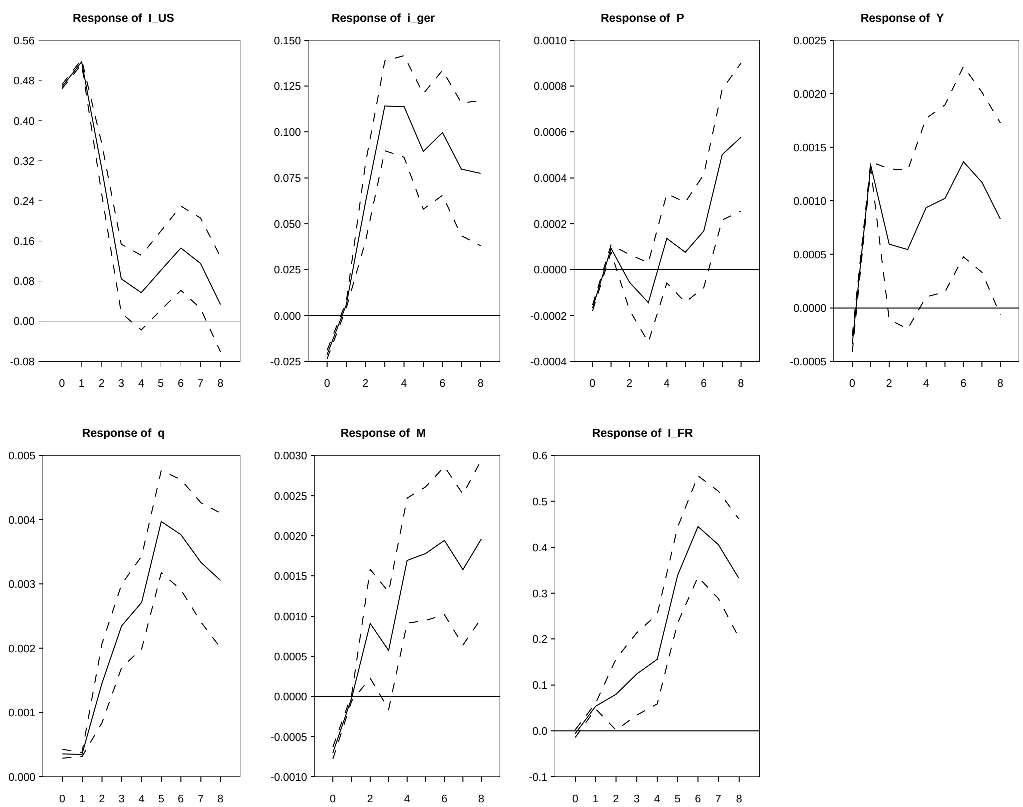
A first assessment of the weight that is assigned to the foreign interest rates in the domestic monetary policy–making can be given by the relative estimated contemporaneous coefficients of the interest–rate equation (see Table 2).[11] They reveal that all domestic rates follow the German rate, but the contemporaneous response in the Dutch rate (0.482) is almost double the response in the other countries. Also, changes in the US rate have a significant but lower impact.[12] The Netherlands is the country with the highest weights in both foreign interest rate, therefore underlying that its monetary policy is the one that is conditioned the most from abroad: this is consistent with the fact that the Netherlands is the smallest and the most open of the three economies.

[11] All the other coefficients in the interest–rate equation are not reported since they are sensitive to the ordering of the other four domestic variables and, therefore, lack structural interpretation.

[12] Any time that the significance level is not explicitily indicated, it is intended as the common 95%.

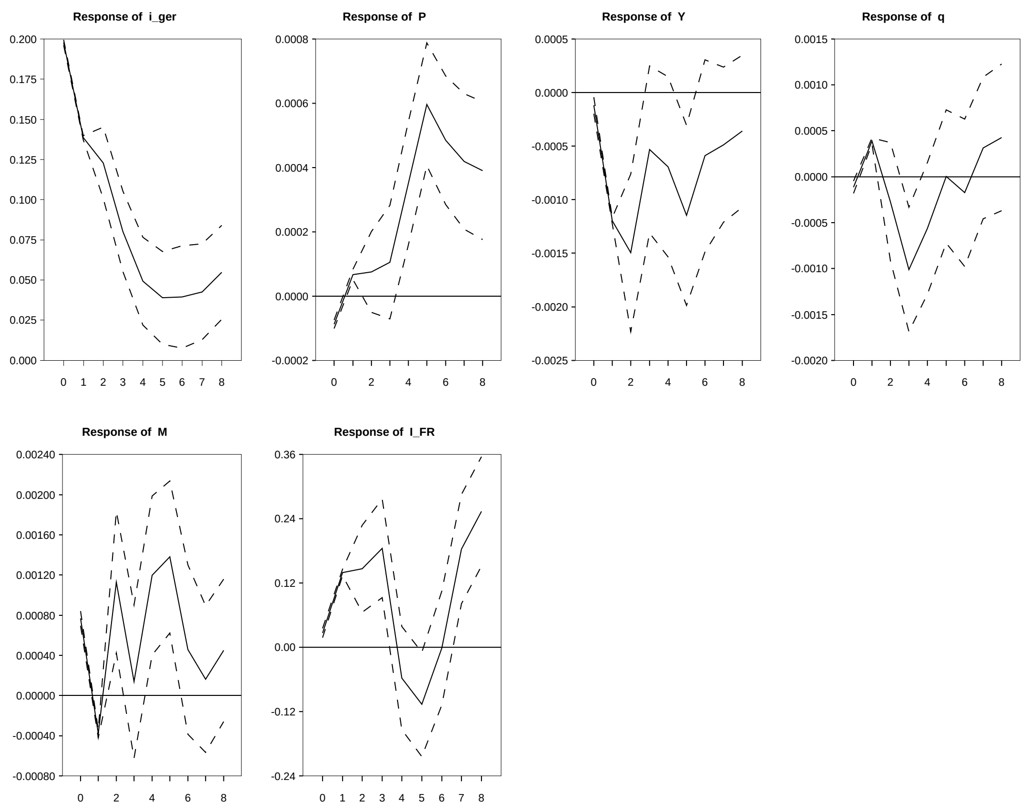
Figure 1: SSVAR Model: Impulse Response Functions for France

*(a) Responses to* $\epsilon_W$



SSVAR Model: Impulse Response Functions for France (continued)

*(b) Responses to $\epsilon_{GER}$*



SSVAR Model: Impulse Response Functions for France (continued)

*(c) Responses to $\epsilon_{MS}$*

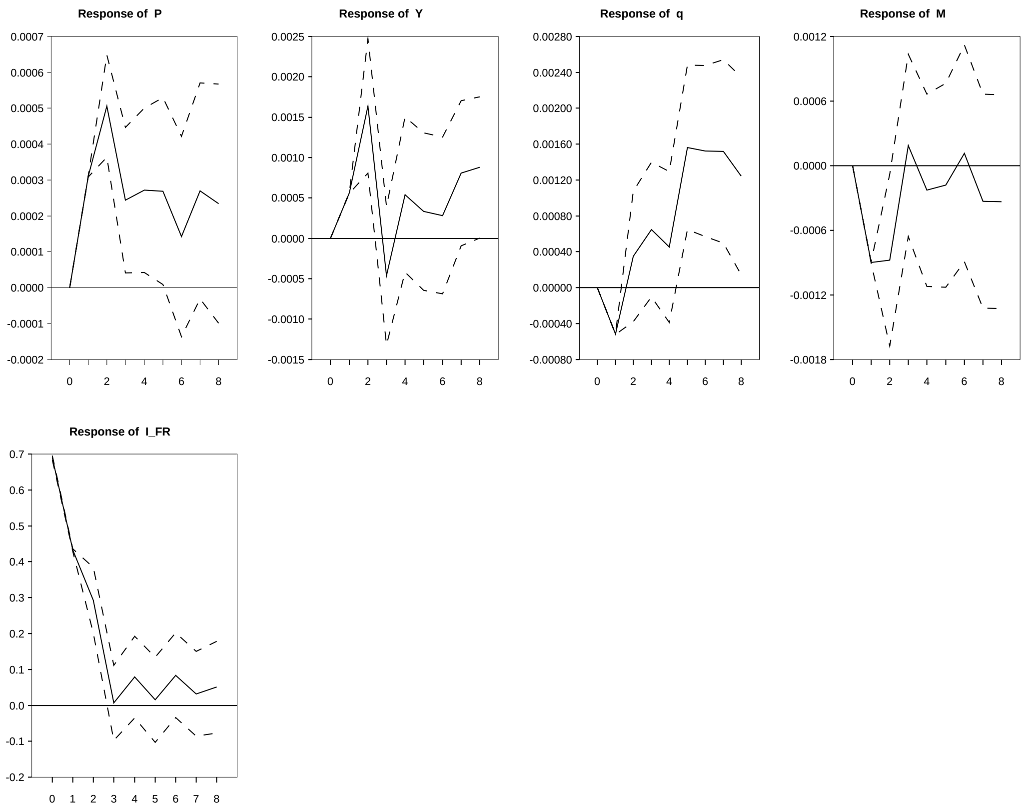
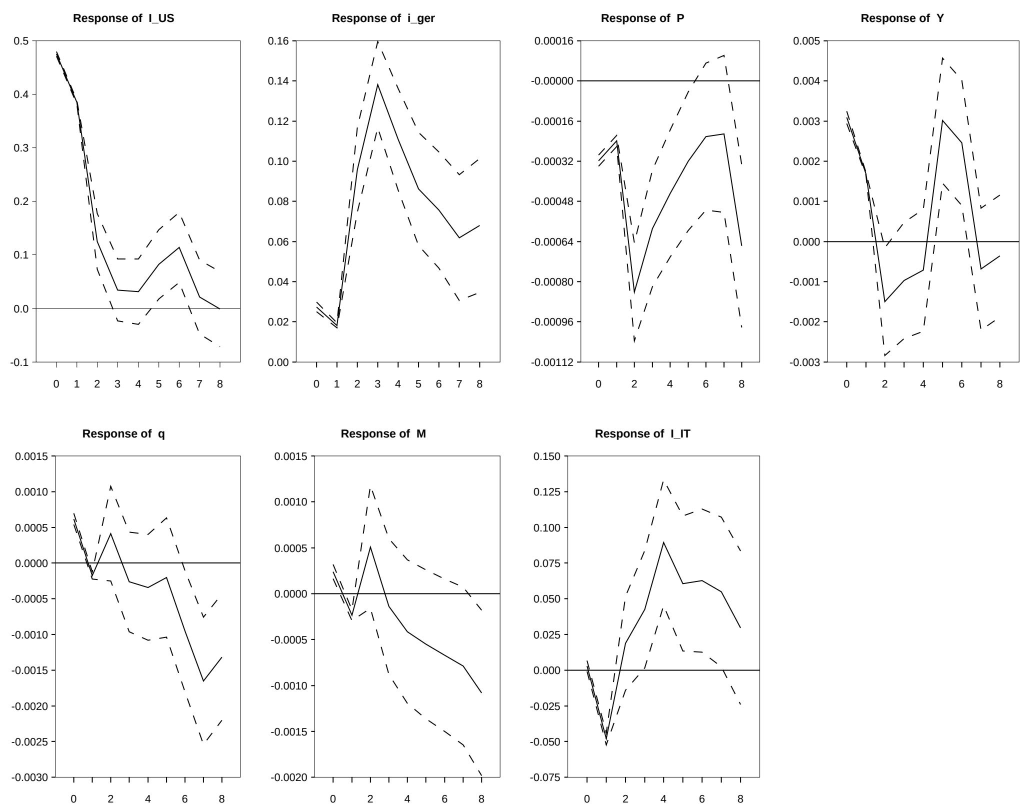


Figure 2: SSVAR Model: Impulse Response Functions for Italy

*(a) Responses to* $\epsilon_W$




Besides the weights of the contemporaneous innovations, we show the impulse response functions (IRF) in Fig. 1–3 for a more thorough dynamic analysis.[13]

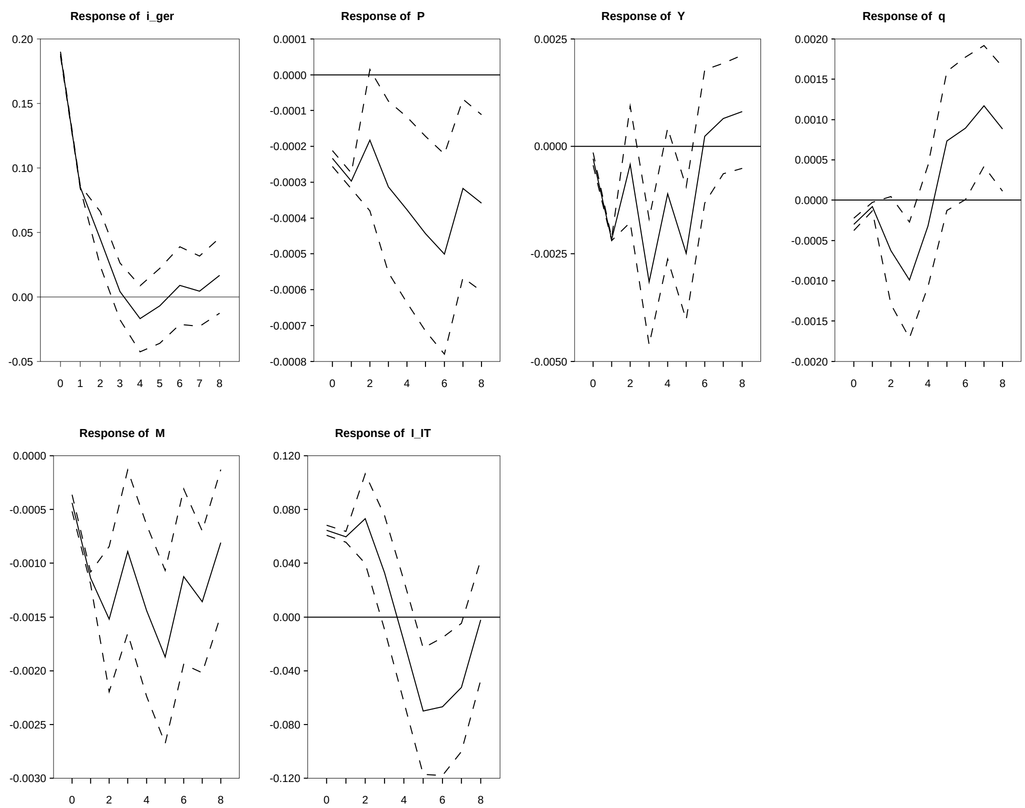
In the parts *(c)*'s of the Figures we show the effects of domestic monetary–policy innovations on the domestic variables of each country. In all cases the domestic interest rate increases and the money stock decreases, therefore indicating that the monetary–policy innovation represents a restrictive monetary measure.

Although the interest rate and the money stock behave consistently, in all countries output initially increases instead of decreasing, and the price level

[13]The responses are relative to a 1% increase in the shocks and are shown for 8 periods with the 95% confidence bounds.

SSVAR Model: Impulse Response Functions for Italy (continued)

*(b) Responses to* $\epsilon_{GER}$



SSVAR Model: Impulse Response Functions for Italy (continued)

*(c) Responses to* $\epsilon_{MS}$

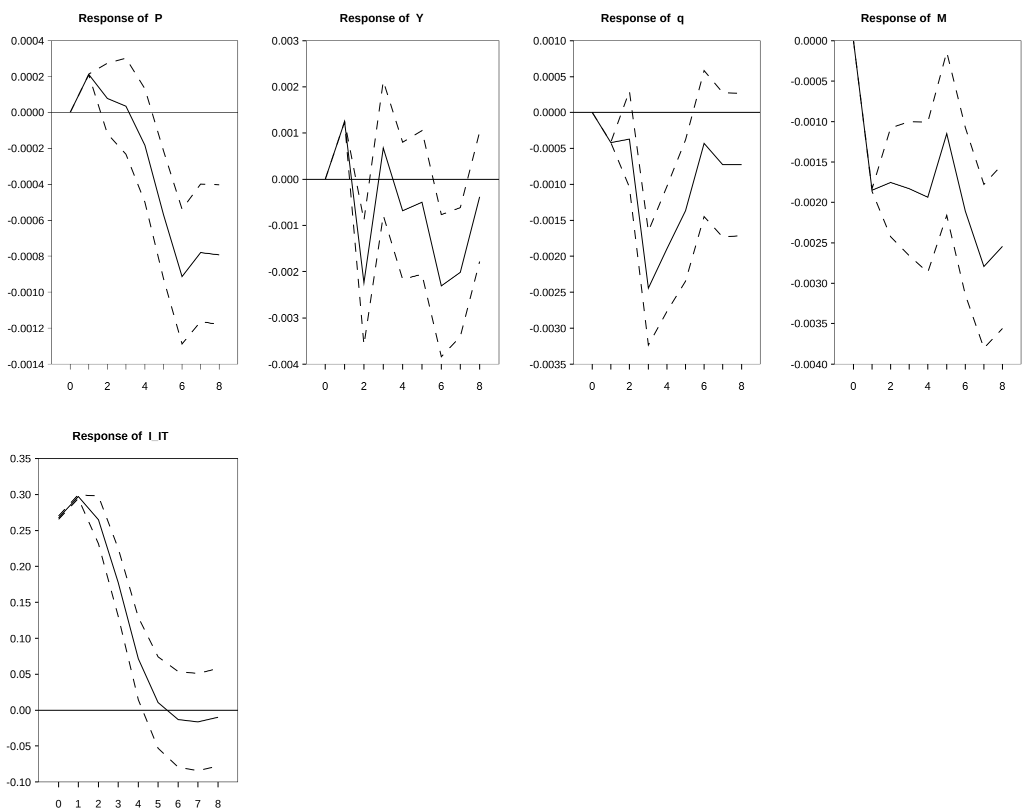
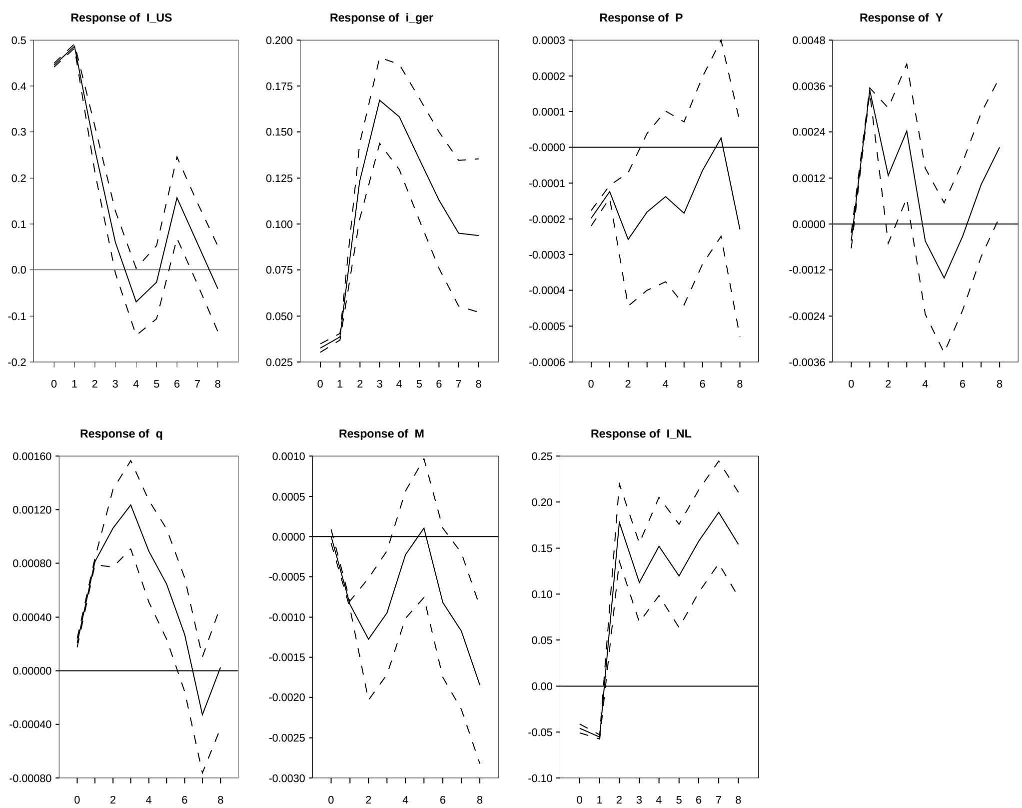


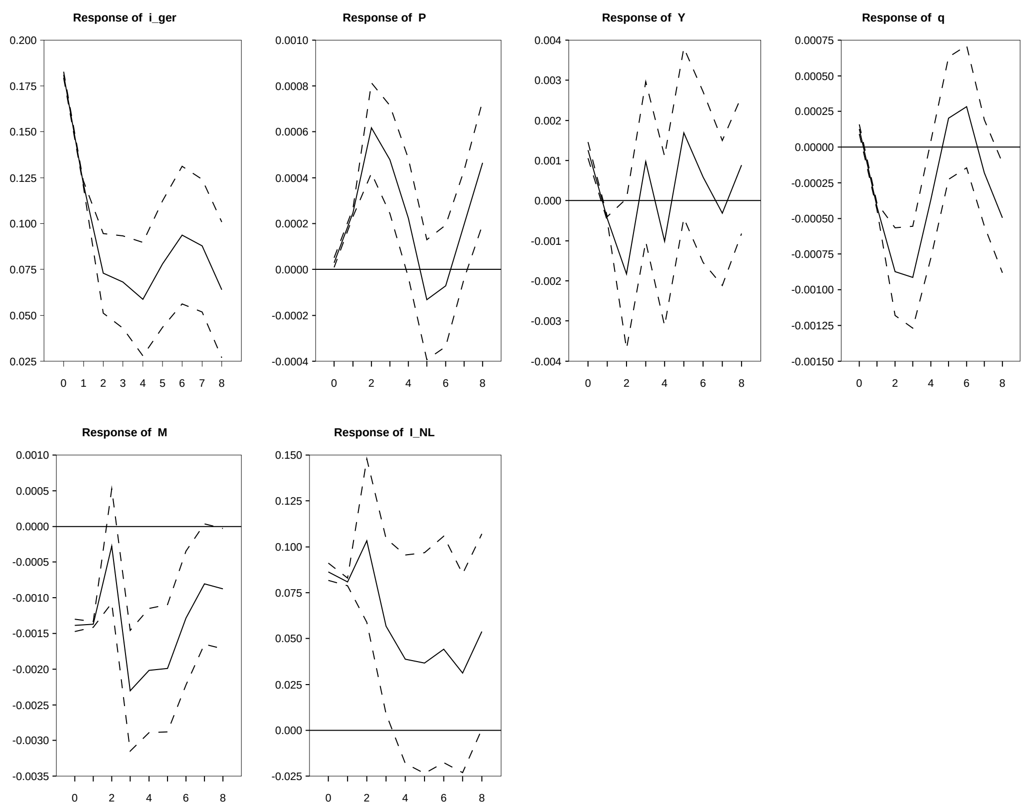
Figure 3: SSVAR Model: Impulse Response Functions for the Netherlands

*(a) Responses to $\epsilon_W$*



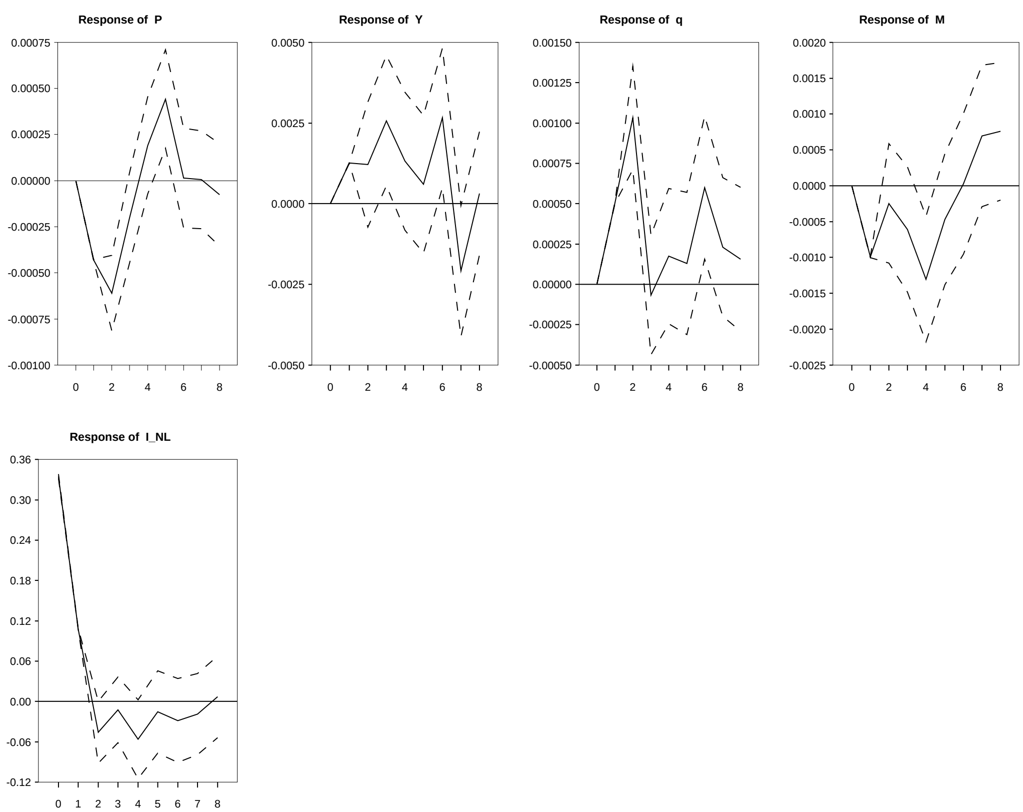
SSVAR Model: Impulse Response Functions for the Netherlands
(continued)

*(b) Responses to $\epsilon_{GER}$*



SSVAR Model: Impulse Response Functions for the Netherlands (continued)

*(c) Responses to $\epsilon_{MS}$*



also increases (except for the Netherlands). This result may suggest that the information set we are considering (i.e., all the variables included in this model) may be smaller than the information set of the monetary authorities, who raise the interest rate since they want to anticipate the increase in output and prices.[14] Output and the price level tend to decrease only after a few months.

The real exchange rate with respect to Germany correctly appreciates in France and Italy, instead depreciates in the Netherlands. This latter result may show that if the restrictive monetary measure in the Netherlands is not independent and is linked to an increase in the German rate, which has occured beforehand, then correctly the real exchange rate depreciates.

When considering next the responses of the domestic variables to a monetary policy innovations in Germany, we find some important differences. The monetary policy in Germany can be qualified as a restrictive monetary measure since the German rate increases. According to the responses in the domestic rates, all countries follows the center country, but with some differences.

First, the highest impact is found for the Dutch interest rate and its response remains positive for all following eight months, although significant only for the first three months. Both in France and Italy the response in the domestic rate becomes rapidly negative.

Next, we found important differences in the impact of the restrictive monetary policy on the other domestic (non–policy) variables of the three countries. In Italy both the price level and output decreases. In France output goes down and the response in the price level shows a decrease, at least at impact. On the contrary, in the Netherlands the price level has a positive and significant response for almost four months, whereas output increases at impact and then the response becomes insignificant.

Therefore, an increase in the interest rate in Germany has different effects on the domestic variables of the three countries. In particular, it does not seem to have a dumping effect on the aggregate demand in the Netherlands as it does in Italy.

One explanation may be found in the initial depreciation of the Dutch real exchange rate with Germany; however, there is only an impact depreciation, which does not last over time and becomes immediately a real appreciation.

Another possible reason of this pattern may be related with the results that we have found for the responses of the domestic variables to a restrictionary monetary–policy measure. We have seen above that the model may not capture the whole information set of the monetary authorities and the

[14] See Sims(1992).

Table 3: SSVAR: Forecast Error Variance Decomposition for the domestic interest rate.(Standard Errors in parenthesis)

| *Shock* | *Steps* | **France** | **Italy** | **Netherlands** |
|---|---|---|---|---|
| $\epsilon_W$ | 1 | 0.004<br>(3.7e-4) | 0.012<br>(0.001) | 0.030<br>(0.002) |
| | 6 | 0.236<br>(0.042) | 0.045<br>(0.022) | 0.296<br>(0.029) |
| | 12 | 0.409<br>(0.053) | 0.050<br>(0.025) | 0.343<br>(0.031) |
| | 24 | 0.527<br>(0.068) | 0.073<br>(0.026) | 0.331<br>(0.034) |
| $\epsilon_{GER}$ | 1 | 0.024<br>(0.001) | 0.039<br>(0.002) | 0.080<br>(0.003) |
| | 6 | 0.059<br>(0.017) | 0.053<br>(0.017) | 0.087<br>(0.014) |
| | 12 | 0.112<br>(0.026) | 0.078<br>(0.027) | 0.098<br>(0.019) |
| | 24 | 0.123<br>(0.025) | 0.079<br>(0.018) | 0.109<br>(0.026) |

increase in the interest rate may actually be caused by the future, expected increase in the price level and output. If we assume that the initial increase in the German interest rate is actually due to a future inflationary shock in Germany (for instance, as an outward shift in the German IS), then we could conclude that inflationary shocks in Germany are highly correlated with inflationary shocks in the Netherlands, but certainly not with the shocks in Italy and doubtfully with the one in France. As a consequence, following the German monetary policy is more costly for Italy and France, than for the Netherlands.

Furthermore, we provide the responses of the domestic variables when there is also a (restrictive) monetary measure in the US (part *(a)*'s of the Fig. 1–3). The responses in the domestic rates are all qualitatively very similar to the response of the German rate, therefore confirming that generally all three countries tends to follow the center country. Moreover, the responses in domestic output and the price level are different among countries, but not very high. However, France is the only country that shows an increase both in the price level and output after at least six months.

The IRF provide a qualitative analysis, but if we want to obtain the

SSVAR: Forecast Error Variance Decomposition for the domestic interest rate.(Standard Errors in parenthesis) (Continued)

| *Shock* | *Steps* | **France** | **Italy** | **Netherlands** |
|---|---|---|---|---|
| $\epsilon_{MS}$ | 1 | 0.796<br>(0.004) | 0.814<br>(0.004) | 0.710<br>(0.004) |
| | 6 | 0.497<br>(0.038) | 0.596<br>(0.042) | 0.346<br>(0.021) |
| | 12 | 0.289<br>(0.042) | 0.524<br>(0.041) | 0.256<br>(0.025) |
| | 24 | 0.145<br>(0.048) | 0.359<br>(0.041) | 0.244<br>(0.026) |
| *other domestic shocks* | 1 | 0.176<br>( n.a.) | 0.135<br>( n.a.) | 0.180<br>( n.a.) |
| | 6 | 0.208<br>( n.a.) | 0.305<br>( n.a.) | 0.270<br>( n.a.) |
| | 12 | 0.191<br>( n.a.) | 0.348<br>( n.a.) | 0.303<br>( n.a.) |
| | 24 | 0.205<br>( n.a.) | 0.489<br>( n.a.) | 0.315<br>( n.a.) |

explanatory power of each structural shock with respect to the variability of each endogenous variable, we need to turn to the forecast error variance decomposition (FEVD). In particular, this is shown for the domestic interest rates of all three countries in Table 3.

The German monetary–policy innovation ($\epsilon_{GER}$) confirms its important role for the Netherlands where it explains over 10% of the variability of the Dutch interest rate at the 2–step–ahead horizon (not shown in the Table). For France the percentage is even higher than 10%, but only in the longer horizon, whereas the percentage is never higher than 8% for Italy, which is not surprising given the effects of increases in the German rate on Italian output and prices.

Instead, the Italian rate is highly characterized by its own innovation ($\epsilon_{MS}$), therefore giving evidence of a much higher independence in the way of setting the domestic rate (at least not explained by any of the variables included in the analysis). The contribution of the $\epsilon_{MS}$ shock is important also for the other two countries, but it decreases more rapidly.

Also, it ought to be noticed the high contribution of the US shock ($\epsilon_{W}$) for the Netherlands and especially for France, where it reaches over 50% after

24 months.

In conclusion, the monetary policy of the Netherlands seems the most consistent with the fixed exchange–rate regime joined by that country: innovations in the monetary policy of the center country strongly affect domestic monetary policy in the short run. In the other two countries, the innovation in the US monetary policy (for France) and the own innovation in monetary policy (for Italy) play a very significant role. However, their difficulties may be explained by the higher cost (in terms of imported recession) of following Germany as closely as the Netherlands.

In the next section we propose a structural model that could characterize not only the monetary–policy shocks, but also other structural shocks for the small economies. The aim of the analysis is then to check for other characteristics of these economies, with particular regards to the effects that devaluations could have on both the price level and output.

# 3 A Theoretical Framework for Structural VAR

In this section we present the economic models for both the small open economy and the center country (i. e., Germany).

In particular, the aim of this section is to provide a theoretical framework that could help identify other structural (domestic) shocks in addition to the foreign monetary–policy shocks introduced in the previous section.

As it will become clearer later, the main scope is to study the effect of devaluations on the three economies, but it is necessary to specify a model for the whole economy in order to correctly identify the dynamic effects of real exchange–rate innovations.

## 3.1 The Structural Model for the Small Open Economy

All the high–frequency components of the variables are indicated by a *. They represent each variable's unforcastable innovations within the period, i.e., $x^* \equiv x_t - E_{t-1}[x_t]$ for a generic variable $x_t$. The driving forces of the system (i.e., the unobservable, normally–distributed, structural shocks, whose effects we want to identify) are indicated by $\epsilon$'s with different subscripts.

The agents' information set within the observation period is the following: all the financial variables are directly observable during the period, whereas the current price level and current production are known only at the end.[15]

The first variables that we consider are two foreign, short–term nominal interest rates:

$$
\begin{aligned}
i^*_{US} &= \epsilon_W & (1)\\
i^*_{GER} + a_{21} i^*_{US} &= \epsilon_{GER} & (2)
\end{aligned}
$$

Innovations in the short–term interest rates of both the US and Germany are assumed to identify respectively a world shock ($\epsilon_W$) and the shock $\epsilon_{GER}$ originating in the center country of the regional exchange–rate system (i. e., Germany for the ERM) in which our small open economy participates.

Once again, we use interest rates to represent "endogenous" shocks coming from abroad by following the same reasoning as in the SSVAR approach.

Next, let us consider the supply side of the domestic economy. A standard Lucas supply curve implies the following relationship between current output ($y_t$, in log terms), full–employment output ($\bar{y}$), the current price level ($p_t$, in log terms) and the expectation of the current (time $t$) price level formed at time $t-1$ ($p^e_{t-1}$), plus an aggregate–supply ($AS$) shock ($\epsilon'_{AS}$):

$$y_t = \bar{y} + \alpha(p_t - p^e_{t-1}) - \epsilon'_{AS}$$

The term in parentheses represents the unforecastable innovation in the domestic price level ($p^*$). If the $t-1$ expectation of current output is equal to the full–employment level (i. e., $y^e_{t-1} = \bar{y}$), then the current innovation in output ($y^*$) corresponds to the output gap.[16]

Hence, we have the following relationship between innovations in output and prices:

$$p^* - a_{34} y^* = \epsilon_{AS} \tag{3}$$

where $\epsilon_{AS} \equiv (1/\alpha)\epsilon'_{AS}$.

Next, according to national accounting, domestic saving net of domestic investment and government dissaving ($S(\cdot)$) must be equal to net exports ($NX(\cdot)$):

---

[15] This assumption corresponds to the actual availability of data: interest rates and exchange rates, for instance, are available on a daily basis, whereas data on the price level and production are known at the end of the month. See also Sims (1992), Kim and Roubini (1995), Bernanke and Mihov (1995) and Clarida–Gertler (1996).

[16] If we assume that full–employment output is the *long–run* expectation on output (which does not necessarily equal the short–run conditional expectation, $y^e_{t-1}$, as assumed in the text), then the shock $\epsilon_{AS}$ also includes this possible difference between long–run and short–run expectation.

$$S(y^*, \epsilon_{IS}) = NX(y^*, q^*)$$

where excess total domestic saving $S$ depends on the innovation in output and on a goods–market shock ($\epsilon_{IS}$).

Usually the real interest rate is a determinant variable to explain domestic investment and therefore to affect $S$ in this framework. Here, the real interest rate is assumed to affect the goods market at least with one–period lag and therefore its current innovation does not enter the goods–market equation. Finally, net exports are a function of the innovations in both current income and the real exchange rate ($q^*$).

Then, when linearizing the above national–accounting relationship and normalizing with respect to output, we obtain:

$$y^* - a_{45}q^* = \epsilon_{IS} \tag{4}$$

Moreover, we consider the balance of payments:

$$NX(y^*, q^*) + NFI(i^* - i^*_{GER} - (s^{e,*} - s^*), \Delta IR^*) + \nu = 0$$

$NFI$ represents the balance in capital account. In particular, $NFI$ includes both private capital flows, which depend on the (innovation in the) interest–rate differential with the center country ($i^* - i^*_{GER}$) adjusted for the expected rate of depreciation of the domestic currency[17] ($s^{e,*} - s^*$), and central–bank interventions ($\Delta IR$).

Although the small economy has a direct relationship also with the other big country (i. e., the US), we assume that capital flows are particularly reactive *within the period* only to the adjusted interest–rate differential with the center country. The influence of the interest–rate differential with the US can still play a role in the model, but only with one or more lags.

Next, the innovation in expected depreciation is assumed to be zero. In other words, if both regime exits and realignments are unforecastable, under fixed exchange rates expected depreciation is always equal to zero according to the econometrician's information set. However, *market* devaluation expectations are not always zero. Then, we assume that the equation shock ($\nu$) would capture it, i.e., it becomes a source of fluctuations in the model.

More exactly, the shock $\nu$ represents a general balance–of–payments shock, whose increase causes a depreciation of the real exchange rate (since we will normalize the above equation with respect to $q$). However, in the short run

[17]The variable $s$ represents the nominal exchange between the domestic currency and the center country and is expressed in units of domestic currency per one Deutsche Mark (DM).

rapid depreciations of the real exchange rate are due to sudden movements in the nominal rate (i.e., realignments). The shock $\nu$ then represents the effect of those sudden changes whose cause could be the realignment expectations that arise in the foreign exchange market and are sometimes responsible for speculative attacks.

As such, $\nu$ is correlated with the structural shock arising in the goods market. In fact, successive positive shocks in the domestic goods market (say, due to a continuously expansionary fiscal policy) will increase both the domestic interest rate and income; the shift in aggregate demand also increases the domestic price level. As a result, the economy will run an increasing deficit in the current account compensated by capital inflows. Competitiveness will worsen, mainly because of increasing domestic prices. Then, devaluation expectations arise since a change in the nominal exchange rate become very likely in order to correct for the misalignment of the real exchange rate.

Moreover, the innovation $\nu$ is correlated also with the idiosyncratic innovations on the money supply ($\epsilon_{MS}$) due to the independent behavior of the domestic monetary authorities with respect to the center country.

In conclusion, we could express the shock $\nu$ as the following:

$$\nu \equiv \epsilon_s + \phi_1 \epsilon_{IS} - \phi_2 \epsilon_{MS}$$

where $\epsilon_s$ is the component of $\nu$ that is orthogonal to both $\epsilon_{IS}$ and $\epsilon_{MS}$ and where $\phi_1$ and $\phi_2$ are directly related to the covariances between $\nu$ and the other two shocks. In other words, $\epsilon_s$ could be considered as the "pure" shock arising from the equation of the balance of payments.

The final component in the capital account is the (innovation in the) intervention by the domestic monetary authorities (i. e., $\Delta IR^*$). In a traditional fixed exchange–rate regime this is an endogenous component of the monetary base. However, in the case of the ERM both the presence of capital controls and the realignment option (exercised quite often in the first eight years of the system) have given a substantial degree of monetary independence to the European countries. Moreover, the rules of the system prescribe mandatory interventions only when the exchange rate has reached the edge of the band.[18] As a result, when the domestic currency is not at the margin, intervention in the foreign exchange market with international reserves is truly a choice of the domestic monetary authorities. Therefore, we assume that innovations in the interventions are a general function $g(\cdot)$

[18]The original EMS Treaty prescribes also that *both* central banks should cooperatively intervene when one exchange rate reaches the edge of the band. More effectively, it designed financing facilities to alleviate the short–run constraint of reserve depletion for currencies under attack.

of the policy (money–supply) innovations $\epsilon_{MS}$:

$$\Delta IR^* = g(\epsilon_{MS})$$

By plugging the latter two assumptions back in the balance–of–payments equation and linearizing, we obtain the following relationship (normalized to the real exchange rate):

$$q^* - a_{54}y^* + a_{57}i^* - a_{52}i^*_{GER} = \epsilon_s + b_{54}\epsilon_{IS} - b_{57}\epsilon_{MS}$$

In addition, we set $a_{54} = 0$ to satisfy the rank condition for identification:

$$q^* + a_{57}i^* - a_{52}i^*_{GER} = \epsilon_s + b_{54}\epsilon_{IS} - b_{57}\epsilon_{MS} \quad (5)$$

In economic terms, this additional assumption means that *contemporaneously* innovations in output do not affect the real exchange rate. However, the effect can arise over time.

Next, we consider the money market. On the demand side, we assume a traditional money–demand equation for the innovations in the different variables:

$$m^* - p^* - a_{64}y^* + a_{67}i^* = \epsilon_{MD} \quad (6)$$

where $m^*$ is the innovation in the domestic nominal money stock and $\epsilon_{MD}$ is the shock to money demand.

Finally, the money supply is controlled by the monetary authorities that are assumed to target the interest rate *within the period*. In the same fashion as Bernanke and Blinder (1992), money–supply shocks are assumed to be captured by the innovations in the domestic call–money rate. Therefore, innovations in the call money–rate depend on the reaction function of the domestic monetary authorities, which takes the following form:

$$i^* - a_{71}i^*_{US} - a_{72}i^*_{GER} - a_{76}m^* = \epsilon_{MS} \quad (7)$$

The domestic monetary authorities are assumed to intervene in the money market in order to change the domestic call money–rate when there are variations in the relevant foreign interest rates and in order to monitor the money supply *within the period*. The absence of prices, output and the real exchange rate is due to the fact that the authorities can observe them only at the end of the period. As made explicit in the initial assumptions, the price level and output are not in the information set at the beginning of the period for all agents, including monetary–policy authorities.[19]

[19]See Sims (1992). For an international setup under flexible exchange rates see Kim and Roubini (1995) and Zha (1995).

Then, the length of the observation period is particularly relevant. For instance, the assumption on the information set of the authorities would be unlikely to hold if the data frequency were quarterly since within three months the authorities have enough information on output and prices. Thus, within the quarter authorities would determine the interest rate also according to contemporaneous innovations in output and the price level.

As a final remark, although the foreign interest rate that the domestic authorities are likely to consider contemporaneously is the German rate, we also include the US rate. We expect this coefficient not to be significant for all the European countries if their main concern is the European exchange–rate regime.

All the equations (1)–(7) can be rearranged in a matrix form as follows:

$$\begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ a_{21} & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & -a_{34} & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & -a_{45} & 0 & 0 \\ 0 & -a_{52} & 0 & 0 & 1 & 0 & a_{57} \\ 0 & 0 & -1 & -a_{64} & 0 & 1 & a_{67} \\ -a_{71} & -a_{72} & 0 & 0 & 0 & -a_{76} & 1 \end{bmatrix} \begin{bmatrix} i^*_{US} \\ i^*_{GER} \\ p^* \\ y^* \\ q^* \\ m^* \\ i^* \end{bmatrix} =$$

$$\begin{bmatrix} b_{11} & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & b_{22} & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & b_{33} & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & b_{44} & 0 & 0 & 0 \\ 0 & 0 & 0 & b_{54} & b_{55} & 0 & -b_{57} \\ 0 & 0 & 0 & 0 & 0 & b_{66} & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & b_{77} \end{bmatrix} \begin{bmatrix} \epsilon_W \\ \epsilon_{GER} \\ \epsilon_{AS} \\ \epsilon_y \\ \epsilon_s \\ \epsilon_{MD} \\ \epsilon_{MS} \end{bmatrix}$$

where $\epsilon \equiv [\epsilon_W, \epsilon_{GER}, \epsilon_{AS}, \epsilon_{IS}, \epsilon_s, \epsilon_{MD}, \epsilon_{MS}]' \sim \mathbf{N}(\mathbf{0}, \mathbf{I})$.

The system above describes the impact of all the structural shocks on the endogenous variables *within one period*. In particular, it includes among the endogenous variables also the real exchange rate. Then, by adding the relationship between the real and the nominal exchange rate (i. e., $s^* = q^* + p^* - p^*_{GER}$), the nominal rate also becomes an endogenous variable.

A potential problem may then arise by considering the traditional approach to fixed versus flexible exchange rates.

Theoretically, in a pure fixed exchange–rate regime $s$ is kept constant at the declared parity by endogenizing the money supply. In the present model this means that the policy shock $\epsilon_{MS}$ should be a linear combination of all the other shocks.

However, in reality the EMS is a target–zone regime and movements (even if only small) in the nominal exchange rates are still possible. Therefore, the requirement of collinearity among the shocks does not necessarily have to hold. Second, *within one period* the authorities may use sterilized interventions, which cannot be fully captured in this model. Third, realignments are possible.

## 3.2 The Structural Model for the Center Country

A very similar model is designed in this section for Germany as the center country. It will then be possible to compare both the structure and the policy preferences of the small open economies and their center country.

The variables in the VAR identify one major world shock, structural shocks from the real sector (i. e., AS, goods–market and balance–of–payments shocks) and from the money market. However, since Germany is the center country there are a few differences to point out.

First, the world shock is now identified uniquely by innovations in the US Federal Funds rate.

Next, in the capital account the relevant interest–rate differential is with the US and the error term from the balance–of–payments equation still identifies a foreign exchange–market shock. We maintain the assumption that this shock is correlated with shocks both in the goods market ($\epsilon_{IS}$) and to the German money supply ($\epsilon_{MS}$).

The model for Germany is then summarized in matrix form as follows:

$$\begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & -a_{23} & 0 & 0 & 0 \\ 0 & 0 & 1 & -a_{34} & 0 & 0 \\ -a_{41} & 0 & 0 & 1 & 0 & a_{46} \\ 0 & -1 & -a_{53} & 0 & 1 & a_{56} \\ -a_{61} & 0 & 0 & 0 & -a_{65} & 1 \end{bmatrix} \begin{bmatrix} i^*_{US} \\ p^* \\ y^* \\ q^*_{DM/\$} \\ m^* \\ i^* \end{bmatrix} =$$

$$\begin{bmatrix} b_{11} & 0 & 0 & 0 & 0 & 0 \\ 0 & b_{22} & 0 & 0 & 0 & 0 \\ 0 & 0 & b_{33} & 0 & 0 & 0 \\ 0 & 0 & b_{43} & b_{44} & 0 & b_{46} \\ 0 & 0 & 0 & 0 & b_{55} & 0 \\ 0 & 0 & 0 & 0 & 0 & b_{66} \end{bmatrix} \begin{bmatrix} \epsilon_W \\ \epsilon_{AS} \\ \epsilon_{IS} \\ \epsilon_s \\ \epsilon_{MD} \\ \epsilon_{MS} \end{bmatrix}$$

where $\epsilon \equiv [\epsilon_W, \epsilon_{AS}, \epsilon_{IS}, \epsilon_s, \epsilon_{MD}, \epsilon_{MS}]' \sim \mathbf{N}(\mathbf{0}, \mathbf{I})$.

# 4 The SVAR Methodology

Let us consider a $(n \times 1)$ vector $\mathbf{X}_t$ with all the observable endogenous variables at time $t$ (for instance, in the case of the small open economy above $n = 7$).[20] Then, the scope of the analysis is to recover the dynamic structural form that links the observable variables in $\mathbf{X}_t$ with the meaningful, structural shocks, $\epsilon$. That is, in VAR form:

$$\mathbf{S}\mathbf{X}_t = \mathbf{S}(L)\mathbf{X}_{t-1} + \epsilon_t \tag{8}$$

where $\mathbf{S}$ is a non–diagonal matrix, $\mathbf{S}(L)$ is a matrix of polynomials in $L$ and $\epsilon_t \sim \mathbf{N}(\mathbf{0}, \mathbf{I})$ is the vector that contains the structural shocks described in the previous section.

However, when directly estimating the system (8), we cannot obtain unbiased and consistent estimates of the parameters in $\mathbf{S}$. Instead, the relative unrestricted/reduced–form VAR can be considered whose estimates have all the desirable properties. The estimated reduced form is the following:

$$\mathbf{X}_t = \mathbf{R}(L)\mathbf{X}_{t-1} + \mathbf{e}_t \tag{9}$$

where $\mathbf{R}(L) \equiv \mathbf{S}^{-1}\mathbf{S}(L)$ is a matrix of polynomials in $L$, $\mathbf{e}_t \equiv \mathbf{S}^{-1}\epsilon_t$ is a $(n \times 1)$ vector of random variables with zero mean and the following variance–covariance matrix: $E[\mathbf{e}_t\mathbf{e}_t{}'] = \mathbf{\Sigma}$.

Although no economic meaning can be attached to the reduced form, $\mathbf{e}_t$ is the vector of unforecastable innovations for which the theory in the previous section was developed.

Moreover, if the matrix $\mathbf{S}^{-1}$ is set equal to $\mathbf{A}^{-1}\mathbf{B}$, where $\mathbf{A}$ and $\mathbf{B}$ are the two matrices discussed in the previous section, then we could take advantage of the contemporaneous relationships that we describe in the theoretical model:

$$\mathbf{A}\mathbf{e}_t = \mathbf{B}\epsilon_t \tag{10}$$

Notice that after the estimation of the reduced form (9), the knowledge of the matrices $\mathbf{A}$ and $\mathbf{B}$ could allow us to go from the reduced form to the structural form.

The parameters included in the matrices $\mathbf{A}$ and $\mathbf{B}$ can be estimated with a maximum–likelihood method. First, we ought to notice that given eq. (10), the following nonlinear relationship holds between the variance–covariance matrix $\mathbf{\Sigma}$ and the two matrices $\mathbf{A}$ and $\mathbf{B}$:

[20] All vectors are column vectors unless transposed with a prime sign.

$$\mathbf{A\Sigma A'} = \mathbf{BB'}$$

since $E[\epsilon_t \epsilon_t'] = \mathbf{I}$. Therefore

$$\mathbf{\Sigma} = \mathbf{A}^{-1}\mathbf{BB'}(\mathbf{A'})^{-1}$$

Since the structural disturbances are assumed to be normally distributed, the concentrated log–likelihood of the system is the following:

$$L = c - \frac{T}{2}\log|\mathbf{\Sigma}| - \frac{T}{2}tr\{\hat{\mathbf{\Sigma}}\mathbf{\Sigma}^{-1}\}$$

where $\hat{\mathbf{\Sigma}} \equiv \frac{1}{T}\sum_{t=1}^{T}\mathbf{e}_t\mathbf{e}_t{}'$. The theoretical variance–covariance matrix $\mathbf{\Sigma}$ can be expressed in terms of $\mathbf{A}$ and $\mathbf{B}$, as shown above. Therefore, by substituting we obtain

$$L(\mathbf{A},\mathbf{B}) = c + T\log|\mathbf{B}| - T\log|\mathbf{A}| - \frac{T}{2}tr\{\mathbf{A}'(\mathbf{B}')^{-1}\mathbf{B}^{-1}\mathbf{A}\hat{\mathbf{\Sigma}}\}$$

Estimates of the parameters in both $\mathbf{A}$ and $\mathbf{B}$ can be obtained by maximizing the log–likelihood with respect to the free parameters in $\mathbf{A}$ and $\mathbf{B}$ (FIML estimates).

Operationally, once consistent estimates of $\mathbf{A}$ and $\mathbf{B}$ are obtained, it is then possible to obtain also a consistent estimate of the structural VAR representation, given consistent estimates of $\mathbf{R}(L)$ and $\mathbf{\Sigma}$.

Under regularity conditions[21] it is then possible to recover the relative structural vector–moving–average (VMA) representation, which provides the dynamic responses of the original variables to the structural shocks, and the relative forecast error variance decompositions.

Besides the estimation, an issue of identification arises.

After the estimation of the reduced form, we have consistent estimates of $n(n+1)/2$ parameters in the matrix $\hat{\mathbf{\Sigma}}$. However, in principle the matrices $\mathbf{A}$ and $\mathbf{B}$ contain $2n^2$ free parameters ($n^2$ in each matrix). Therefore, in order to identify $\mathbf{A}$ and $\mathbf{B}$, $2n^2 - n(n+1)/2$ extra pieces of information are needed. This is analogous to the order condition for identification in simultaneous equation systems.

The matrices $\mathbf{A}$ and $\mathbf{B}$ discussed in the previous section contain only 19 free parameters in the case of the small open economy and 28 covariances are available from the estimated $\Sigma$. In the case of Germany we have 16 free parameters and 21 covariances. Thus, the order condition is satisfied

[21] See Lippi and Reichlin (1993).

because the economic structure was able to impose a sufficient number of zero restrictions in the contemporaneous relationships between innovations in the endogenous variables and structural shocks.[22]

However, the order condition is only a necessary condition.

In addition, the rank condition for identification requires that the Hessian of the function that maps the free parameters to the values of $\mathbf{\Sigma}$ be full–rank.[23]

When both the rank and the order conditions are satisfied, then the likelihood function can be maximized with respect to the free parameters in the matrices **A** and **B**, and it has a unique maximum. Also the asymptotic standard errors for the parameters in **A** and **B** can be directly obtained from the inverse of the information matrix. Moreover, asymptotic standard errors for the IRF and the FEVD are functions of the variances of those coefficients and can be analytically computed without resorting to either bootstrapping or Monte Carlo methods.[24]

Examples of first applications of this method are Bernanke (1986), Blanchard and Watson (1986), Sims (1986) and many others.

# 5 Empirical Results of the SVAR Model

The estimation of the structural model consists of a two–step procedure. The first step consists of the estimation of the non–structural/reduced–form VAR and has been performed by including a constant term in each equation.

The second stage is needed to obtain the structural coefficients in the matrices **A** and **B**. The estimated contemporaneous equations specified in the theoretical models are shown in Tables 4–6 for the three "small" European countries and in Table 7 for Germany.

[22]Alternatively, SVARs can be identified by imposing restrictions on the long–run, zero–frequency behavior of the variables. See, as first applications, Shapiro and Watson (1988), Blanchard and Quah (1989). Lippi and Reichlin (1993) and Faust and Leeper (1994) discuss the necessary conditions to have a meaningful economic interpretation of the structural shocks in this approach.

[23]This function is nonlinear in the free parameters to be estimated and the rank condition requires a numerical check that will insure *local identification* (Rothenberg, 1971). See Giannini (1992) and Hamilton (1994, p. 332–4). As a matter of fact, when leaving $a_{54}$ unconstrainedly different from zero, the rank condition fails.

[24]The computation to obtain these standard errors is illustrated in Giannini (1992).

Table 4: Estimated Contemporaneous Equations for France. (Standard Errors in parentheses)

| France |
|---|
| $i^*_{US} = \underset{(0.003)}{0.677}\ \epsilon_W$ |
| $i^*_{GER} \underset{(0.002)}{+0.023}\ i^*_{US} = \underset{(0.001)}{0.247}\ \epsilon_{GER}$ |
| $p^* \underset{(0.002)}{-0.036}\ y^* = \underset{(7.0e-6)}{0.002}\ \epsilon_{AS}$ |
| $y^* \underset{(1.964)}{-6.727}\ q^* = \underset{(0.015)}{-0.052}\ \epsilon_y$ |
| $q^* \underset{(6.1e-05)}{-8.2e-4}\ i^* \underset{(7.7e-05)}{-2.7e-4}\ i^*_{GER} = \underset{(3.5e-4)}{-0.001}\ \epsilon_s \underset{(2.9e-5)}{+2.5e-4}\ \epsilon_{MS} \underset{(7.4e-5)}{+0.007}\ \epsilon_{IS}$ |
| $m^* - p^* \underset{(0.281)}{-0.986}\ y^* \underset{(0.004)}{-0.024}\ i^* = \underset{(0.003)}{0.027}\ \epsilon_{MD}$ |
| $i^* \underset{(0.012)}{-0.016}\ i^*_{US} \underset{(0.035)}{-0.101}\ i^*_{GER} \underset{(13.198)}{+164.203}\ m^* = \underset{(0.089)}{-1.385}\ \epsilon_{MS}$ |

Table 5: Estimated Contemporaneous Equations for Italy. (Standard Errors in parentheses)

| Italy |
|---|
| $i^*_{US} = \underset{(0.003)}{0.664}\ \epsilon_W$ |
| $i^*_{GER} \underset{(0.002)}{-0.042}\ i^*_{US} = \underset{(0.001)}{0.263}\ \epsilon_{GER}$ |
| $p^* \underset{(8.7e-4)}{-0.002}\ y^* = \underset{(1.1e-5)}{0.002}\ \epsilon_{AS}$ |
| $y^* \underset{(0.030)}{-0.178}\ q^* = \underset{(8.5e-5))}{0.018}\ \epsilon_{IS}$ |
| $q^* \underset{(2.3e-4)}{-0.005}\ i^* \underset{(2.8e-4)}{+0.003}\ i^*_{GER} = \underset{(5.2e-5)}{0.011}\ \epsilon_s \underset{(8.3e-5)}{-0.003}\ \epsilon_{MS} \underset{(2.2e-4)}{-6.2e-4}\ \epsilon_{IS}$ |
| $m^* - p^* \underset{(0.012)}{-0.188}\ y^* \underset{(0.002)}{-0.037}\ i^* = \underset{(7.3e-4)}{0.020}\ \epsilon_{MD}$ |
| $i^* \underset{(0.010)}{+0.045}\ i^*_{US} \underset{(0.040)}{-0.773}\ i^*_{GER} \underset{(6.121)}{+127.879}\ m^* = \underset{(0.043)}{-1.083}\ \epsilon_{MS}$ |

Table 6: Estimated Contemporaneous Equations for the Netherlands. (Standard Errors in parentheses)

**Netherlands**

$$i^*_{US} = \underset{(0.002)}{0.594} \; \epsilon_W$$

$$i^*_{GER} \; \underset{(0.002)}{-0.022} \; i^*_{US} = \underset{(0.001))}{0.236} \; \epsilon_{GER}$$

$$p^* \; \underset{(7.0e-4)}{+0.010} \; y^* = \underset{(1.0e-5)}{0.002} \; \epsilon_{AS}$$

$$y^* \; \underset{(1.052)}{-24.396} \; q^* = \underset{(0.004)}{0.099} \; \epsilon_{IS}$$

$$q^* \; \underset{(2.6e-4)}{+0.005} \; i^* \; \underset{(1.1e-4)}{-0.002} \; i^*_{GER} = \underset{(1.0e-4)}{0.002} \; \epsilon_s \; \underset{(5.8e-5)}{-2.7e-4} \; \epsilon_{MS} \; \underset{(3.4e-5)}{-0.003} \; \epsilon_{IS}$$

$$m^* - p^* \; \underset{(0.464)}{+3.855} \; y^* \; \underset{(0.009)}{-0.064} \; i^* = \underset{(0.011)}{0.093} \; \epsilon_{MD}$$

$$i^* \; \underset{(0.022)}{-0.056} \; i^*_{US} \; \underset{(0.121)}{+0.605} \; i^*_{GER} \; \underset{(26.469)}{+243.149} \; m^* = \underset{(0.221)}{-2.096} \; \epsilon_{MS}$$

Table 7: Estimated Contemporaneous Equations for Germany. (Standard Errors in parentheses)

**Germany**

$$i^*_{US} = \underset{(0.003)}{0.710} \; \epsilon_W$$

$$p^* \; \underset{(7.6e-4)}{+0.009} \; y^* = \underset{(8.0e-6)}{0.002} \; \epsilon_{AS}$$

$$y^* \; \underset{(0.013)}{-0.081} \; q^* = \underset{(9.3e-5)}{-0.015} \; \epsilon_{IS}$$

$$q^* \; \underset{(8.7e-4)}{-0.004} \; i^* \; \underset{(2.6e-4)}{-0.009} \; i^*_{US} = \underset{(1.9e-4)}{0.030} \; \epsilon_s \; \underset{(2.1e-4)}{+0.002} \; \epsilon_{MS} \; \underset{(8.4e-4)}{+0.005} \; \epsilon_{IS}$$

$$m^* - p^* \; \underset{(0.011)}{+0.049} \; y^* \; \underset{(0.008)}{-0.091} \; i^* = \underset{(0.002)}{0.026} \; \epsilon_{MD}$$

$$i^* \; \underset{(0.006)}{-0.025} \; i^*_{US} \; \underset{(4.813)}{+49.390} \; m^* = \underset{(0.051)}{0.634} \; \epsilon_{MS}$$

Table 8: Likelihood-Ratio Tests for the Overidentifying Restrictions.

| *Country* | *Statistics* | *P-value* |
|---|---|---|
| **France** | 6.671 | 0.671 |
| **Italy** | 22.805 | 0.007 |
| **Netherlands** | 81.331 | 8.8e-14 |
| **Germany** | 1.962 | 0.854 |

As a general evaluation of the estimation, the LR tests for the overidentifying restrictions are illustrated in Table 8. They indicate that the zero restrictions imposed in the model are not rejected for France and Germany at the common significance level, whereas the acceptance p–value for Italy is 0.7%. The test highly rejects the restrictions for the Netherlands.[25]

Although the results from the overidentifying restrictions are only partly satisfactory, the same cannot be said for the expected signs of the coefficients. All the estimates are again summarized in Table 9 for the three "small" European countries and in Table 10 for Germany. In the same tables are also shown the expected, correct signs. France is the country with the highest number of correct signs in the coefficients: only the signs of the interest rate in money demand ($a_{67}$) and in the real exchange–rate equation ($a_{57}$) are significantly wrong. For Italy also the sign of the German interest rate ($a_{52}$) is positive instead of negative; whereas for the Netherlands the signs in the real exchange–rate equations are correct, but both output and the interest rate have the wrong signs in the money demand equation, the AS curve slopes downwards (i.e., positive $a_{34}$) and in the reaction function of the monetary authorities the domestic rate moves in the opposite direction with respect to the German rate (i.e., positive $a_{72}$). Also in the case of Germany the money–demand and AS coefficients are wrongly signed, as well as the sign of the German rate in the real exchange–rate equation.

[25]The LR test considers the unrestricted likelihood as the one obtained by taking the variance–covariance matrix of the first stage (unrestricted) VAR. The restricted likelihood is instead obtained by using the variance–covariance matrix implied by the second stage, which is related to the estimated matrices **A** and **B**.

Figure 4: SVAR Model: Impulse Response Functions for France

*(a) Response to $\epsilon_s$*

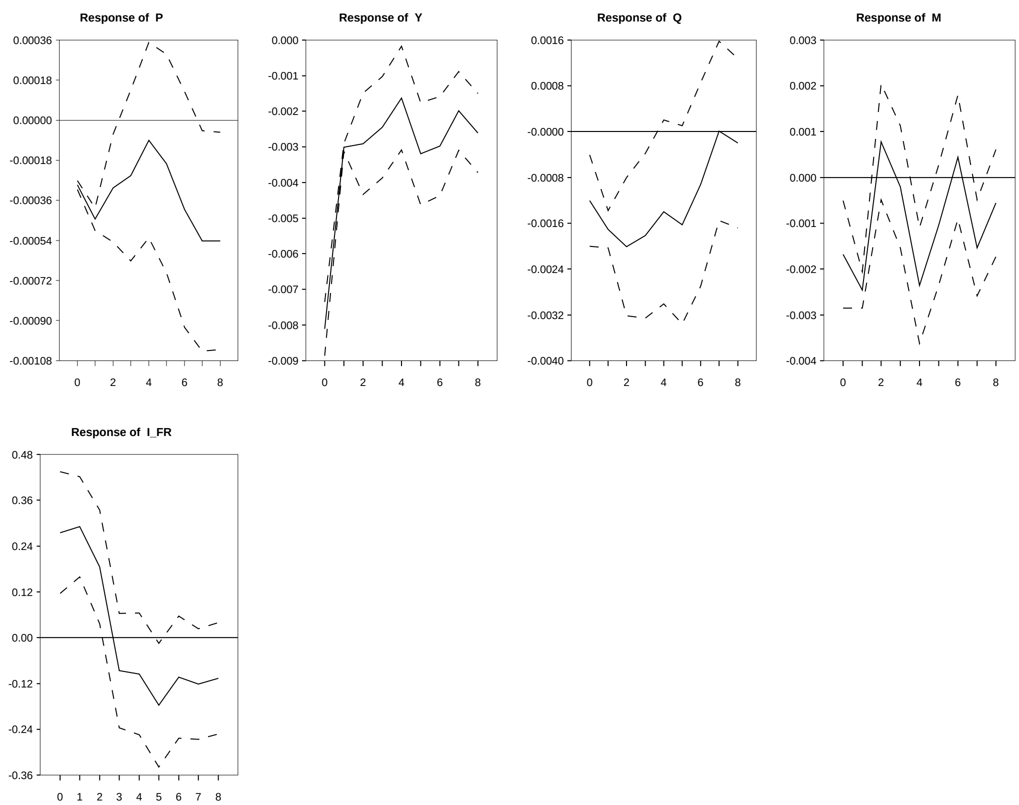


Table 9: Estimated Short-Run Coefficients for the Small Countries. (Standard errors in parenthesis)

| *Coefficient* | **France** | **Italy** | **Netherlands** | *Correct sign* |
|---|---|---|---|---|
| $a_{21}$ | 0.023 (0.002) | -0.042 (0.002) | -0.022 (0.002) | $\pm$ |
| $a_{34}$ | -0.036 (0.002) | -0.002 (7.0e−4) | 0.010 (7.0e−4) | − |
| $a_{45}$ | -6.727 (1.964) | -0.178 (0.030) | -24.396 (1.052) | − |
| $a_{52}$ | -2.7e-4 (7.7e−5) | 0.003 (2.8e−4) | -0.002 (1.1e−4) | − |
| $a_{57}$ | -8.2e-4 (6.1e−5) | -0.005 (2.3e−4) | 0.005 (2.6e−4) | + |
| $a_{64}$ | -0.986 (0.281) | -0.188 (0.011) | 3.855 (0.464) | − |
| $a_{67}$ | -0.024 (0.004) | -0.037 (0.002) | -0.064 (0.009) | + |
| $a_{71}$ | -0.016 (0.012) | 0.045 (0.010) | -0.056 (0.022) | $\pm$ |
| $a_{72}$ | -0.101 (0.035) | -0.773 (0.040) | 0.605 (0.120) | − |
| $a_{76}$ | 164.203 (13.198) | 127.879 (6.121) | 243.149 (26.469) | $\pm$ |

Estimated Short-Run Coefficients for the Small Countries. (Continued)

| *Coefficient* | **France** | **Italy** | **Netherlands** | *Correct sign* |
|---|---|---|---|---|
| $b_{11}$ | 0.677 (0.003) | 0.664 (0.003) | 0.594 (0.002) | $\pm$ |
| $b_{22}$ | 0.247 (0.001) | 0.263 (0.001) | 0.236 (0.001) | $\pm$ |
| $b_{33}$ | 0.002 (7.0e−6) | 0.002 (1.1e−5) | 0.002 (1.0e−5) | $\pm$ |
| $b_{44}$ | -0.052 (0.015) | 0.018 (8.5e−5) | 0.099 (0.004) | $\pm$ |
| $b_{54}$ | 0.007 (7.4e−5) | -6.2e-4 (2.2e−4) | -0.003 (3.4e−4) | $+$ |
| $b_{55}$ | -0.001 (3.5e−4) | 0.011 (5.2e−5) | 0.002 (1.0e−4) | $\pm$ |
| $b_{57}$ | 2.5e-4 (2.9e−5) | -0.003 (8.3e−5) | -2.7e-4 (5.8e−5) | $-$ |
| $b_{66}$ | 0.027 (0.003) | 0.019 (7.3e−4) | 0.093 (0.011) | $\pm$ |
| $b_{77}$ | -1.385 (0.089) | -1.083 (0.043) | -2.096 (0.221) | $\pm$ |

Table 10: Estimated Short-Run Coefficients for Germany. (Standard errors in parenthesis)

| *Coefficient* | *Value* | *Correct sign* |
|---|---|---|
| $a_{23}$ | 0.009 (7.6$e$−4) | − |
| $a_{34}$ | -0.081 (0.013) | − |
| $a_{41}$ | -0.009 (2.6$e$−4) | − |
| $a_{46}$ | -0.004 (8.7$e$−4) | + |
| $a_{53}$ | 0.049 (0.011) | − |
| $a_{56}$ | -0.091 (0.008) | + |
| $a_{61}$ | -0.025 (0.006) | ± |
| $a_{65}$ | 49.390 (4.813) | ± |
| $b_{11}$ | 0.710 (0.003) | ± |
| $b_{22}$ | 0.002 (8.0$e$−6) | ± |
| $b_{33}$ | -0.015 (9.3$e$−5) | ± |
| $b_{43}$ | 0.005 (8.4$e$−4) | + |
| $b_{44}$ | 0.030 (1.9$e$−4) | ± |
| $b_{46}$ | 0.002 (2.1$e$−4) | − |
| $b_{55}$ | 0.026 (0.002) | ± |
| $b_{66}$ | 0.634 (0.051) | ± |

SVAR Model: Impulse Response Functions for France (continued)

*(b) Response to $\epsilon_{MS}$*

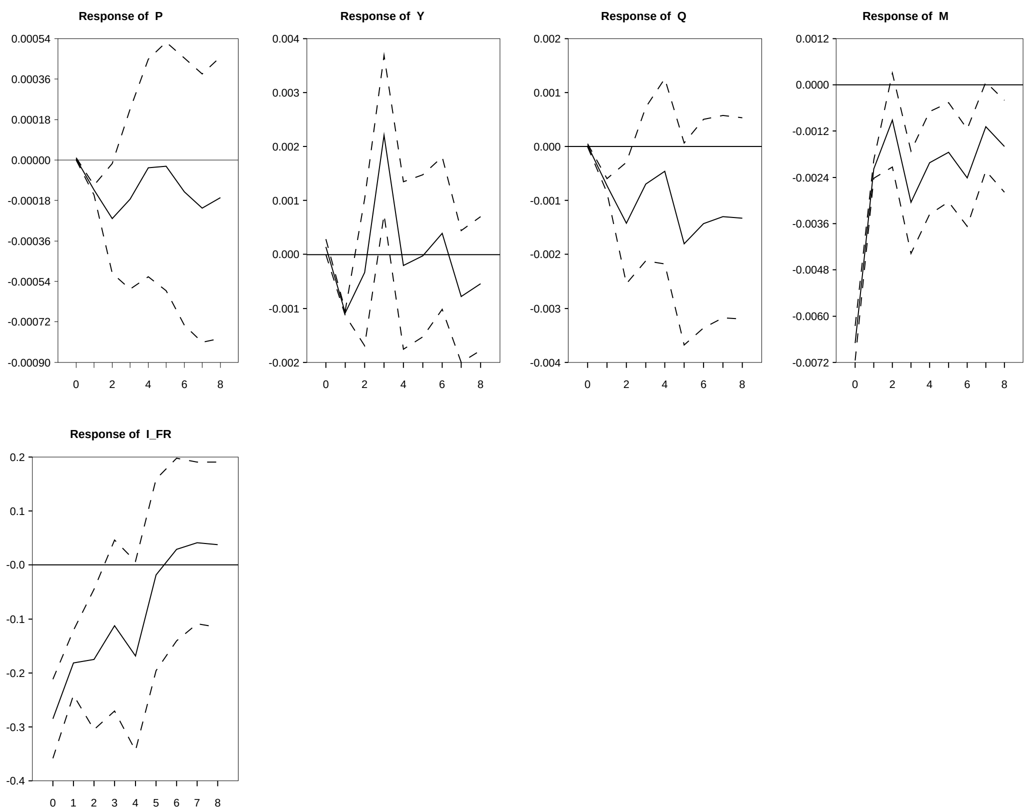
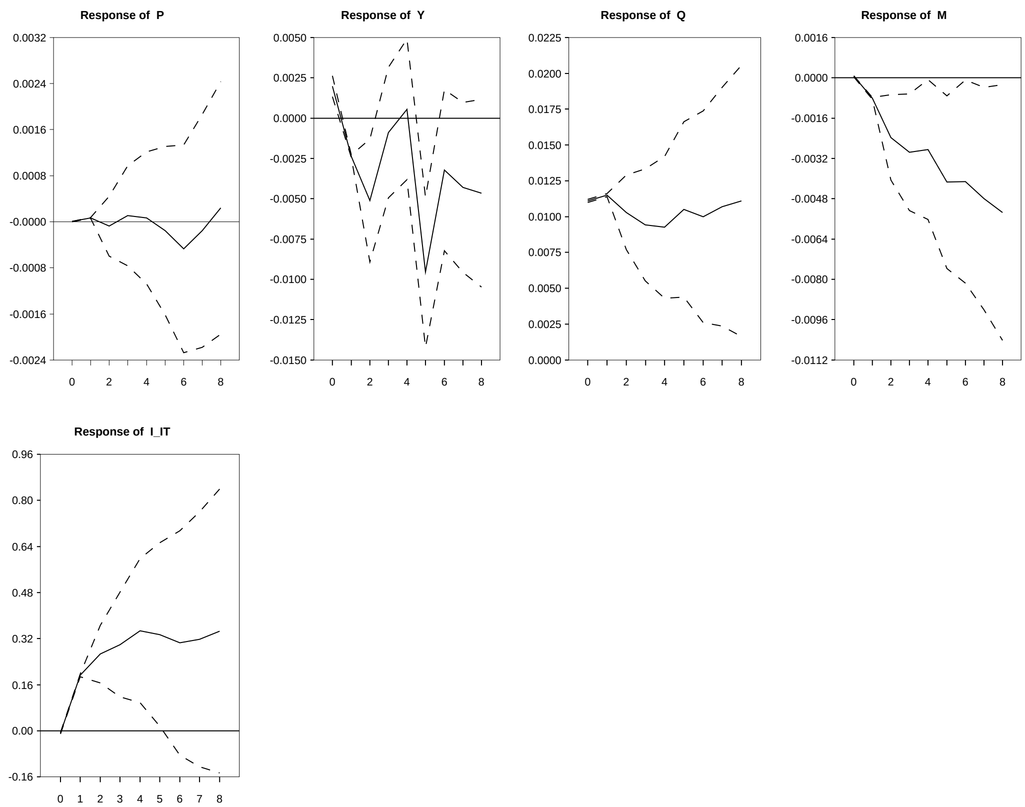


Figure 5: SVAR Model: Impulse Response Functions for Italy

*(a) Response to* $\epsilon_s$




Another way to test the validity of the model is to consider the implied dynamics, i.e., the shape of the impulse response functions (IRF) for the domestic variables. The most relevant ones are presented in Figures 4–7 for all four countries.

In particular, with regards to the effects of monetary–policy innovations (responses to $\epsilon_{MS}$ in part *(b)* of the Figures), results differ among countries. In all three small economies a 1% increase in $\epsilon_{MS}$ causes a decrease in the domestic interest rate and represents an expansionary monetary policy. Therefore, we have a different normalization with respect to the SSVAR analysis, where a 1% increase in $\epsilon_{MS}$ was identifying a restrictive monetary measure. The response of output is then positive at impact only in the Netherlands, whereas it is insignificant in France and even negative in Italy. The response of the price level is correctly positive only in the Netherlands

SVAR Model: Impulse Response Functions for Italy (continued)

*(b) Response to* $\epsilon_{MS}$

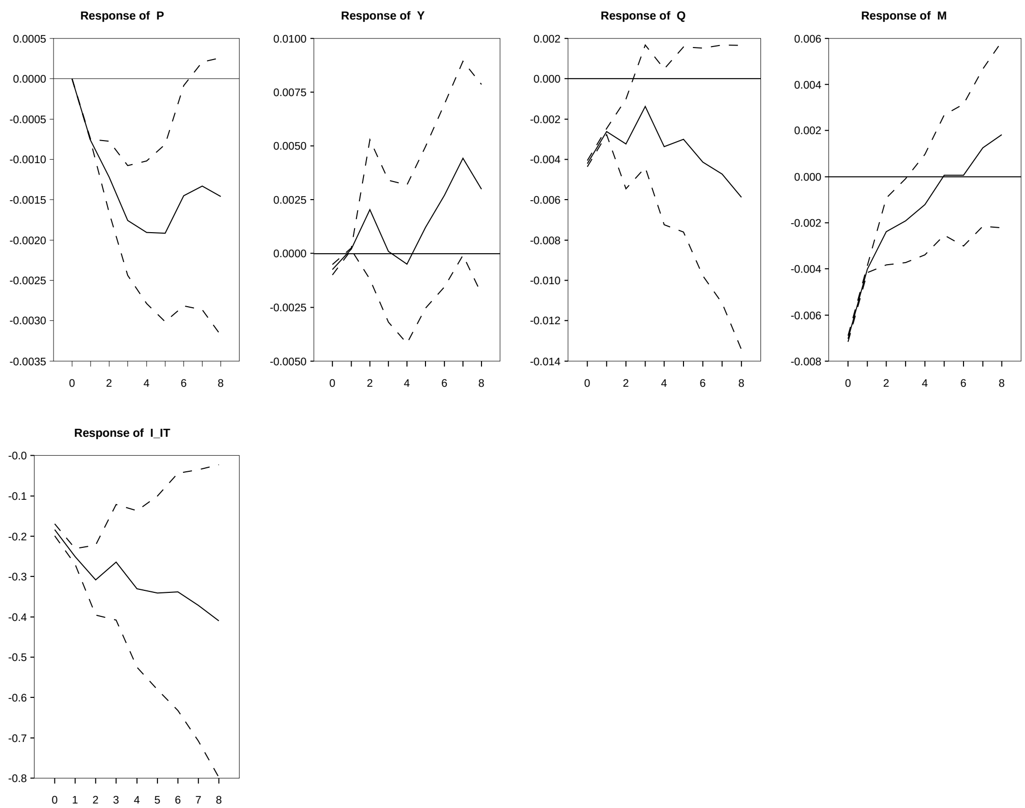
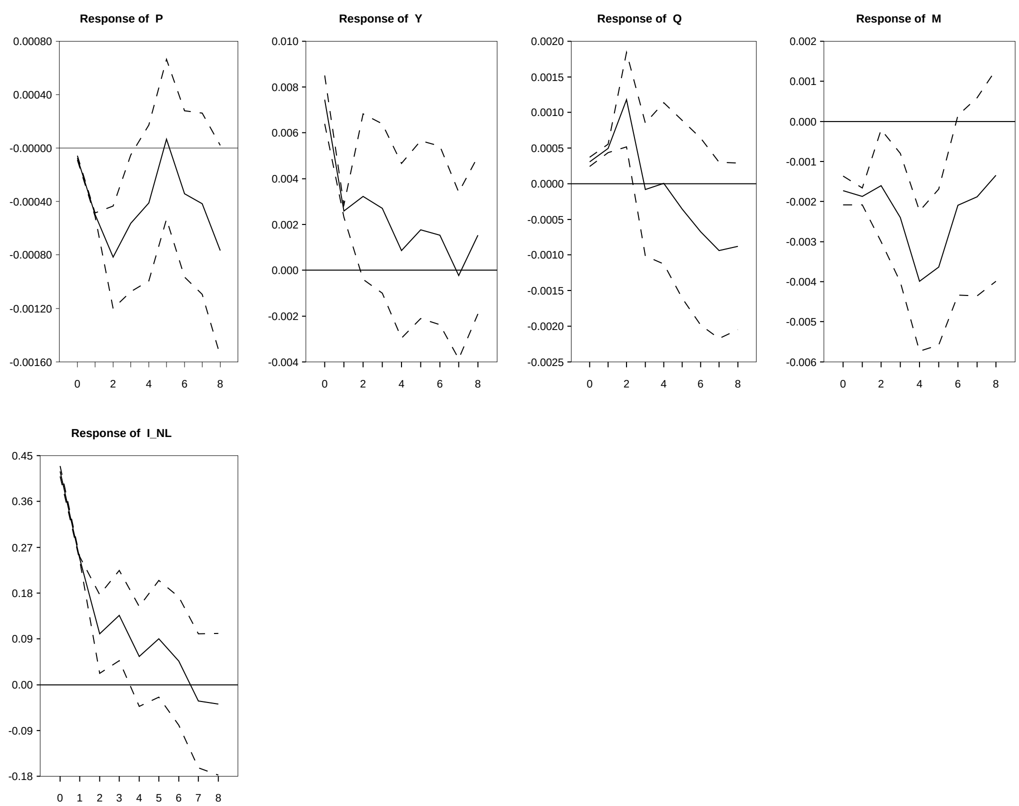


Figure 6: SVAR Model: Impulse Response Functions for the Netherlands

*(a) Response to $\epsilon_s$*



SVAR Model: Impulse Response Functions for the Netherlands (continued)

*(b) Response to* $\epsilon_{MS}$

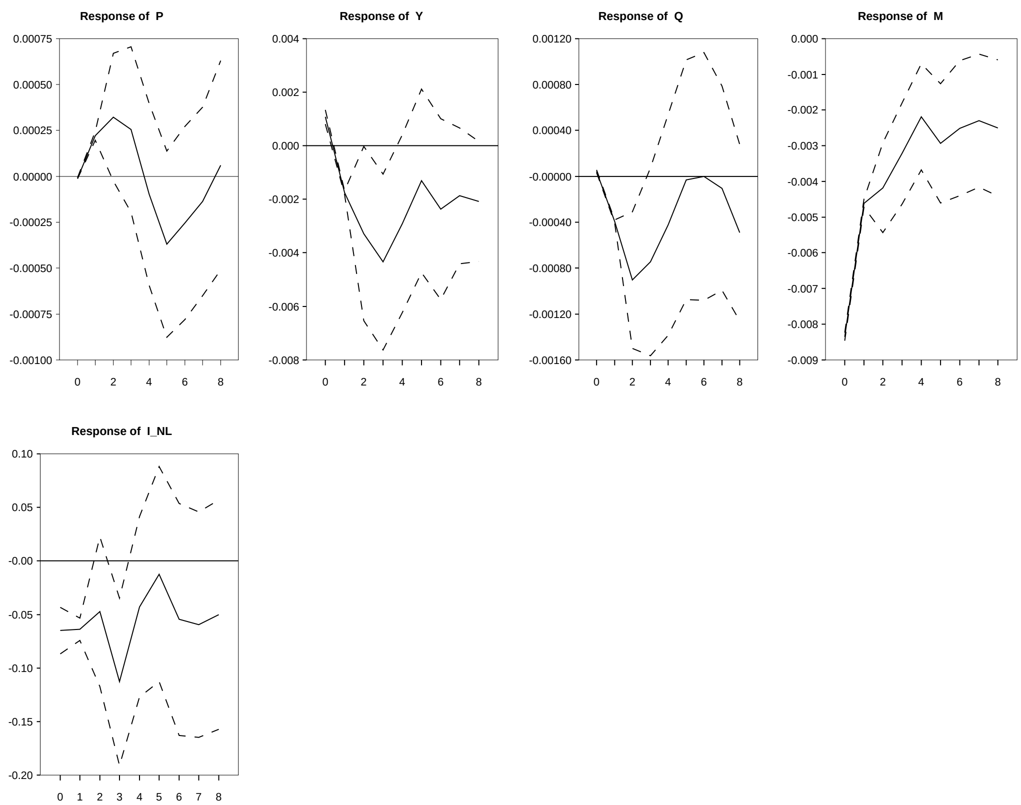
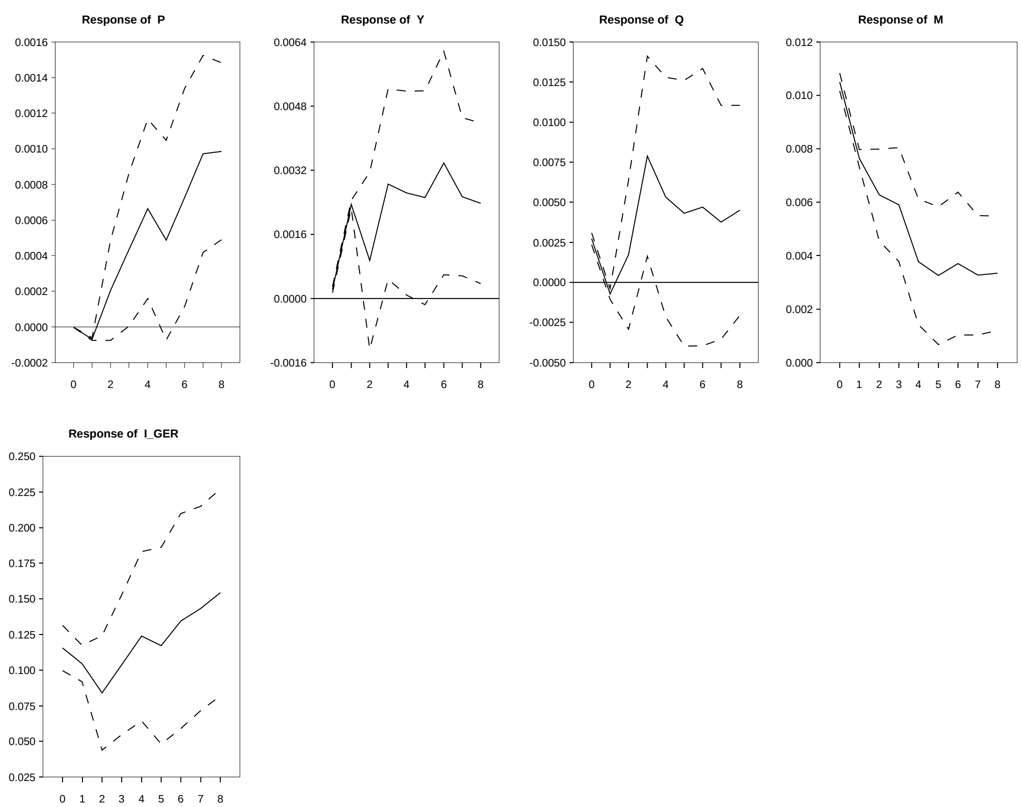


Figure 7: SVAR Model: Impulse Response Function for Germany

*Response to* $\epsilon_{MS}$



again. In the other two countries is negative. By reversing the sign of the type of monetary policy we would then find the same patterns that we have found for the SSVAR model: a restrictive monetary policy (i.e., a shock that casues an increase in the interest rate) would go together with increasing prices in all countries, except the Netherlands.

In Germany instead a positive shock to $\epsilon_{MS}$ causes an increase in the interest rate and we have a restrictive monetary policy. Here the price level reacts initially with a decrease, but output increases.

Although the results of the structural contemporaneous equations (Tables 4–7) show mixed evidence, we will still try to evaluate monetary policymaking in the four countries considered.

When going back to the estimated contemporaneous equations, we can analyse the interest–rate equations, which represent the impact reaction functions of the authorities. The highest weight is assigned to money, but also the German rate enters all equations with a significative sign. In particular, Italy shows now the biggest contemporaneous reaction (0.773), whereas for France we have the lowest weight (0.101). With respect to the US rate, only Italy shows a significant coefficient. Hence, the overall results appear quite different from the SSVAR approach, probably due to the absence of both output and the price level in the contemporaneous reaction functions.

Moreover, the FEVD analysis for the interest rate (not shown here) confirms most of the conclusions of SSVAR analysis: for instance, the French interest rate is still highly affected by innovations in the US rate; the weight does not reach 50% after 24 periods, but it is still the most important factor. Next, in the Netherlands it is confirmed the important role of both the balance–of–payments shock (in the short run) and the German shock (in the longer run).

Finally, in Germany the interest rate is highly characterized by both money–market shocks (i.e., $\epsilon_{MD}$ and $\epsilon_{MS}$) and the world/US shock. All the other sources of fluctuations are either negligible and not significant.

However, the main scope of this more structured model is to provide additional evidence with respect to the structures of the small economies in order to understand whether the different performances in the EMS were mainly due to different burdens for these countries to stay in the fixed exchange–rate regime.

In the Fig. 4–7 (Parts *(a)*'s) we show the IRF of the domestic variables with respect to the balance–of–payments shocks in order to show the effects of a devaluation (or revaluation) on the domestic variables.

A 1% increase in $\epsilon_s$ shows real depreciation (i.e., $q$ increases) in Italy and the Netherlands and appreciation (i.e., $q$ decreases) in France. The price level in all countries have a very small short–run response (however significant) in

France and the Netherlands. In particular, the appreciation causes a price decrease in France. This means on the contrary that depreciations will have inflationary effects in France.

With respect to output, in all three countries real depreciations have an initially positive effect on output, although not long–lasting.

In conclusion, the analysis of the effects of balance–of–payments shocks finds that France is the only country where a real depreciation causes both an increase in output and the price level, hence indicating a positive effect on the French aggregate demand. This may explain why France realigned so many times during the Eighties.

# 6 Summary and Conclusions

In this paper we used two empirical approaches based on VAR to thoroughly analyze the monetary policymaking in France, Italy and the Netherlands during the "small–band" EMS period. Given the different performances of the three countries with respect to the ERM, the paper wanted to test whether these differences were due to divergent and highly autonomous monetary policies with respect to the center country (Germany). Moreover, explanations of these different performances are related to the economic structures.

More specifically, our aim was twofold: first, to check whether countries that experienced more realignments were the countries whose monetary policies were the most divergent ones with respect to the center country (Germany). Second, we wanted to analyse the costs for each country in following Germany. Did some countries (like France and Italy) have to pay a high cost to stay in the fixed exchange–rate regime with Germany?

In order to answer these questions we employed first a semi–structural approach, whose main task was to highlight how restrictive monetary policy is transmitted from the center country to the small economies. Qualitatively the impulse response functions show that an increase in the interest rate in Germany has a definite recessionary effect in France and Italy. In the Netherlands instead the increase in the German interest rate (closely followed by the Dutch rate) seems to anticipate an inflationary (IS–type) shock and this may mean that there is a higher correlation between Dutch and German inflationary (IS–type) shocks rather than between similar shocks in Germany and France or Italy.

The FEVD analysis reveals that German monetary–policy innovations are particularly important to explain the short–run variability of the Dutch and French domestic interest rates, but also shows that the US monetary–policy innovations play an important role.

Since the second task of our analysis was to identify the possible costs that the fixed exchange–rate regime with Germany could have had on the small economies, next we specified a fully structural (VAR) model for each economy in order to study the effects of devaluation shocks. The same model has been also specified for the center country, Germany.

The structural model is overidentified and the test for the overidentifying restrictions do not reject the constraints only for two countries. Overall, estimates of the (contemporaneous) structural equations present the expected signs for most equations only in the case of France and Italy. For the Netherlands and Germany some important structural equations show wrongly–signed estimates, maybe due to the constraints imposed on the reaction function of the monetary authorities.

The IRF regarding the reactions of domestic variables to devaluation shocks reveal that France is the country that had to pay the most for giving up nominal devaluations.

In conclusion, the results of our analysis confirm that the different performances in the EMS of the three "small" countries were due to the different conducts of monetary policies. In particular, Italy seems to have been strongly characterized by interest–rate variations that could be related neither with the German rate nor with the other variables included in the model. This could be interpreted as evidence of more independent monetary policy with respect to the other two countries.

In addition, our model also suggests that such different behaviors could be explained by different structures for the three economies. For instance, some countries (like France) may have payed a high cost in terms of giving up an important policy instrument like the exchange rate in order to stay in the EMS.

The result that we obtained from our estimation could then provide some evidence on why Italy and France decided to realign more times than the Netherlands.

# References


[1] Batten, D.S., M.P. Blackwell, I. Kim, S. Nocera and Y. Ozeki (1990), "The Conduct of Monetary Policy in the Major Industrial Countries: Instruments and Procedures", *Occasional Papers*, n. 70, International Monetary Fund.

[2] Bernanke, Ben S. (1986), "Alternative Explanations of the Money-Income Correlation", *Carnegie-Rochester Conference Series on Public Policy*, vol. 25, pp. 49-99.

[3] Bernanke, Ben S. and Alan S. Blinder (1992), "The Federal Funds Rate and the Channels of Monetary Transmission", *American Economic Review*, vol. 82, pp. 901-21.

[4] Bernanke, Ben S. and Ilian Mihov (1995), "Measuring Monetary Policy", mimeo, Princeton University.

[5] Blanchard, Olivier J. and Mark W. Watson (1986), "Are Business Cycles All Alike?" in Gordon, Robert ed., *The American Business Cycle: Continuity and Change*, Chicago, University Press, p.123-56.

[6] Blanchard, Olivier J. and Danny Quah (1989), "The Dynamic Effects of Aggregate Demand and Supply Disturbances", *American Economic Review*, vol. 79, p.655-73.

[7] Campbell, John Y. and Philip Perron (1991) "Pitfalls and Opportunities: What Macroeconomists Should Know About Unit Roots", *NBER Macroeconomic Annuals*, p. 141-201.

[8] Clarida, Richard and Mark Gertler (1996), "How the Bundesbank Conducts Monetary Policy", paper presented at the "Monetary Policy and Low Inflation" Conference, Islamorada (FL, USA), January 11-13.

[9] Faust, Jon and Eric M. Leeper (1994), "When Do Long-Run Identifying Restrictions Give Reliable Results?" International Finance Discussion Paper, n. 462, Board of Governors of the Federal Reserve System.

[10] Giannini, Carlo (1992), *Topics in Structural VAR Econometrics*, Lecture Notes in Economics and Mathematical Systems, Springer Verlag, Berlin.

[11] Hamilton, James D. (1994), *Time Series Analysis*, Princeton University Press, Princeton, New Jersey.

[12] Kim, Seoyung and Nouriel Roubini (1995), "Liquidity and Exchange Rates: A Structural VAR Approach", paper presented at the CEPR Workshop on "Monetary Policy and Exchange Rates in Europe", Bonn Feb. 10-11, 1995.

[13] Krugman, Paul (1979), "A Model of Balance-of-Payments Crises", *Journal of Money Credit and Banking*, vol. 11 n. 3, pp. 311-25.

[14] Lippi, Marco and Lucrezia Reichlin (1993), "The Dynamic Effects of Aggregate Demand and Supply Disturbances: A Comment", *American Economic Review*.

[15] Litterman, R. and L. Weiss (1985), "Money, Real Interest Rates, and Output: A Reinterpretation of Postwar US Data", *Econometrica*, vol. 52, p. 129-56.

[16] Rothenberg, Thomas J. (1971), "Identification in Parametric Models", *Econometrica*, vol. 39, p. 577-91.

[17] Sims, Christopher A. (1992), "Interpreting the Macroeconomic Time Series Facts: the Effect of Monetary Policy", *European Economic Review*, vol. 36, pp. 975-1000.

[18] Sims, Christopher A. (1986), "Are Forecasting Models Usable for Policy Analysis?" *Quarterly Review*, Federal Reserve Bank of Minneapolis, n.10.

[19] Shapiro, Matthew D. and Mark W. Watson (1988), "Sources of Business Cycles Fluctuations", *NBER Macroeconomic Annuals*, MIT Press, Cambridge (Mass.).

[20] Zha, Tao (1995), "Identifying Monetary Policy in a Small Open Economy under Flexible Exchange Rates", mimeo, Yale University.