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Information from financial markets and VAR measures of monetary policy

Fabio C. Bagliano[a,*], Carlo A. Favero[b,c]

[a] *Dipartimento di Scienze Economiche e Finanziarie, Università di Torino, "G. Prato", Corso Unione Sovietica 218bis, 10134, Torino, Italy*

[b] *Università "L. Bocconi", Via Sarfatti 25, 20136, Milano, Italy*

[c] *Centre for Economic Policy and Research, London, UK*

Abstract

Exogenous measures of monetary policy shocks, directly derived from financial market information, are used in close (US) and open (US–Germany) economy VAR models to evaluate the robustness of the dynamic effect of monetary policy obtained from traditional identified VAR. The empirical analysis confirms the main features of the monetary policy transmission mechanism in US and Germany, explicitly addressing the issue of simultaneity between the German policy interest rate and the US dollar–DMark exchange rate.

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1. Introduction

Over the last 15 years the empirical evaluation of the effects of monetary policy actions has widely used Vector Autoregressive (VAR) models.

Estimation of VAR models for close and open economies has produced a number of reasonably interpretable and therefore generally accepted results

* Corresponding author. Tel.: 39 11 670 6084; fax: 39 11 670 6020; e-mail: bagliano@econ.unito.it.

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and some empirical regularities that still need a final explanation. These puzzles also motivated some of the criticisms addressed to VAR methodology.

The crucial point in the VAR approach to monetary policy analysis is the identification of monetary policy *shocks* as distinct from monetary policy *actions*. Policy makers' actions to some extent respond to current developments in the economy; this response is captured by a policy reaction function. The remaining movements in policy instruments, the deviations of authorities from their rule, are interpreted as monetary policy shocks and their effects can be meaningfully investigated by means of the impulse response function techniques.[1]

The use of different identification schemes characterizes the proposed solutions to the empirical puzzles in the VAR literature. The present paper describes a different approach, deriving measures of monetary policy shocks from the information content of financial markets data and using them to evaluate VAR-based measure of monetary policy and strengthen their identification.

In Section 2 the fundamental identification problem is stated and the potential role of non-VAR measures of policy shock is discussed. In Section 3 some alternative measures of this kind are presented for the US and Germany. Results for the close (US) economy and open (US–Germany) economies are presented in Section 4. Section 5 briefly concludes.

2. The identification issue and the role of non-VAR measures of monetary policy shocks

VAR models are designed to assist in the selection of the best theoretical model to answer convincingly questions like 'how does the economy respond to an exogenous monetary policy shock?'[2] Therefore, the identification problem has to be solved by imposing restrictions independent of the specific predictions of theoretical models. The commonly adopted *recursiveness* assumption satisfies this criterion and achieves identification by assuming that monetary policy shocks take at least one period to affect macroeconomic variables and by imposing restrictions on the simultaneous relations among monetary variables derived by careful analysis of Central Banks' operating procedures.

Using this set of assumptions, the more recent empirical literature has produced a number of robust results in *close*-economy applications. In particular, two puzzles that characterized the earlier literature have been solved: the 'liquidity puzzle' (when monetary policy shocks are identified as innovations in

[1] Christiano et al. (1998) provide a thorough review of the empirical VAR literature.

[2] See, for example, Bernanke and Mihov (1998) and Christiano et al. (1998).

relatively broad monetary aggregates, positive shocks are associated with nominal interest rate increases) and the 'price puzzle' (the positive response of the price level to a contractionary monetary policy shock identified with innovations in interest rates). On the one hand, better specifications of the policy variables, including bank reserve aggregates and policy rates whose innovations are identified as monetary policy shocks, provided the negative association between innovations in interest rates and narrow monetary aggregates (liquidity effect) suggested by basic theory. On the other hand, the inclusion of a commodity price index as a leading indicator for domestic inflation in the policy reaction function, eliminates the positive response of prices to a contractionary monetary policy shock.[3]

When the VAR methodology is applied to an *open*-economy framework, additional complications arise. The simultaneous relation between the monetary policy instrument and the exchange rate innovations makes it difficult to correctly identify monetary policy shocks only by means of recursiveness assumptions. Early symptoms of these difficulties are some of the empirical regularities documented, among others, by Eichenbaum and Evans (1995) and Grilli and Roubini (1996b): (i) a contractionary monetary policy shock in the US generates a persistent appreciation of the dollar along with a persistent decrease in the spread between foreign and US interest rates, implying a long-lasting deviation from the uncovered interest parity in favour of US investments (the 'forward discount bias' puzzle); (ii) contractionary monetary policy shocks in the G7 countries other than the US are associated with an impact depreciation of their currency relative to the US dollar (the 'exchange rate puzzle').

Some efforts aimed at solving the identification problem in open-economy VAR models have been made, among others, by Grilli and Roubini (1996a), Kim and Roubini (1996), Cushman and Zha (1997) and Smets (1997), for different countries and different sample periods.

Even though the latter papers present refinements of earlier VAR models, all are in principle subjected to the Rudebusch's (1996) critique of the whole VAR approach to the identification of monetary policy shocks. All VAR models derive policy shocks as innovations with respect to a time-invariant, linear reaction function of the monetary authority, which is assumed to react only to the limited set of variables included in the model. The resulting estimate of monetary policy disturbances may bear little or no relation with the true underlying policy shocks. As an alternative identification strategy, Rudebusch (1996) favours the direct use of expectations of future monetary policy actions embodied in some relevant financial prices.

In the following sections we assess the relevance of some measures of monetary policy shocks derived from financial market prices for the problem of

[3] See Christiano et al. (1996), Sims (1992) and Bernanke and Blinder (1992).

measurement of monetary policy shocks in the close- and open-economy case. We do so by directly including some market-based measures of policy shocks as exogenous variables in two benchmark (close- and open-economy) VAR systems, in which we consider the vector of endogenous variables (Y_t^{US} Pcm_t P_t^{US} FF_t) for the *close* (US) economy, and the vector of variables (Y_t^{US} Pcm_t P_t^{US} FF_t Y_t^{GER} P_t^{GER} R_t^{GER} e_t) for the *open* (US–Germany) economy. The variables are defined as follows: Y^{US} and Y^{GER} are the logs of US and German industrial production indices, Pcm is the log of the commodity price index in US dollars, P^{US} and P^{GER} are the logs of US and German consumer price indices, FF is the US effective Federal funds rate, R^{GER} is the German call money rate, and e is the log of the US dollar/DeutscheMark exchange rate (unit of DMark for one US dollar). Estimation is conducted on monthly data over the 1984(1)–1997(11) period with six lags of all variables.

3. Non-VAR measures of monetary policy shocks

Several measures of monetary policy shocks derived in various ways from financial markets data have been used in the recent literature.

Rudebusch (1996) constructs a measure of US monetary policy shocks based on the difference between the Federal funds rate at month t and the 30-day Federal funds rate future at month $t-1$. Such measure is available from the end of 1988, when future contracts on the Fed funds rate were introduced. The sample can be extended by applying the same technique to the future on one-month Euro-dollar rates (as suggested to us by Gerlach), which is available from the beginning of the 1980s and produces very similar shocks to the one derived from the Federal funds future for the overlapping sample. For an even longer sample, starting in the mid-1970s, Skinner and Zettelmeyer (1996) use the change in the three-month US Treasury bill rate on the days of policy announcements, selected from central bank reports and newspaper information.

An alternative approach to the construction of a measure of monetary policy shocks directly using financial markets data has been implemented by Bagliano and Favero (1998), applying the methodology set out in Svensson (1994) and Soderlind and Svensson (1997). The methodology is based on the derivation of instantaneous forward rates from the estimation of a continuous zero-coupon (spot) yield curve. Since the observable equivalent of the instantaneous forward rate is the overnight (policy) rate, the curve of forward rates can be interpreted as an indicator of expected monetary policy, based on the pure expectation theory of the term structure of interest rates. Focusing on the dates of the FOMC meetings (regularly held eight times per year from 1994), monetary policy shocks may be obtained as the difference between the target rate decided upon in the meeting and the forward rate for the day after the meeting implicit in the spot yield curve estimated the day before the meeting.[4] The same procedure has been applied to the dates of policy announcements used by Skinner and Zettelmeyer (1996) for the period 1988–1993 and the resulting series, labelled IFS^{US}, has been used in Bagliano and Favero (1998).

Using the one-month Euro-dollar future measure of shocks, labelled $EUR\$$, we can present estimates over an extended sample starting in 1984. Fig. 1a shows the $EUR\$$ series and the monetary policy shock series (v^{FF}) obtained from as the orthogonalized residual from the equation for FF in the close economy VAR (three-month centered moving averages are computed to make the comparison easier). Fig. 1b shows the IFS^{US} and v^{FF} series. Table 1(A) reports correlations between the above alternative measures of monetary policy shocks (and standard errors on the diagonal). The correlations between the non-VAR measures of policy shocks and the benchmark VAR residuals are relatively low, ranging from 0.3 to 0.5. However, when the $EUR\$$ and IFS^{US} series are included in the system as exogenous variables, the estimated impact coefficients (highly statistically significant in the equation for the policy rate) support the fact that these non-VAR measures capture important innovations in the Federal funds rate.

We have also applied the implied forward rate methodology to Germany, where monetary policy actions are taken at the Bundesbank Council meetings, regularly held every two weeks (an information available to the public). From 1983 onwards, we estimated a smooth spot yield curve on each day before a Council meeting and determined the curve of implied istantaneous forward rates. Therefore, we are able to compute the overnight interest rate expected for the day following the Council. The difference between the realized overnight interest rate the day after the Council meeting and the expected overnight interest rate for that day, conditional upon information available before the meeting, is our measure of monetary policy shocks for Germany, labelled IFS^{GER}.[5] Fig. 1c shows three-month moving averages of IFS^{GER} and of the orthogonalized residual for the German call money rate equation in the open economy VAR, v^{RGER}. Table 2(B) reports a low correlation (0.16) between the two variables; however, the impact coefficient on IFS^{GER} when included in the system is statistically significant. As for the US measures, also for Germany this measure is able to capture some variability in the policy rate.

[4] The estimated curve is fitted to the following rates: the Federal fund target, 1-, 3-, 6- and 12-month Euro, 3-, 5-, 7- and 10-year fixed interest rate swap. Further details are provided in Bagliano and Favero (1998).

[5] The yields used in estimation are then the one-week rate, the 1-, 3-, 6-, and 12-month Euro, and the 3-, 5-, 7- and 10-year fixed rate swap. Details are provided in Bagliano et al. (1998).

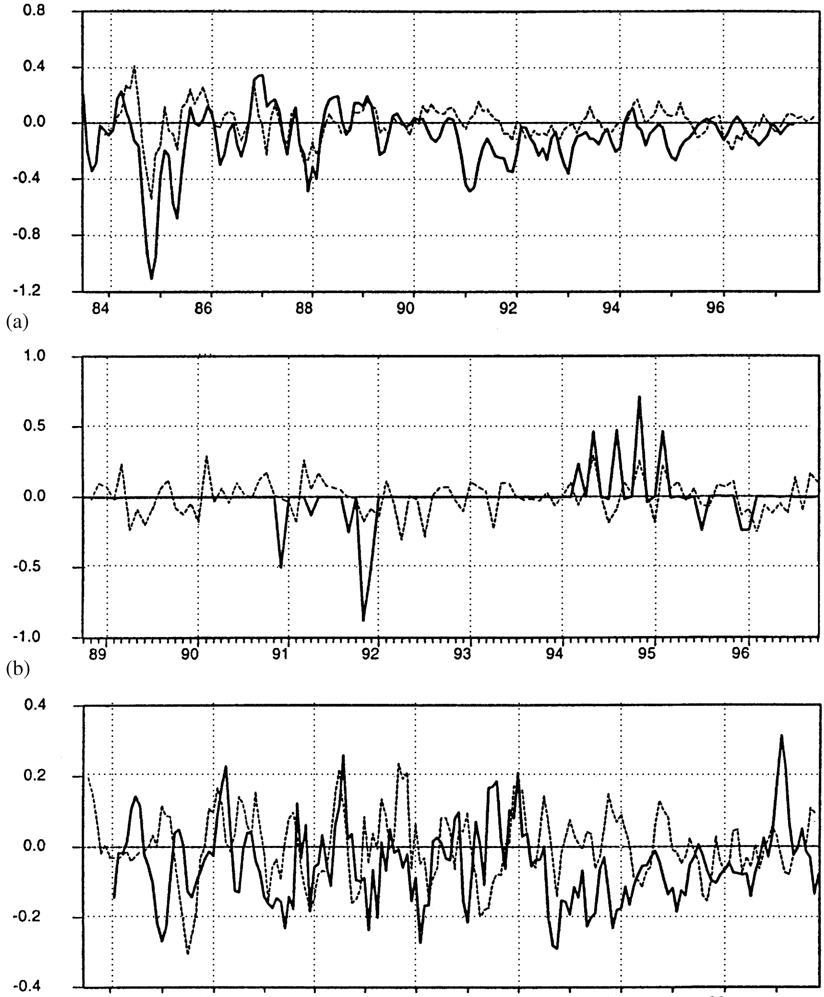

Fig. 1. VAR and non-VAR measures of monetary policy shocks. (a) three-month centered moving averages of *EUR$* shocks (solid line)and close economy VAR monetary policy shocks (dotted line); (b) IFS^{US} shocks (solid line) and close economy VAR monetary policy shocks (dotted line); (c) three-month centered moving averages of IFS^{GER} shocks (solid line) and open economy VAR German monetary policy shocks (dotted line).

Table 1
Correlations between benchmark VAR and non-VAR monetary policy shocks

A. Close economy
Correlation coefficients (standard errors on the diagonal)
Sample: 1988(11)–1996(10)

	$EUR\$$	IFS^{US}	v^{FF}
$EUR\$$	0.185		
IFS^{US}	0.203	0.169	
v^{FF}	0.352	0.319	0.123

Coefficients on $EUR\$$ and IFS^{US} in the close-economy VAR

	Y^{US}	Pcm	P^{US}	FF
$EUR\$$	0.0061	0.0055	0.0013	**0.468**
	(0.0032)	(0.0121)	(1.0633)	**(0.097)**
IFS^{US}	0.0025	0.0082	0.0009	**0.356**
	(0.0031)	(0.0116)	(0.0013)	**(0.099)**

Sample: 1984(1)–1997(11)

	$EUR\$$	v^{FF}
$EUR\$$	0.277	
v^{FF}	0.500	0.211

	Y^{US}	Pcm	P^{US}	FF
$EUR\$$	0.0026	0.0007	0.0058	**0.552**
	(0.0016)	(0.0006)	(0.0063)	**(0.062)**

B. Open economy
Sample: 1984(1)–1997(11)

	IFS^{GER}	v^{RGER}
IFS^{GER}	0.194	
v^{RGER}	0.163	0.169

Coefficients on IFS^{GER} in the open-economy VAR

	Y^{US}	Pcm	P^{US}	FF	Y^{GER}	P^{GER}	e	R^{GER}
IFS^{GER}	− 0.007	− 0.010	− 0.0013	− 0.089	0.00002	0.0029	0.0084	**0.230**
	(0.002)	(0.008)	(0.0008)	(0.115)	(0.0011)	(0.007)	(0.0127)	**(0.097)**

In the following section we investigate the dynamic response of macroeconomic variables to movements in our monetary policy shock measure.

Table 2
The simultaneous determinants of US and German policy rates and of the US dollar/D Mark exchange rate. [Based on the benchmark VAR models in close and open economy (1984–1997) (+ denotes the standard error of the corresponding residual)]

	Y^{US}	Pcm	P^{US}	FF	Y^{GER}	P^{GER}	e	IFS^{GER}
FF US close	**0.090** (0.033)	0.017 (0.0099)	**0.262** (0.094)	0.207+	–	–	–	–
FF US open	**0.090** (0.035)	0.013 (0.010)	**0.378** (0.095)	0.178+	0	0	0	– 0.089 (0.115)
R^{GER}	– 0.015 (0.032)	– 0.004 (0.009)	– 0.048 (0.089)	0.015 (0.070)	**0.025** (0.010)	– 0.098 (0.066)	0.004 (0.006)	**0.230** (0.097)
e	**1.355** (0.375)	– 0.0148 (0.111)	– 0.150 (1.101)	**0.022** (0.008)	0.045 (0.126)	**2.440** (0.787)	0.019+	0.0084 (0.0127)

4. Empirical results on the effect of monetary policy

4.1. *Close economy* (*US*)

To evaluate the role of non-VAR-based measures of monetary policy shock, we first estimate the close-economy four-variable version of the VAR model for the US and compute impulse response functions of all variables to a shock in the Federal funds rate. The ordering chosen allows for a contemporaneous response of the policy rate to innovations in output, consumer prices and the commodity price level. The orthogonalized residual of the Federal funds rate equation, v^{FF}, is identified as a monetary policy shock. No structural interpretation is given to the (orthogonalized) residuals from the other equations in the system. The impulse responses are shown, along with one-standard deviation bands, in Fig. 2 as the dotted lines.

A contractionary monetary policy shock produces the expected negative effect on output and a persistent effect on the Federal funds rate. The inclusion of the commodity price index is successful in solving the price puzzle: the consumer price level does not show a perverse response to restrictive policy.

Now our measure of monetary policy shocks derived from the one-month Eurodollar forward rate ($EUR\$$) is included in the VAR as exogenous variable. Following Amisano and Giannini (1996), we represent the estimated system as follows:

$$\boldsymbol{A}\begin{pmatrix} Y_t^{US} \\ Pcm_t \\ P_t^{US} \\ FF_t \end{pmatrix} = \boldsymbol{C}(L)\begin{pmatrix} Y_{t-1}^{US} \\ Pcm_{t-1} \\ P_{t-1}^{US} \\ FF_{t-1} \end{pmatrix} + \begin{pmatrix} g_1 \\ g_2 \\ g_3 \\ g_4 \end{pmatrix} EUR\$_t + \boldsymbol{B}\begin{pmatrix} v_t^1 \\ v_t^2 \\ v_t^3 \\ v_t^{FF} \end{pmatrix}, \tag{4.1}$$

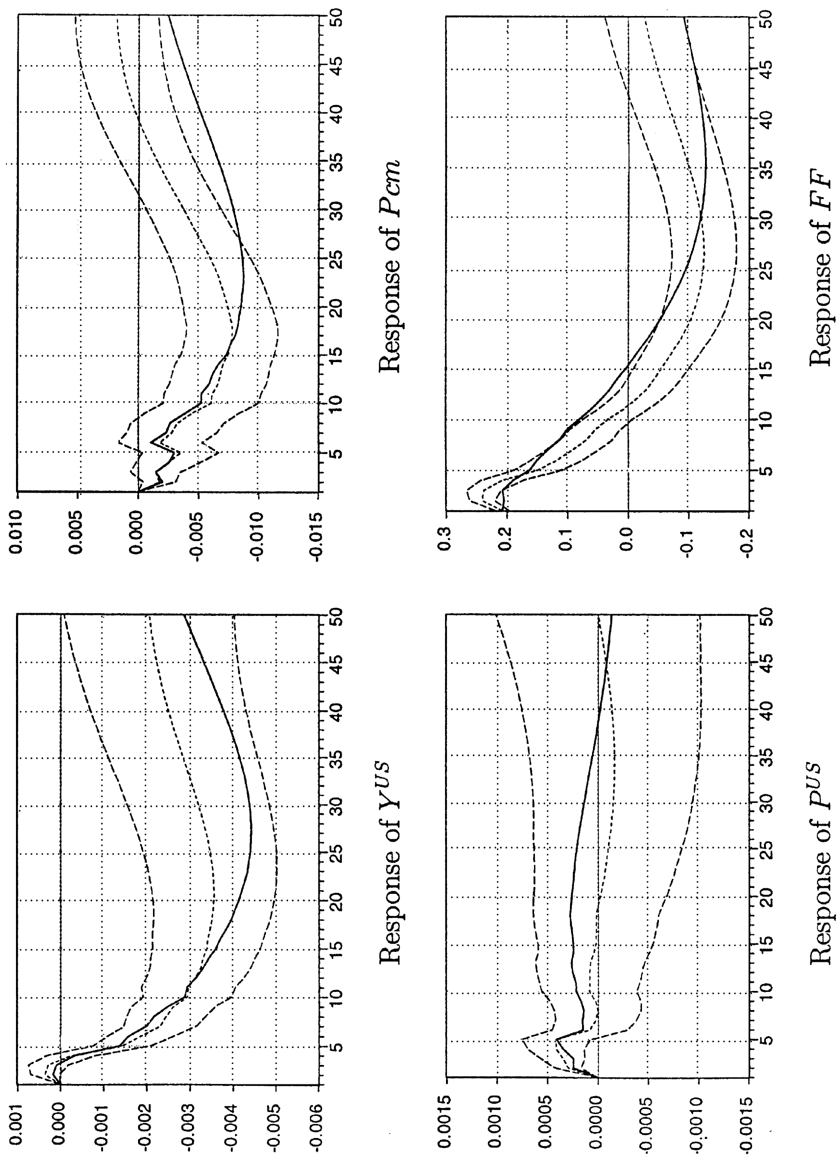

Fig. 2. Impulse responses to alternative US monetary policy shocks in close economy. Responses to $EUR\$$ shocks (solid line) and to VAR-based structural shocks v^{FF} (dotted line) with one standard deviation confidence intervals from the benchmark VAR.

where $\boldsymbol{A}$ is lower traingular and $\boldsymbol{B}$ is diagonal. The estimated values of the coefficients g_i are reported in Table 1(A) and the dynamic responses of all endogenous variables to a monetary policy shock measured by $EUR\$$ are shown in Fig. 2 as the solid lines. The main features of the effects of monetary policy shocks already detected in the benchmark system are confirmed here, as the two impulse response functions describe a very similar transmission mechanism, supporting the evidence already provided by Brunner (1996) and Bagliano and Favero (1998) with different exogenous measures. Despite a correlation of 0.5 between $EUR\$$ and the measure of policy shock obtained from the benchmark VAR, the dynamic effects of monetary policy show very close features: both measures capture unexpected variations in the policy rate related to monetary policy and the existence of other non-policy disturbances does not change the basic features of the response to a policy shock. Finally, as shown in the first row of Table 2, the estimated coefficients of the policy reaction function show that the policy rate positively reacts to innovations in output and the price level.

4.2. Open economy (US–Germany)

Let us now consider the open-economy version of the VAR system. The dynamic responses of all endogenous variables to a German monetary policy shock identified as the orthogonalized residual of the German call money rate equation (v^{RGER}) are shown in Fig. 3 as the dotted lines, along with one-standard deviation bands. The responses of German output, prices and the policy rate are consistent with the results obtained for the US. In particular, we note that the response of consumer prices to a contractionary monetary policy shock is as expected. The response of the exchange rate shows an impact depreciation of the DMark which is not strongly significant, followed by some months of appreciation. The estimated standard errors, however, are fairly large and do not allow sharp inference on the dynamic behaviour of the exchange rate.

As in the close-economy case, we augment the previously estimated system by including the exogenous measure of German monetary policy shocks IFS^{GER} described in the previous section. The open-economy VAR is now the following:

$$\boldsymbol{A}\begin{pmatrix} Y_t^{\mathrm{US}} \\ Pcm_t \\ P_t^{\mathrm{US}} \\ FF_t \\ Y_t^{\mathrm{GER}} \\ P_t^{\mathrm{GER}} \\ e_t \\ R_t^{\mathrm{GER}} \end{pmatrix} = \boldsymbol{C}(L)\begin{pmatrix} Y_{t-1}^{\mathrm{US}} \\ Pcm_{t-1} \\ P_{t-1}^{\mathrm{US}} \\ FF_{t-1} \\ Y_{t-1}^{\mathrm{GER}} \\ P_{t-1}^{\mathrm{GER}} \\ e_{t-1} \\ R_{t-1}^{\mathrm{GER}} \end{pmatrix} + \begin{pmatrix} g_1 \\ g_2 \\ g_3 \\ g_4 \\ g_5 \\ g_6 \\ g_7 \\ g_8 \end{pmatrix} IFS_t^{\mathrm{GER}} + \boldsymbol{B}\begin{pmatrix} v_t^1 \\ v_t^2 \\ v_t^3 \\ v_t^{\mathrm{FF}} \\ v_t^5 \\ v_t^6 \\ v_t^e \\ v_t^{\mathrm{RGER}} \end{pmatrix}. \tag{4.2}$$

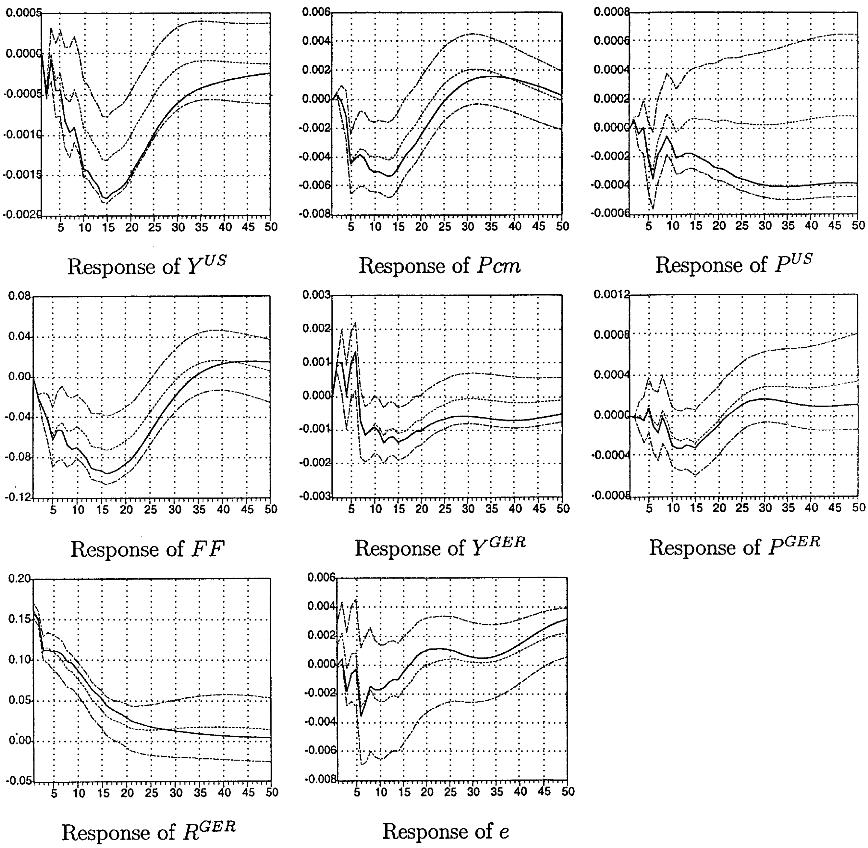

Fig. 3. Impulse responses to alternative German monetary policy shocks in open economy. Responses to IFS^{GER} shocks (solid line) and to VAR-based structural shocks ν^{RGER} (dotted line) with one standard deviation confidence intervals from the benchmark VAR.

Using our exogenous measure of monetary policy shocks in combination with a Choleski ordering with the German policy rate coming last, we are able to directly address the issue of simultaneity between German monetary policy and the exchange rate. The contemporaneous effect of a monetary policy shock on the exchange rate is given by the coefficient on IFS^{GER} in the exchange rate equation (g_7), while the response of the German interest rate to innovations in the exchange rate is endogenized by the ordering chosen.

The impulse response functions shown in Fig. 3 with solid lines confirm qualitatively the results obtained for the close US economy: measuring monetary policy shocks using financial market data does not alter the main features of the monetary transmission mechanism for Germany. As shown in Table 1(B) the impact coefficient of IFS^{GER} is significant in the equation for the German call money rate (supporting the view that our measure captures some important unanticipated movements in the policy rate) but not in the exchange rate equation. No impact depreciation of the DMark is detected, and the subsequent response of e shows an appreciation for the first five months after the shock, followed by a depreciation. From the estimated coeffi cients of the policy reaction functions reported in Table 2 we note that the endogenous response of the US Federal funds rate is unchanged with respect to the close-economy case and the German policy rate responds significantly only to innovations in the German consumer price index, signalling inflationary pressures. No significant response to the exchange rate is detected. This latter result, along with the previous observation of no significant impact of monetary policy shocks on the exchange rate, suggests that the potential simultaneity between the exchange rate and the German policy rate is not an empirically relevant problem. Finally, the last row of Table 2 shows that innovations in the exchange rate are positively related to fluctuations in US output, German prices and the US Federal funds rate.

5. Conclusions

This paper presented some evidence on the effects of monetary policy shocks in close (US) and open (US–Germany) economies when exogenous, non-VAR measures of policy disturbances are used. Such measures are directly derived from financial market prices and do not rely on specific identification assumptions imposed in the estimation of the VAR system.

The use of non-VAR measures of policy shocks may be useful in evaluating the robustness of the dynamic effect of monetary policy obtained from traditional identified VAR, since it may help to solve the simultaneity problem between policy instruments and other endogenous variables to which monetary policy systematically reacts. Our empirical analysis confirms the main features of the monetary policy transmission mechanism in US and Germany, explicitly addressing the issue of simultaneity between the German policy interest rate and the US dollar–DMark exchange rate.

Future research in this direction can widen the direct use of financial market information to evaluate the effects of monetary policy. For example, prices of interest rate (Euro) options provide implicit measures of the uncertainty surrounding monetary policy. Such measures might then be used to assess the effects of 'uncertainty shocks' on interest rates and macroeconomic quantities.

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