Measuring Monetary Policy in Open Economies *

Fabio C. Bagliano, Carlo A. Favero and Francesco Franco
Università di Torino, Università Bocconi and CEPR, Università Bocconi

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Abstract

The empirical VAR literature on the monetary transmission mechanism in open economies has not yet provided a commonly accepted solution to the problem of simultaneity between interest rates and the exchange rate. In this paper we propose to solve the identification problem by using information extracted from financial markets independently from the VAR to measure monetary policy shocks. We also evaluate the relative importance of macroeconomic and monetary policy variables in explaining short-term fluctuations in the nominal exchange rate. Our main results are that the simultaneity between German policy rates and the US dollar/D Mark exchange rate is not an empirically relevant problem, and that monetary variables are dominated by macroeconomic factors in the explanation of exchange rate fluctuations.

JEL classification: E44, E52, F41

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Non-Technical Summary

The empirical VAR literature on the monetary transmission mechanism in closed economies has produced solution to a number of empirical puzzles and has been successful in providing evidence with which theoretical models of the monetary transmission mechanism are now confronted. The empirical VAR literature on the monetary transmission mechanism in open economies has not enjoyed the same success and it is still marred with a number of empirical puzzles.

In closed-economy analyses, the "liquidity puzzle" (the positive reaction of interest rates to an expansionary shock to monetary aggregates) and the "price puzzle" (the positive reaction of the price level to a contractionary monetary policy shock) have been explained and solved by focusing on the market for banks reserves rather than on broader monetary aggregates to extract monetary policy shocks, and by the inclusion of the commodity price index as a leading indicator of inflation in the VAR specification .

In the open-economy literature, the emergence of the "forward discount premium puzzle" for the US (i.e. following a restrictive monetary policy move in the US, the dollar persistently appreciates and the response of the US interest rate is persistently higher than that of the foreign rate) and of the "exchange rate puzzle" (i.e. a restrictive monetary policy shock in non-US countries causes a depreciation of the foreign currency vis-à-vis the US dollar) has not yet found a widely accepted explanation. As argued by McCallum, such puzzles could be explained by the incapability of VAR models to distinguish exogenous monetary policy shocks from the endogenous reaction of monetary authorities to exchange rate fluctuations in open economies. Indeed, the existence of a simultaneous feedback between interest rates and the exchange rate poses a formidable identification problem for structural VAR models.

In this paper we propose to solve the simultaneity bewteen exchange rate and policy interest rates by using information extracted from financial markets independently from the VAR. We concentrate on the US-German case to address the problem of identifying exogenous Bundesbank policy moves from the reaction of policy rates to fluctuations in the US Dollar-Deutschemark exchange rate. Exploiting the fact that intervention on policy rates takes place on occasion of regular bi-weekly meetings of the Bundesbank Council, we estimate the term structure of spot rates and of instantaneous forward rates the day before regular meetings, obtaining a measure of expectations for Bundesbank interventions. With such direct measure of the shock we evaluate the importance of the simultaneity of exchange rates and policy rates and we re-assess the puzzles observed in the literature. Lastly, we evaluate the relative importance of macroeconomic and monetary policy variables in explaining short-term fluctuations in the nominal exchange rates.

Our analysis shows that there is no within-month simultaneous feedback between policy rates and the exchange rate.

We also evaluate the relative importance of macroeconomic and monetary policy variables in explaining short-term fluctuations in the nominal exchange rates. The results from simultaneous feedbacks, impulse responses and variance decompositions reveal that monetary factors play a very limited direct role in explaining exchange rate fluctuations, which are largely determined by macroeconomic factors.

1. Introduction

The empirical VAR literature on the monetary transmission mechanism in closed economies has produced solution to a number of empirical puzzles and has been successful in providing evidence with which theoretical models of the monetary transmission mechanism are now confronted. The empirical VAR literature on the monetary transmission mechanism in open economies has not enjoyed the same success and it is still marred with a number of empirical puzzles.

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In the open-economy literature, the emergence of the "forward discount premium puzzle" for the US (i.e. following a restrictive monetary policy move in the US, the dollar persistently appreciates and the response of the US interest rate is persistently higher than that of the foreign rate) and of the "exchange rate puzzle" (i.e. a restrictive monetary policy shock in non-US countries causes a depreciation of the foreign currency vis-à-vis the US dollar) has not yet found a widely accepted explanation. As argued by McCallum (1994), such puzzles could be explained by the incapability of VAR models to distinguish exogenous monetary policy shocks from the endogenous reaction of monetary authorities to exchange rate fluctuations in open economies. Indeed, the existence of a simultaneous feedback between interest rates and the exchange rate poses a formidable identification problem for structural VAR models.

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2. Structural VAR models in closed and open economies

VAR models of the monetary transmission mechanism are estimated within a research programme aiming at using general equilibrium models for policy analysis. As described by Christiano, Eichenbaum and Evans (1998) empirical analysis should provide evidence on the stylized facts to be included in the theoretical model adopted for policy analysis and should allow to discriminate between competing general equilibrium monetary models.

The empirical success of VAR models is to be related to their capacity to identify monetary policy shocks and responses of relevant macroeconomic variables to monetary shocks in actual economies. Monetary policy shocks are not readily observable: given a statistical model for the vector of variables of interest, some structure has to be assumed to identify the monetary policy shocks. Such structure must be identified independently of specific predictions of the alternative theoretical models. In fact only in this case we can choose between alternative models on the basis of the empirical evidence (Uhlig (1997)).

Cumulative work on the analysis of the monetary transmission mechanism in the U.S. (the prototype of closed economy) led to the specification of a VAR system which has by now become the standard reference model (Strongin (1995), Bernanke and Mihov (1998), Gordon and Leeper (1994), Christiano, Eichenbaum and Evans (1996, 1998), Leeper, Sims and Zha (1996)). Such "benchmark" specification contains six variables. The vector of macroeconomic non-policy variables includes gross domestic product, the consumer price index and the commodity price level. The vector of policy variables includes the federal funds rate, the quantity of total bank reserves and the amount of nonborrowed reserves.

Given the estimation of the reduced form VAR for the six macro and monetary variables a structural model is then identified by: (*i*) assuming orthogonality of the structural disturbances; (*ii*) imposing that macroeconomic variables do not simultaneously react to monetary variables, while the simultaneous feedback in the other direction is allowed, and (*iii*) imposing restrictions on the monetary block of the model reflecting the operational procedures implemented by the monetary policy maker. All identifying restrictions satisfy the criterion of independence from specific theoretical models.

The estimation of benchmark VAR models has generated a number of "stylized facts" on the effect of a contractionary policy shock: *(i)* the aggregate price level initially responds very little; *(ii)* interest rates initially rise, and *(iii)* aggregate output initially falls, with a j-shaped response, with a zero long-run effect of the monetary impulse. Such evidence leads to the dismissal of traditional real business cycle models, which are inconsistent with the liquidity effect of monetary policy on interest rates, and of the Lucas (1972) model of money, in which the effect of monetary policy on output depends on price misperceptions. The evidence seems to be more in line with alternative intepretations of the monetary transmission mechanism based on sticky prices models (Goodfriend and King (1997)), limited participation models (Christiano and Eichenbaum (1992)) or models with indeterminacy-sunspot equilibria (Farmer (1997)). Interestingly, such evidence seems to be robust to the choice of the sample and on the policy regime under which the model is estimated (Christiano and Eichenbaum (1998)).

Various papers have examined the effects of monetary shocks in open economies, but this strand of literature has been distinctly less successful in providing accepted empirical evidence than the VAR approach in closed economies. The first results have been provided by Eichenbaum and Evans (1995). We represent their model as a special case of the A-B structure in Amisano-Giannini(1996):

$$\mathbf{A_0 y}_t = \sum_{i=1}^{k} \mathbf{A}_i \mathbf{y}_{t-i} + \mathbf{B}\boldsymbol{v}_t \tag{2.1}$$

where $\mathbf{y}_t = \left[\begin{array}{ccccccc} Y_t^{US} & P_t^{US} & NBRX_t^{US}(FF_t) & Y_t^{FOR} & P_t^{FOR} & R_t^{FOR} & e_t(q_t) \end{array} \right]'$. Y^{US}, P^{US} are logs of US output and price, $NBRX^{US}$ is the ratio of non-borrowed to total reserves (the appropriate variable from which extract monetary policy shocks under a regime of non-borrowed reserves targeting). FF is the Federal Funds rate, which is considered in alternative to $NBRX^{US}$, and it is the informative variable for the extraction of monetary policy shocks under the regime of interest rate targeting; Y^{FOR}, P^{FOR}, and R^{FOR} are respectively the logs of output, prices, and the level of short-term interest rate in the foreign country; e is the nominal bilateral exchange rate, while q is the real bilateral exchange rate. The matrix $\mathbf{B}$ is diagonal and $\mathbf{A_0}$ is lower-triangular. The empirical analysis is implemented by considering in turn as a foreign country each of the G7 countries on a sample of monthly data from 1974:1 to 1990:5. The following evidence emerges: (i) a restrictive US monetary policy shock generates a significant and persistent appreciation of the

US dollar; (*ii*) a restrictive US monetary policy shock generates a significant and persistently larger effect on the domestic interest rate with respect to the foreign rate; (*i*) and (*ii*) imply a sharp deviation from the uncovered interest parity condition in favour of US dollar-denominated investments (the "forward-discount puzzle"); (*iii*) identified US monetary policy shocks are not different from the shocks derived within closed-economy VARs (*iv*) the closed-economy response of US prices and output to monetary policy shocks is robust to the extension of the VAR to the open economy; (*v*) a restrictive foreign monetary policy shock generates an appreciation of the US dollar (the "exchange-rate puzzle"); and (*vi*) the response of the real exchange rate to the US and foreign monetary policy shocks does not differ significantly from the response of the nominal exchange rate. Such evidence is substantially confirmed by the the work of Schlagenhauf and Wrase (1995), who consider a very similar specification for the G-5 countries over the sample 1972:2-1990:2, using quarterly data. Some considerations are in order to help the interpretation of the above results.

First, the empirical models are estimated over samples including shifts in US and foreign monetary policy regimes: therefore, parameter instability is a potential problem.

Second, the extension to the open economy features the omission from the VAR of the commodity price index and of the monetary variables not relevant to the extraction of the policy shocks. While the simplification of the monetary block is sustainable in the light of the absence of contemporaneous feedback between the informative variables and the other monetary variables under the chosen identification schemes, the omission of the commodity price index is not justifiable as it leads to the same mis-specification as in the closed economy model for US monetary policy shocks. Moreover, such omission might well also bias the identification of the foreign monetary policy shocks if the commodity price index is regarded as a leading indicator of inflation by the foreign policymaker.

Third, while some rationale can be provided for a quasi-recursive scheme in closed economies, a similar justification is much harder to accept in open economies. In fact, the recursive identification scheme with the exchange rate ordered last implies that neither the US nor the foreign monetary authority react contemporaneously to exchange rate fluctuations. This assumption seems to be sustainable for the US (the FED benign neglect for the dollar) but it is certainly heavily questionable when the foreign countries are considered, as they are much more open economies than the US. In fact, most of the recent empirical work is aimed at breaking such recursive structure in the identification scheme.

Kim and Roubini (1997) obtain such aim by introducing a structural identification by the explicit consideration of a money demand and supply functions. They specify a model for non-US countries including seven variables: two non-domestic (the world index of oil price in dollars and the Federal Funds rate)and five domestic (the short-term policy rate, a monetary aggregate (M0 or M1), the log of consumer price index, the log of industrial production, and the nominal exchange rate against the dollar). The identifying restrictions are as follows: the US economy is taken as exogenous and the exchange rate does not enter in the FED reaction function, US output and prices are not included in the VAR, while a simultaneous feedback is allowed between money demand and supply (the central bank rule). According to this rule, contemporaneous US interest rate movements are relevant to the foreign central bank only if they affect the exchange rate. Only the exchange rate is allowed to contemporaneously react to news in all the other variables. The coefficients determining the simultaneous feedbacks are estimated rather imprecisely and the potential simultaneous feedback between foreign monetary policy and the exchange rate does not seem to be empirically relevant. However, all puzzles disappear and the empirical results for the impulse response functions are broadly in line with results from the US closed economy model.

We note that also in this case the sample considered spans different regimes. Moreover this methodology brings back into the specification broad monetary aggregates. Interestingly money is used to extract demand rather than supply shocks, however the specification of money demand implicit in the VAR might not be rich enough to capture the dynamic in the data. As pointed out by Faust and Whiteman (1997), single equation work by Hendry and colleagues on money demand has clearly shown the importance of including in the model the opportunity cost of holding money, which is often a spread between the interest rates. Interest spreads capturing the opportunity cost of holding money are never included in VAR models of the MTM. An identification similar to the one adopted by Kim-Roubini is the one proposed for the Canadian case by Cushman and Zha (1997), who aid the strucutral identification by introducing explicitly the trade sector into the model.

An interesting alternative approach to the identification of the simultaneous feedback between non-US interest rates and exchange rates is proposed by Smets (1996, 1997). Smets considers a structural model for non-US countries including four variables:output growth, inflation, a short term interest rate and the exchange rate appreciation. No US variable is introduced, and the commodity price index is also excluded. Both macroeconomic and monetary shocks are identified by imposing three type of restrictions. First the semi-structural restrictions, macro variables do no react contemporaneously to monetary variables. Second, macroeconomic supply shocks are identified for macroeconomic demand shocks by following Blanchardand Quah (1989) to assume that the long-run effect of demand shocks on outptut is zero. Third, monetary policy shocks are identified from exchange rate shocks by assuming that the Central Bank reacts proportionally to interest rate and exchange-rate developments (short-term MCI). The relative weights in the MCI's can be estimated or imposed given the knowledge of the relative weights in several Central Banks condition indexes. This approach encompasses as special case the pure interest rate targeting and the pure exchange rate targeting.The proposed strategy is judged rather successfull in the solution of the relevant puzzles The main empirical problem with this procedure are the instability of the estimated weights in the Monetary Condition Indexes and the potentially disruptive implications of mis-specification for the identification of aggregate demand and supply shocks (see Faust and Leeper (1997) on this point).

To sum up, our analysis of VAR models of the monetary transmission mechanism points towards two possible explanations of the observation of the puzzles in open economies: mis-specification, via the omission of a commodity price index in the benchmark open-economy VAR and problems of identification related to the simultaneity between interest rates and exchange rates in small open-economies. We include the commodity price index in our VAR and explicitly address the identification problem by using a non-VAR measure of monetary policy shocks to investigate the simultaneus feedback between exchange rates and policy rates. consider these two potential explanations in turn, by concentrating on open economy VAR model linking the US and the German economy. The choice of Germany is justified by the opportunity of identifying monetary policy shocks using directly information from financial markets and independently from a VAR model. Such an opportunity is closely linked to the operational procedures adopted by the Bundesbank in setting policy rates.

3. An open-economy VAR model for US and Germany

We estimate first a benchmark open economy model for the US and the German economy. The model is estimated on monthly data over the sample 1983:1 1997:11. The VAR is specified by including six lags of US industrial production (Y^{US}), the commodity price index (Pcm), US consumer price index $\left(P^{US}\right)$, Federal Funds rate (FF), German industrial production $\left(Y^{GER}\right)$,German consumer price index $\left(P^{GER}\right)$, German call money rate $\left(R^{GER}\right)$, and the US-dollar/Deutschemark nominal exchange rate (unit of DM for one US dollar, e). All the variables used in our empirical analysis are reported in Figure 1. Our preliminary statistical anlysis of the VAR revealed the presence of some outliers, we have then augmented the specification with three dummies: a first one, taking a value of 1 in June 1984 and zero everywhere else, a second one taking a value of -1 in June 1988, 1 in July 1988 and zero everywhere else, and a last one taking a value of 1 in January 1993 and zero everywhere else. such dummies have been kept thorugh all the VARs analyzed in our work.

Insert figure 1 here

The choice of the sample is motivated by two reasons: (i) having a single monetary policy regime for the US, featuring Fed funds targeting, (Bagliano and Favero (1998), Bernanke and Mihov (1998)), (ii) estimation on the model over a sample allowing alternative derivation of monetary policy shocks. Our alternative methodology involves the estimation of term structures of German interest rates on occasion of Council meeting, such data are available on Datastream form 1983 onwards. The results of the estimation of the structural parameters in the benchmark VAR model in open economies are reported in Table 1, while responses of all the variables to US and German monetary policy shocks are reported in Figures 2 and 3.

Insert Table 1 and Figures 2-3 here

We adopt a standard recursive specification which does not allow any simultaneous feedback between German policy rates and the exchange rate. In fact, being ordered last, the exchange rate reacts simultaneously to all the other variables in the VAR, but the German policy rate is not allowed to react simultaneously to the exchange rate. The analysis of the contemporaneous feedback between variables within the recursive specification provides evidence on the endogeneity of US monetary policy, which reacts significantly to internal conditions(the US policy rate responds significantly simultaneously to shocks to US inflation and US outptut, the magnitude of coefficients is such that an unexpected one per cent increase in inflation induces an increase of 37 basis points in the policy rate, while an unexpected increase in output induces an increase of 8.6 basis points in the policy rate), and of the German monetary policy which reacts to internal conditions only(an unexpected increase in output induces an increase of 2.6 basis points in the policy rate). The exchange rates reacts contemporaneously significantly to US monetary policy (a one-per-cent positive interest rate shock in the US induces appreciation of the US dollar vis-a-vis the DM of 2.3 per cent) and to macroeconomic conditions in US and Germany (a one per cent positive shock in US industrial production generates an 1.22 per cent impact appreciation of the dollar, a one per cent positive shock in GErman inflation generates a 2.57 appreciation of the dollar).

The analysis of the responses to monetary impulses in the US and Germany confirms all the main findings of the literature namely:

- a significant U-shaped response of US output to US monetary policy;
- the absence of a price puzzle both for the US and Germany, due to the inclusion of the Commodity Price index in the set of variables;
- an unexpected increase in the US policy rates induces an temporary appreciation of the US Dollar/D.Mark exchange rate. The maximum appreciation does not occur on impact, but after about fifteen periods. This is due to a less than one-to-one response of German short-term rates. However, over a longer horizon the German rate reacts and we do not observe a forward discount bias;
- the effect of an unexpected increase in German policy rates is not symmetric to the US case. In fact the Federal Fund rate and the exchange rate do not significantly respond to German monetary policy.

This last set of responses would suffer most from potential simultaneity problem between German policy rates and the exchange rate. To address explicitly this issue we propose to solve the identification problem by using a non-VAR measure of German monetary policy shocks.

4. Measuring monetary policy shocks in Germany without a VAR.

In order to measure monetary policy shocks without imposing any linear, time-invariant, backward- looking structure to the data , we define a monetary policy shock (mps) as the unexpected change in the very short term interest rate occurring at "special" dates. These special dates are the days of Bundesbank Council meetings, where most relevant decisions on monetary policy are taken(modifications in all the reference rates– marginal lending rate, marginal deposit rate and repo rate– have been regularly taken at Bundesbank Council meetings dates). The Bundesbank council meets regularly every two weeks and the calendar of the meetings is information available to the public.

The unexpected change in the policy rates is derived following Svensson (1994), and Soderlind and Svensson (1997). We estimate a term structure of spot interest rates on the day before the Council meeting by fitting a smooth interpolant function through the observed rates. Given the availability of a smooth yield curve for spot rates, we can unequivocally determine the curve of istantaneous forward rates the day before the meeting. Interpreting the istantaneous forward rate as the over-night interest rate, the curve of instantaneous forward rates gives us the succession of expected overnight rates at all future dates. Therefore, we are able to compute the overnight interest rate expected for the day following the council. The difference between the overnight interest rate the day after the Council meeting and the expected overnight interest rate for the day following the Council, conditional upon information available before the meeting, is our measure of monetary policy shocks.

The hypothesis involved in the estimation of the istantaneous forward rates, the pure expectation model, implies that the market incorporates an expected monetary policy action in the yields with a maturity exceeding the day of the decision on the monetary policy action. In practice, for the short-end of the term structure, this means that whenever the Buba Council is expected to change the stance of monetary policy on occasion of a given meeting, then a significative difference between the over-night rate and forward rates with maturity higher than two days should emerge. We construct the series of overnight rates at any future day by estimating a yield curve for spot rates and by deriving the associated yield curve for instantaneous forward rates. Following Svensson's methodology we use the continous functional form proposed by Nelson and Siegel, extended if appropriate, to fit the observed interest rates. One of the standard practice in the application of this curve-fitting approach is to include the overnight rate in the information set and sometime to constrain the estimation to force the fitted overnight rate to match the observed one. However, a monetary policy shock implies by definition a jump in, at least, the short end of the term structure. Forcing the smooth instantaneous forward rate curve to fit exactly the observed overnight rate would not allow to seize an eventual expected monetary policy action.We therefore exclude the overnight rate from the information used for estimation. Exploiting then the continuity of the functional form we reconstruct the very short end of the term structure allowing for a gap between the estimated overnight and the observed overnight. Such gap represents the jump in the very short-end of the term structure associated with expectations of intervention by the Council.

An example can clarify matters. On occasion of the meeting held on the 2nd of December 1993 the Bundesbank reduced the repo rate by 25 basis points. In Figure 4 we report Nelson-Siegel interpolants of the term structure of interest rates observed on the close of the markets before the meeting. We report two yield curves for spot rates, the first one fits the data including the overnight (SPOTYO), while the second one excludes the overnight (SPOTYW). We also report the two instantaneous forward curves associated respectively to the spot curve estimated excluding the overnight rate (IFW) and to the spot curve estimated including the overnight rate (IFOY).

Insert Figure 4 here

The figure shows clearly that the term structure reflected the expectation of a cut in policy rate. Therefore, fitting the curve on data including the overnight without allowing for a jump in the term structure from the date of the Bundesbank Council meeting afterwards, would have spuriously generated an interest rate shock.

4.1. Analysing interesting episodes.

In this section we consider the performance of our methodology for estimating monetary policy shocks on specific occasions. We illustrate examples of monetary shocks generated by unanticipated action or by unanticipated inaction by the Bundesbank, likewise we consider examples of markets' anticipation of Bundesbank behaviour when expectations on monetary policy turned out to be correct and no shocks were observed.

Consider first July 1988. In this month the Bundesbank Council met twice,on the 14th and on the 28th. During the first Council the Bundesbank didn't take any action, during the second the Council it was decided to raise the Lombard Rate by 50bp. In Figure 5 we report the the weekly and the overnight rate, alongwith the monetary policy action(PMA).

Insert Figure 5 here

We shade areas of three days centered around meetings. We note that no monetary policy action was expected during the first meeting, while some action was expected before the second one. Six days before the meeting the weekly rate contains the first six days of maturity which doesn't include the action and the seventh one which instead does include the action, so the weekly rate should start to "reflect" the monetary policy action six days before the meeting. Of course the weight of the seventh day is one-seventh so the information doesn't appear clearly six days before, but as we approach the date of the council the weight of the action becomes greater and the expectation discloses itself. It can be observed that the weekly rate starts reacting three days before the meeting. It is also possible than the market realizes that the Bundesbank will act only a few days before the Council (say less than six days before), in this case the weekly rate starts reacting later than six days before the Council. The weekly rate should be the best observed interest rate to identify expections on monetary policy actions. In fact Council meetings take place fortnightly and the 1-month rate immediately before any meeting reflects expectations on the outcome of the following two meetings.

The second episode we consider is the tightening of monetary policy occurred after German reunification in January-February 1991. Two meetings were held in this period, the 17th of Janauary and the 2nd of February. As Figure 5 clearly shows, the weekly rate increased sharply just before the first Council revealing an expected increase in the interest rates. The Bundesbank didn't act on that meeting. We immediately observe than the expected tightening happened during the following Council meeting, when the Bundesbank raised the Discount Rate and the Lombard Rate by 50 bp. To summarize, on the fourteenth of January we observed a monetary policy shock arising from an anticipated action that did't occur, meanwhile on the second of February there is no shock as the policy move has been correctly anticipated.

The third episode we single out occurred in December 1991, when the Bundesbank tightened the monetary policy, raising once again the Discount Rate and the Lombard Rate by 50 bp.The dates of the Bundesbank Councils are the fifth and the nineteenth of December. During the latter meeting the German Central Bank surprised the market creating the monetary policy shock, so we observe a shock arising from an unexpected action.

4.2. An assessment of our methodology.

The main strength of our methodology is its flexibility and its capability to capture shocks independently from the specification of a linear auto-regressive model. Other approaches to derive monetary shocks independently from a VAR have been followed by Skinner and Zettelmeyer (1996) and Rudebusch (1996). Skinner and Zettelmeyer derive a measure of unanticipated monetary policy shocks by following a two-step methodology: first, using information from central bank reports and newspapers they construct a list of days on which monetary policy moves occurred; second, monetary policy shocks are identified with the changes in the three-month interest rate on those days. The main problem with the index so obtained is that it can only pin down shocks associated to monetary policy decisions reflected in some action on controlled variables, whereas shocks associated with *no* action (while some action was expected by the markets) are neglected. Rudebusch derives monetary policy shocks for the US case from the 30-Day Fed funds future contracts, which have been quoted on the Chicago Board of Trade since October 1988, and are bets on the average overnight fed funds rate for the delivery month, corresponding to the variable included in the benchmark VAR. Shocks are constructed as the difference between the federal funds rate at month t and the 30-day federal funds future at month $t-1$. This procedure produces shocks, which are comparable to the reduced form innovations from the VAR and not to the structural monetary policy shocks, because surprises relative to the information available at the end of month $t-1$ may reflect endogenous policy responses to news about the economy that become available in the course of month t. Moreover, such procedure cannot be extended to other, non U.S., countries.

We believe that the methodology we employ delivers monetary policy shocks which are not affected by the sample selection problem of Skinner and Zettelmeyer (1996) and which should be strongly dominated by exogenous monetary policy. In fact all the information on the endogenous part of monetary policy should be incorporated in markets' assessment of the term structure immediately before the Bundesbank Council meetings.

The main limitation of our approach is caused by the volatility of very short-term rates not related to expectations on monetary policy. Figure 6 reports daily observations on the over-night rate and the weekly rate for the estimation sample period used in the VAR.

Insert Figure 6 here

We immediately notice a number of blips in the series. Those blips could be very damaging to our methodology whenever they happen on occasion of a

Bundesbank Council meeting. Most of those blips are generated by banks reserves management which run into a non perfecly liquid markets, such as on the occasion of the last day of the average reserves maintenaince period. We make an effort to render our inference robust to blips. In fact, we have estimated our curves starting from the 7-day rather than the overnight rate, and our methodology of estimation considers the information contained in the whole term structure. However, we have run a further check and avoid to label as policy shocks all unexpected movements in policy rates which have disappeared within a week after the Council Meeting. Such correction led us to single out two outliers in 1988:9 and 1991:12. The 1988:9 outlier, whose determination is described in Figure 7, is the only one of a relevant magnitude.

Insert Figure 7 here

In Figure 7 we report the behaviour of the 7-days and the 1-month rate in the course of September 1988. No policy intervention was decided in September 1988, however just before the meeting of mid September we observe an hike in the 7-day rate. Such hike is not reflected in the term structure for longer maturities (we report 1-month for reference). This hike would have been labelled as a shock by our methodology, however, as it is reversed, within the week after the meeting we do not consider this episode as monetary policy shock.

5. An evaluation of the simultaneous feedback between interest rates and the exchange rate

Having derived a direct measure of monetary policy shock we aggregate it to construct a monthly variable and include it as an exogenous variable in the benchmark VAR specification. Using this exogenous variable in combination with a Choleski ordering with the German policy rate coming last, we are able to identify the simultaneous feedback between German monetary policy and the exchange rate. We read the response of exchange rates to a monetary policy shock from the coefficient on our exogenous variable in the equation for the exchange rate, while the response of interest rate to fluctuations in the exchange rate is endogeneized by the ordering chosen. Moreover, we can assess the relation between VAR-based monetary policy indicators and our direct measure of monetary policy shocks by analysing the estimated coefficient on the exogenous variable in the equation for the German policy rate. Our estimated simultaneous feedbacks alongwith impulses reponses to monetary shocks and responses of the exchange rate to all the variables included in our specification are reported in Table 2 and Figure 8-9.

Insert Table 2 and Figure 8-9 here

On the simultaneous relations we do not observe a significant contemporaneous feedback between German interest rates and the exchange rate in any direction. In our framework, this is a testable proposition rather than an assumed identified restriction. We note that our measure of monetary policy shocks enters significantly in the German policy rate equation and that the contemporaneous response of US output to German monetary policy shocks is small but marginally significant.[1] Overall, impulse responses are not different from those obtained by the benchmark specification. We can therefore conclude that the potential simultaneity between exchange rate and German policy rate is not empirically relevant and that explicitly addressing such simultaneity does not add vey much to the explanation of the puzzles provided by the inclusion of the commodity price index in the benchmark open-economy VAR.

5.1. The relative importance of macroeconomic and monetary factors in the determination of exchange rate fluctuations

We conclude our analysis of monetary policy in open economies by loooking at the relative importance of macroeconomic and monetary factors in the determination of exchange rate fluctuations. We do so by looking at the contemporaneous determinants of exchange rate fluctuation in the structural VAR, assessing the dynamic responses of the exchange rate to monetary and macro structural shocks and lastly analyzing the Forecast Error Variance Decomposition of the US dollar/D-Mark exchange rate.

The evidence on the simultaneous relationship between exchange-rate and the other variables included in the open economy VAR is robust to the alternative specifications considered in this paper.

Insert Table 3 here

[1] We report impulse responses based on restricting such coefficient to zero; relaxing this restriction does not affect the shape and magnitude of impulse responses.

The exchange rate is significantly contemporaneously affected by fluctuations in the US Fed Fund rate (an increase in the FED fund generates simultaneous appreciation of the US dollar), by outptut fluctuations in the US (an increase in US output generates a simultaneous appreciation of the dollar) and by price fluctuations in Germany (an increase in the German price level generates a simultaneous appreciation of the dollar), the fluctuations in the other variables do not affect contemporaneously the exchange rate. Within our framework, we are able to identify the source of fluctuations in the US Fed fund rate, which is monetary policy, but not the source of fluctuations in macroeconomic variables. We note that the magnitude of the impact of macroeconomic variables is much higher than that of US monetary policy.

The impulse response analysis reported in Figure 10 reveals that the effect of monetary policy on the exchange rate is very short lived while over the 50-month horizon macroeconomic factors play an important role, with some factors being significant in the first months following the shocks and other picking up significance later on.

To corroborate this evidence, we examine the Forecasting Error Variance Decomposition of the exchange rate by considering the contribution of three type shocks in explaining the variance of the forecasting error of the US dollar/D.Mark exchange rate at different horizons: own shocks, monetary policy shocks (both US and Germany) and macroeconomic shocks (US industrial production, US prices, German industrial production, German prices and the commodity price index). The results are reported in Figure 11.

Insert Figure 11 here

Our decomposition of the variance of the forecasting error of the exchange rate shows that the contribution of monetary factor is constantly negligible, while the variance of innovations in macroeconomic factors has an increasing importance and explains up to half the total variance of the fifty period ahead forecasting error. Own shocks are dominant over short horizons but their importance decreases as the importance of macroeconomic factor increases.

6. Conclusions

In this paper we addressed the issue of the potential simultaneity bewteen the exchange rate and policy interest rates in open economy VAR models by using information extracted from financial markets. By considering the US-German case we have derived a direct measure of German monetary policy shocks independently from the VAR, and we have then directly tested the existence of a simultaneous feedback between the German policy rate and the D.Mark/US dollar exchange rate. Our analysis shows that there is no within-month simultaneous feedback between policy rates and the exchange rate.

We have also evaluated the relative importance of macroeconomic and monetary policy variables in explaining short-term fluctuations in the nominal exchange rates. The results from simultaneous feedbacks, impulse responses and variance decompositions reveal that monetary factors play a very limited direct role in explaining exchange rate fluctuations, which are largely determined by macroeconomic factors.

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Table 1 : The Benchmark VAR in open economy

The estimated VAR model is:

$$A\begin{pmatrix} Y_t^{US} \\ Pcm_t \\ P_t^{US} \\ FF_t \\ Y_t^{GER} \\ P_t^{GER} \\ R_t^{GER} \\ e_t \end{pmatrix} = \mathbf{B}^*(L)\begin{pmatrix} Y_{t-1}^{US} \\ Pcm_{t-1} \\ P_{t-1}^{US} \\ FF_{t-1} \\ Y_{t-1}^{GER} \\ P_{t-1}^{GER} \\ R_{t-1}^{GER} \\ e_{t-1} \end{pmatrix} + B\begin{pmatrix} \nu_{1t}^{NP} \\ \nu_{2t}^{NP} \\ \nu_{3t}^{NP} \\ \nu_t^{FF} \\ \nu_{3t}^{NP} \\ \nu_{4t}^{NP} \\ \nu_t^{s} \\ \nu_t^{e} \end{pmatrix}$$

where **A** is a (eight-dimensional) lower-triangular matrix of coefficients. The sample period is 1983(1)-1997(11).

	Estimated elements of matrix **A** :						
	a_{21}	a_{31}	a_{32}	$\mathbf{a}_{41}$	a_{42}	$\mathbf{a}_{43}$	a_{51}
coeff.	-0.537	-0.034	-0.008	**-8.629**	-1.279	**-37.288**	-0.290
(s.e.)	(0.2505)	(0.0261)	(0.0078)	**(3.2672)**	(0.9768)	**(9.4788)**	(0.2183)
	$\mathbf{a}_{52}$	a_{53}	a_{54}	a_{61}	a_{62}	a_{63}	a_{64}
coeff.	**0.209**	-0.77	-0.002	-0.031	-0.014	-0.118	0.001
(s.e.)	**(0.0643)**	(0.6481)	(0.005)	(0.0351)	(0.0106)	(0.1042)	(0.0008)
	a_{65}	a_{71}	a_{72}	a_{73}	a_{74}	$\mathbf{a}_{75}$	a_{76}
coeff.	0.008	2.773	0.604	7.726	-0.031	**-2.68**	8.112
(s.e.)	(0.0122)	(3.0447)	(0.9217)	(9.0431)	(0.0696)	**(1.0539)**	(6.572)
	$\mathbf{a}_{81}$	a_{82}	a_{83}	$\mathbf{a}_{84}$	a_{85}	$\mathbf{a}_{86}$	a_{87}
coeff.	**-1.221**	0.153	0.328	**-0.023**	-0.037	**-2.57**	-0.009
(s.e.)	**(0.3677)**	(0.1112)	(1.0918)	**(0.0084)**	(0.1293)	**(0.7953)**	(0.0092)

	Estimated elements of matrix **B** :							
	b_{11}	b_{22}	b_{33}	b_{44}	b_{55}	b_{66}	b_{77}	b_{88}
coeff.	0.004	0.014	0.001	0.178	0.012	0.002	0.162	0.019
(s.e.)	(0.0002)	(0.0007)	(0.0001)	(0.0096)	(0.002)	(0.0001)	(0.0087)	(0.0010)

Pcm is the log of commodity price index in US dollars, Y^{US} is the log of U.S. industrial production, P^{US} is the log of U.S. Consumer Price Index, Y^{GER} is the log of German industrial production, P^{GER} is the log of German Consumer Price Index, FF is the U.S. effective federal funds rate, R^{GER} is the German call money rate, e is the log of the U.S. dollar/DeutscheMark exchange rate (unit of D.Mark for one US dollar). All data are taken from Datastream.

Table 2: The VAR with a exogenous measure of German monetary policy shocks

The estimated *VAR* model is:

$$A\begin{pmatrix} Y_t^{US} \\ Pcm_t \\ P_t^{US} \\ FF_t \\ Y_t^{GER} \\ P_t^{GER} \\ e_t \\ R_t^{GER} \end{pmatrix} = \mathbf{B}^*(L)\begin{pmatrix} Y_{t-1}^{US} \\ Pcm_{t-1} \\ P_{t-1}^{US} \\ FF_{t-1} \\ Y_{t-1}^{GER} \\ P_{t-1}^{GER} \\ e_{t-1} \\ R_{t-1}^{GER} \end{pmatrix} + \begin{pmatrix} g_1 \\ g_2 \\ g_3 \\ g_4 \\ g_5 \\ g_6 \\ g_7 \\ g_8 \end{pmatrix} Gercmrs_t + B\begin{pmatrix} \nu_{1t}^{NP} \\ \nu_{2t}^{NP} \\ \nu_{3t}^{NP} \\ \nu_{4t}^{FF} \\ \nu_t^{NP} \\ \nu_t^{NP} \\ \nu_t^{e} \\ \nu_t^{S} \end{pmatrix}$$

where **A** is a (eight-dimensional) lower-triangular matrix of coefficients. The sample period is 1983(1)-1997(11).

	Estimated elements of matrix **A** :						
	a_{21}	a_{31}	a_{32}	$\mathbf{a}_{41}$	a_{42}	$\mathbf{a}_{43}$	a_{51}
coeff.	-0.48	-0.025	-0.007	**-8.997**	-1.307	**-37.802**	-0.333
(s.e.)	(0.258)	(0.0267)	(0.0078)	**(3.3517)**	(0.9779)	**(9.5310)**	(0.2238)
	$\mathbf{a}_{52}$	a_{53}	a_{54}	a_{61}	a_{62}	a_{63}	a_{64}
coeff.	**0.205**	-0.833	-0.002	-0.036	-0.015	-0.126	0.001
(s.e.)	**(0.0643)**	(0.6512)	(0.005)	(0.0361)	(0.0106)	(0.1049)	(0.0008)
	a_{65}	$\mathbf{a}_{71}$	a_{72}	a_{73}	$\mathbf{a}_{74}$	a_{75}	$\mathbf{a}_{76}$
coeff.	0.008	**-1.355**	0.148	0.15	**-0.022**	-0.045	**-2.439**
(s.e.)	(0.0122)	**(0.375)**	(0.1105)	(1.091)	**(0.0083)**	(0.1264)	**(0.7873)**
	a_{81}	a_{82}	a_{83}	a_{84}	$\mathbf{a}_{85}$	a_{86}	a_{87}
coeff	1.49	0.432	4.872	-0.015	**-2.494**	9.767	-0.389
(s.e.)	(3.1892)	(0.9105)	(8.9464)	0.0698	**1.0369**	6.633	0.6234

	Estimated elements of vector **g** :							
	g_1	g_2	g_3	g_4	g_5	g_6	g_7	g_8
coeff.	-0.007	-0.010	-0.0013	-0.0892	-2.16E-05	0.0029	0.0084	0.2297
(s.e.)	(0.002)	(0.008)	(0.0008)	(0.1146)	(0.0011)	(0.0070)	(0.0127)	(0.0974)

	Estimated elements of matrix B:							
	b_{11}	b_{22}	b_{33}	b_{44}	b_{55}	b_{66}	b_{77}	b_{88}
coeff.	0.004	0.014	0.001	0.178	0.012	0.002	0.019	0.159
(s.e.)	(0.0002)	(0.0007)	(0.0001)	(0.0096)	(0.0006)	(0.0001)	(0.0010)	(0.0085)

Table 3: The simultaneous effect of macroeconomic and monetary shocks on the exchange rate

Simultaneous feedback from variables in the VAR and the exchange rate (e)								
		Y^{US}	Pcm	P^{US}	FF	Y^{GER}	P^{GER}	R^{GER}
MODEL 1	coeff	**-1.22**	0.15	0.33	**-0.023**	-0.037	**-2.57**	-0.009
	(s.e.)	(0.37)	(0.11)	(1.09)	(0.008)	(0.129)	(0.79)	(0.009)
MODEL 2	coeff	**-1.36**	0.15	0.15	**-0.022**	-0.045	**-2.44**	0.008
	(s.e.)	(0.37)	(0.11)	(1.09)	(0.0083)	(0.126)	(0.79)	(0.01)

Reported coefficient for MODELS 1 are the estimated parameters of the appropriate row of $\mathbf{A}_0$ matrix in the following representation of the VAR :

$$\mathbf{A}_0\mathbf{y}_t = \sum_{i=1}^{k} \mathbf{A}_i\mathbf{y}_{t-i} + \mathbf{B}\boldsymbol{v}_t$$

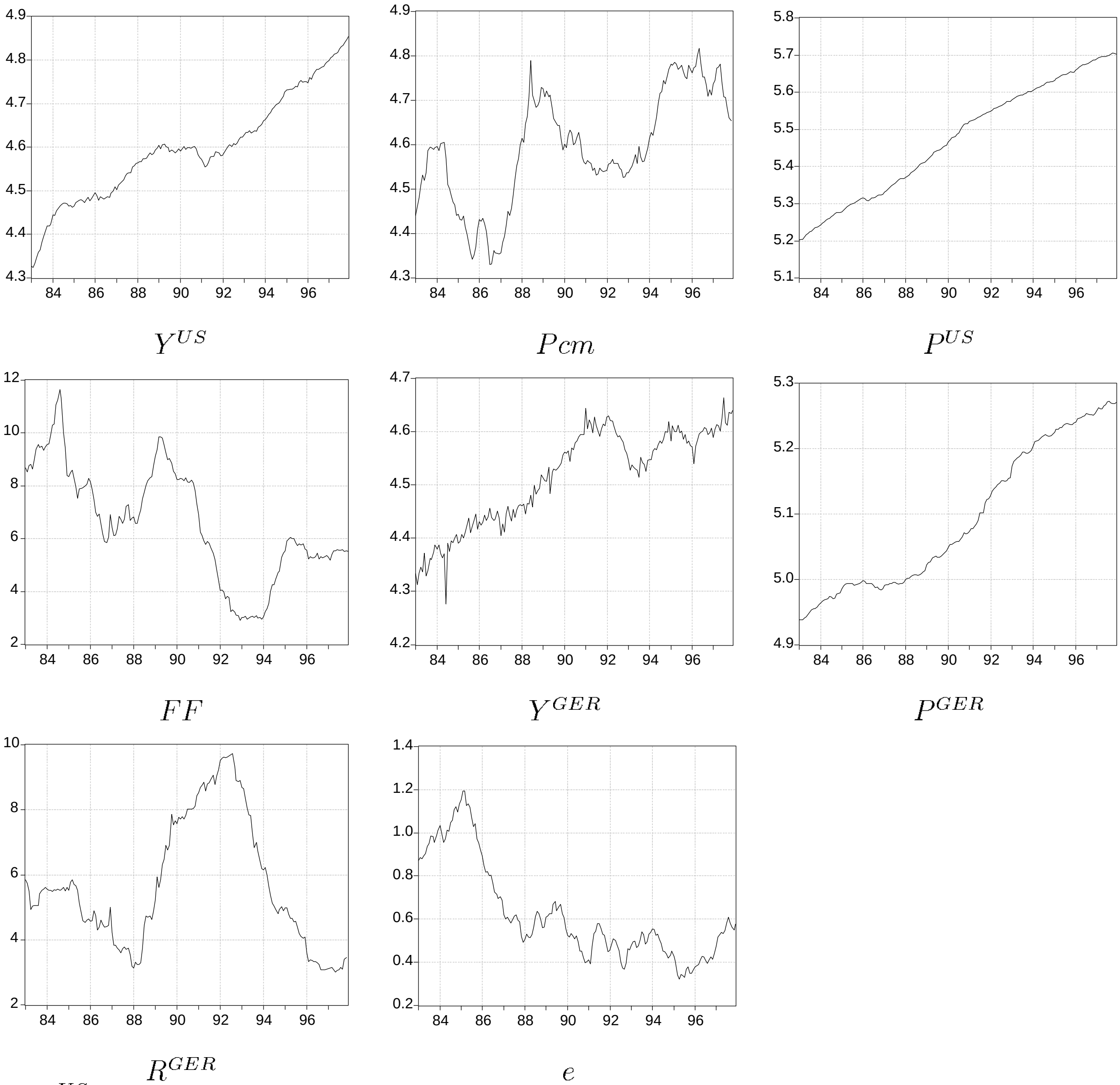
$\mathbf{y} = \left[Y^{US}, Pcm,\ P^{US},\ FF,\ Y^{GER},\ P^{GER},\ R^{GER}, e\right]'$

Reported coefficient for MODEL 2 are the estimated parameters of the appropriate row of $\mathbf{A}_0$ matrix and of the element g_7 of the $\mathbf{b}$ vector in the following representation of the VAR :

$$\mathbf{A}_0\mathbf{y}_t = \sum_{i=1}^{k} \mathbf{A}_i\mathbf{y}_{t-i} + \mathbf{g}Gercmrs + \mathbf{B}\boldsymbol{v}_t$$

$\mathbf{y} = \left[Y^{US}, Pcm, P^{US}, FF, Y^{GER}, P^{GER}, e, R^{GER}\right]'$

Figure 1: The variables used in our empirical analysis



Y^{US} is the log of U.S. industrial production, Pcm is the log of commodity price index in US dollars,P^{US} is the log of U.S. Consumer Price Index, $Y^{GER}$is the log of German industrial production, P^{GER} is the log of German Consumer Price Index, FF is the U.S. effective federal funds rate, R^{GER} is the German call money rate, e is the log of the U.S. dollar/DeutscheMark exchange rate (unit of D.Mark for one US dollar).

Figure 2: Impulse responses to US monetary policy shock in the benchmark VAR

(dashed lines : 68% interval confidence band)

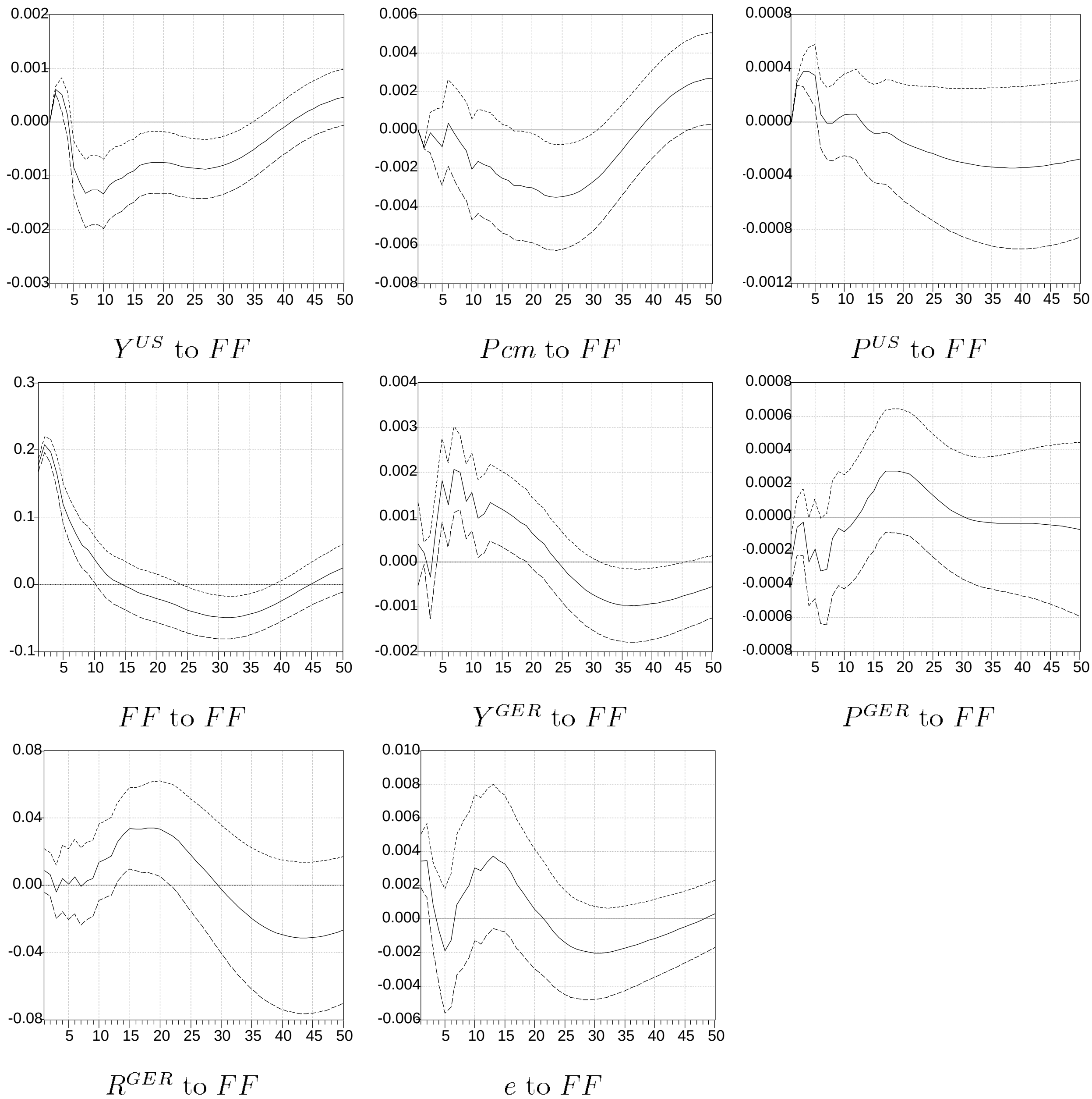


Figure 3: Impulse responses to German monetary policy shock in the benchmark VAR

(dashed lines : 68% interval confidence bands)

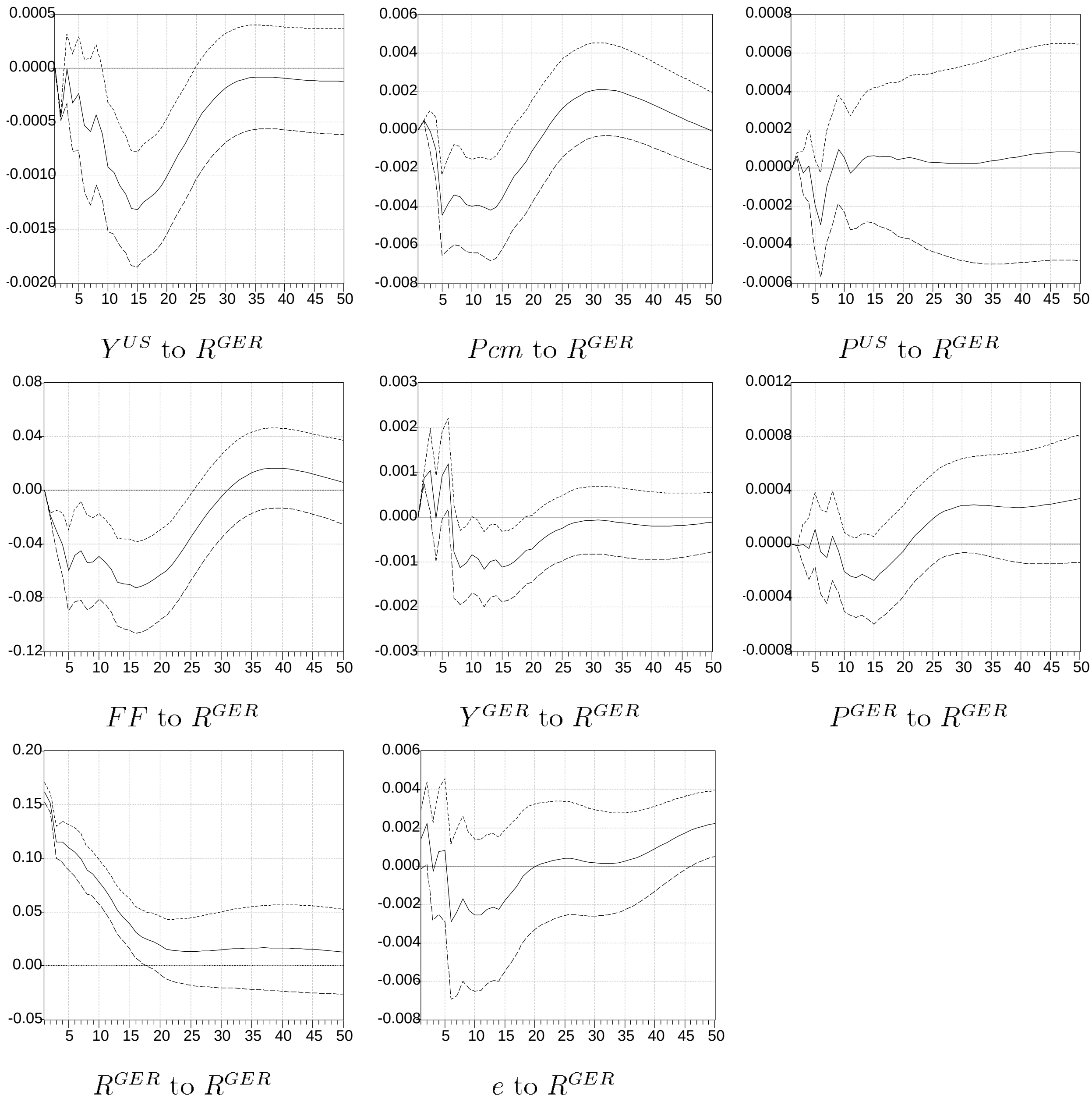
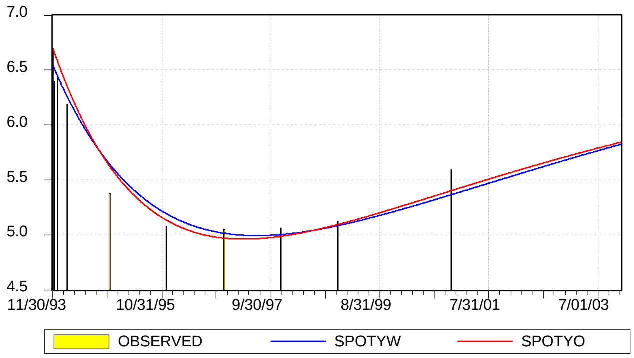
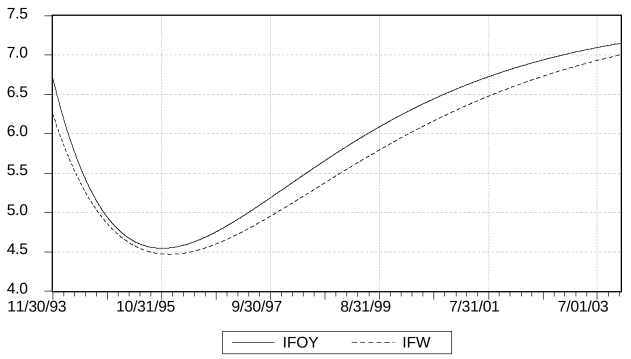


Figure 4

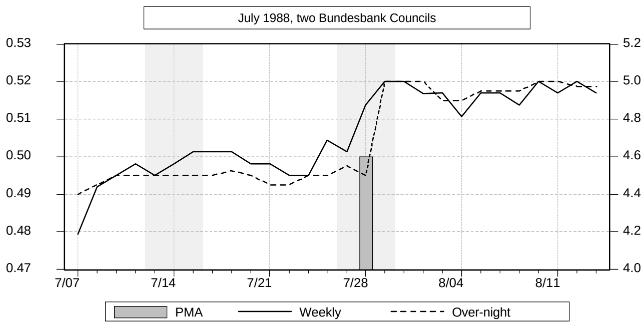


Estimated spot-rate curves on the 30/11/93 with(SPOTYO) and without(SPOTYW) the overnight rate

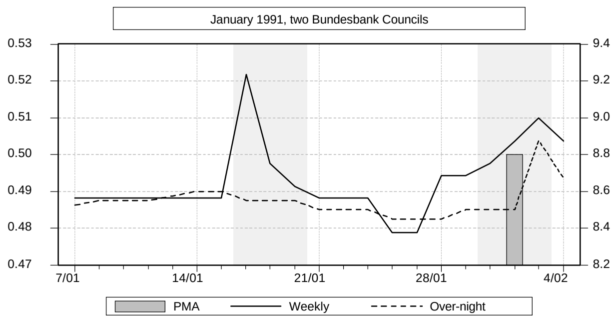


Estimated forward-rate curves on the 30/11/93 with(IFOY) and without(IFW) the overnight rate

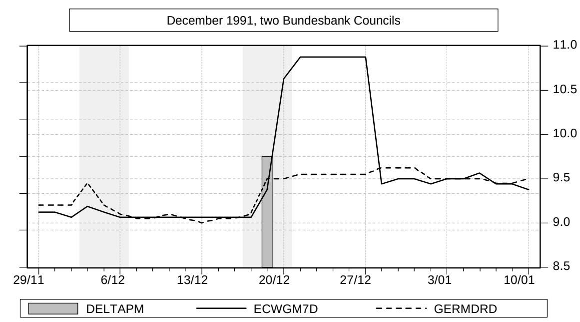
Figure 5: Monetary policy interventions and short-term interest rates in Germany.



July 1988

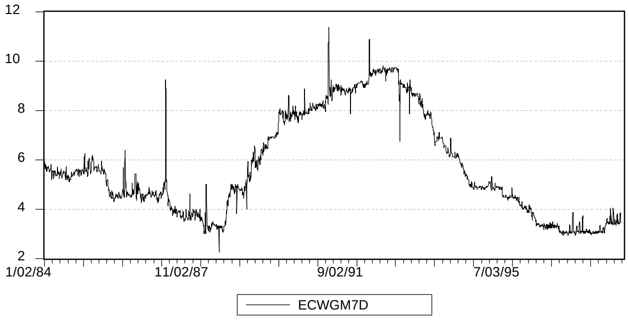


July 1991

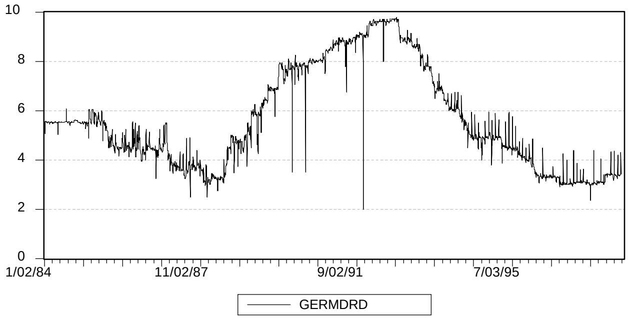


December 1991

Figure 6



German seven-days rate



German overnight rate

Figure 7: The German 7-days and one-month rate in September 1988

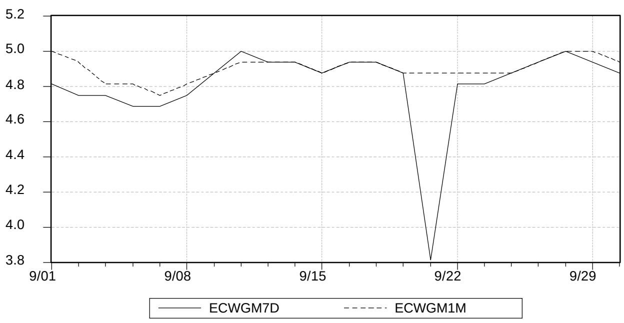


Figure 8: Impulse responses to a US monetary policy shock in our VAR with an exogenous measure of German monetary policy shocks

(dashed lines : 68% interval confidence bands)

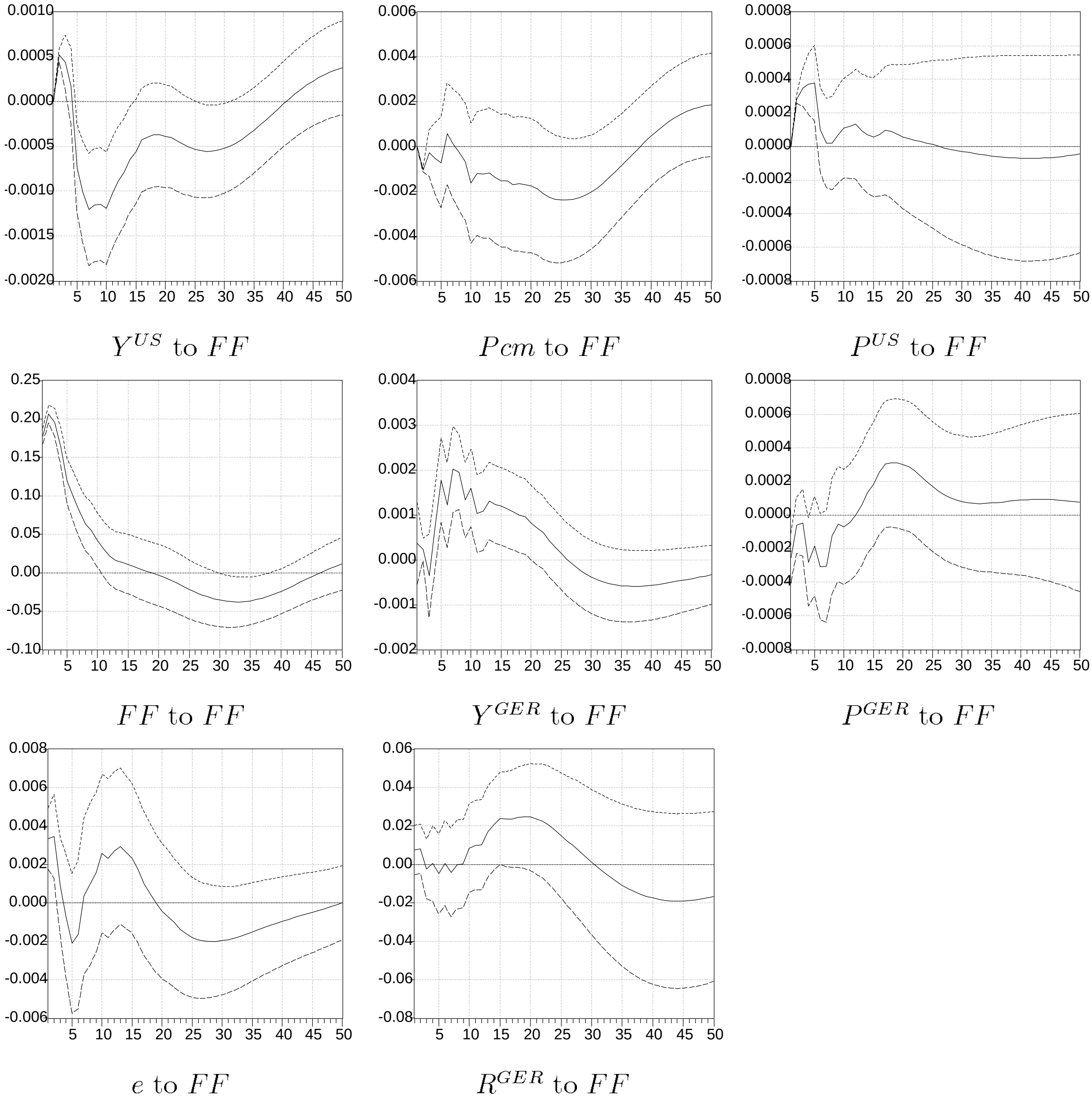
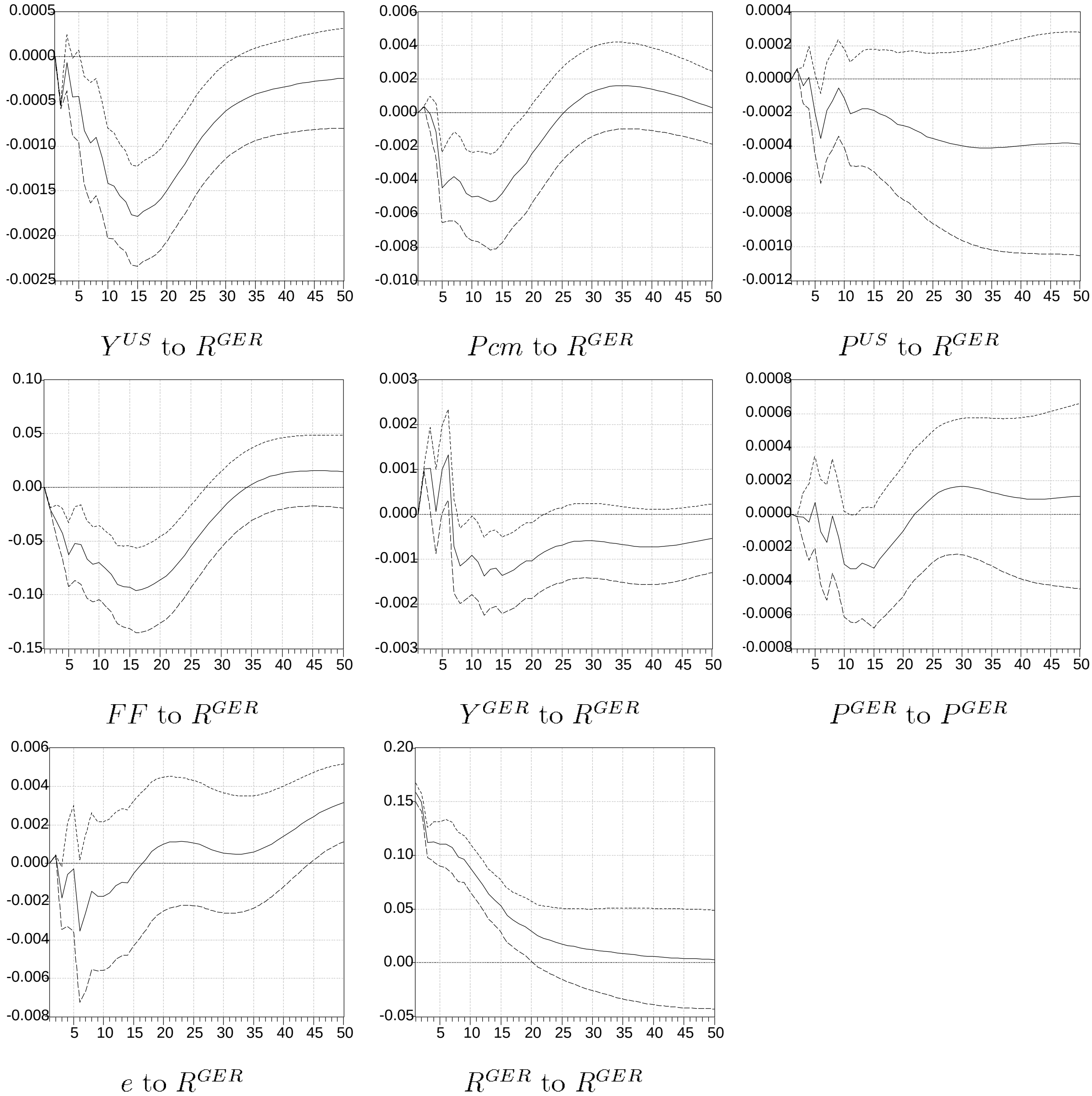


Figure 9: Impulse responses to a German monetary policy shock in our VAR with an exogenous measure of German monetary policy shocks

(dashed lines : 68% interval confidence bands)



Y^{US} to R^{GER} | Pcm to R^{GER} | P^{US} to R^{GER}

FF to R^{GER} | Y^{GER} to R^{GER} | P^{GER} to P^{GER}

e to R^{GER} | R^{GER} to R^{GER}

Figure 10: Responses of the D.Mark/US dollar exchange rate to structural shocks in a VAR with an exogenous measure of German monetary policy

(dashed lines : 68% interval confidence bands)

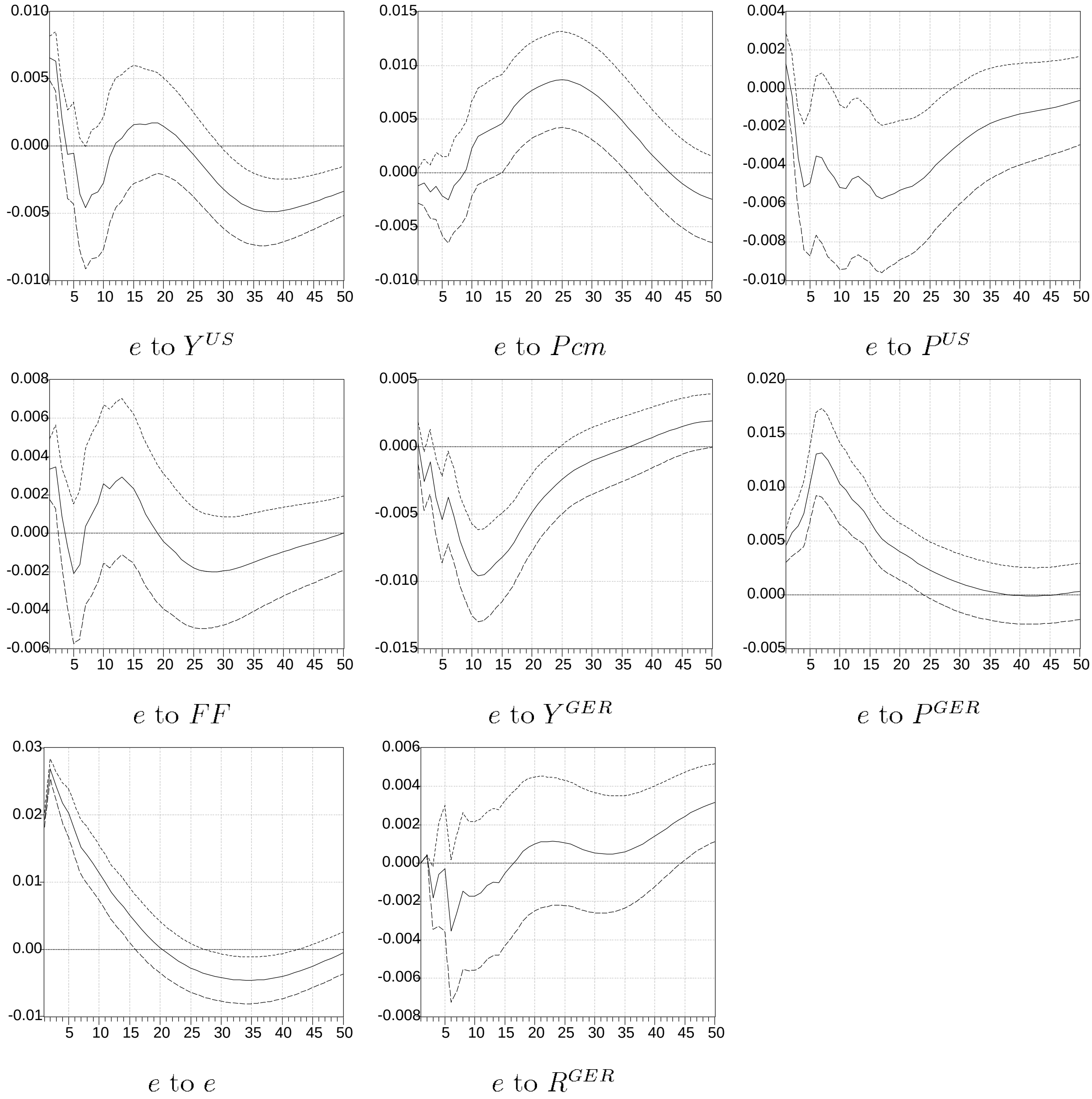
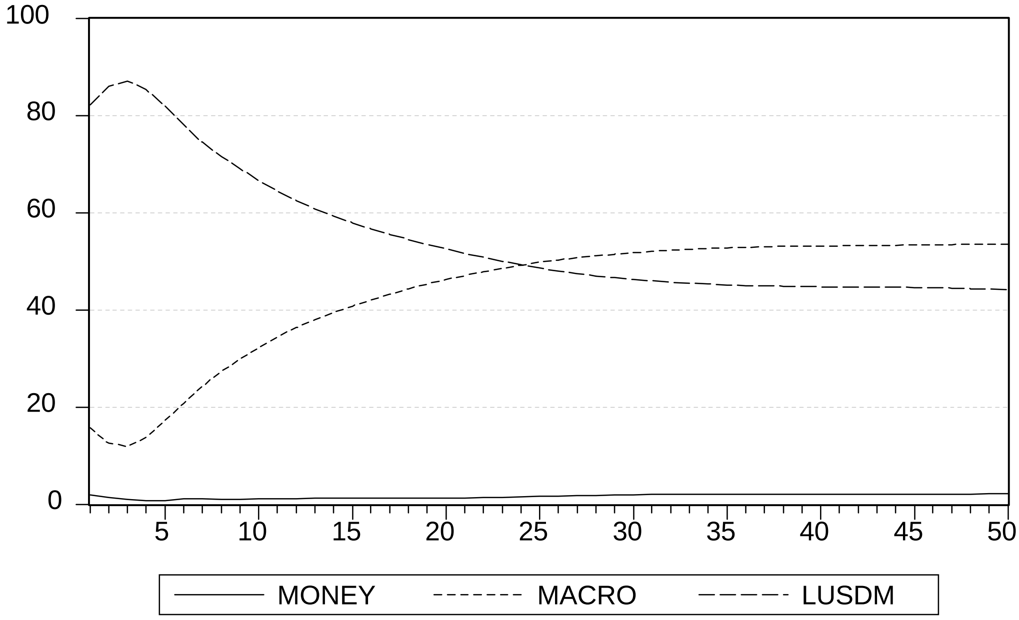


Figure 11: Forecasting Error Variance Decomposition of the (log of) US Dollar/D.Mark exchange rate



MONEY is the component attributable to monetary shocks (US and Germany monetary policy shocks)

MACRO is the component attributable to macroeconomic shocks (US industrial production and CPI, German Industrial production and CPI)

LUSDM is the component attributable to own shocks, orthogonal to the MONEY and MACRO shocks