Germany and the euro area: Differences in the transmission process of monetary policy

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ABSTRACT

This study analyses the transmission of monetary policy in Germany for the EMS period in the framework of a structural vector error correction model (S-VECM) analysis. Three stable cointegration relationships are found: a money demand relation, an interest rate spread and a stationary real interest rate. Based on both contemporaneous and long-run restrictions, five structural shocks to the economy are identified. In contrast to the euro area, output and inflation are not independent in the long run for Germany. In accordance with results for Europe, we do not find strong support for monetary targeting for Germany. The results indicate that considerable uncertainties remain concerning the controllability of money and its usefulness as a leading indicator with respect to inflation.

Keywords: Monetary transmission, Germany, generalised common trends model

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1 INTRODUCTION

Recently a number of studies have analysed the transmission process of monetary policy in Europe based on aggregated euro area data. However, conclusions for the monetary policy of the European Central Bank (ECB) drawn from past experience on the basis of the aggregated European level have to be considered with some caution. In comparison with the aggregate euro area experience the national experiences have to be taken into account. The national experience as well as the past European experience based on aggregated data can serve as a benchmark against which to evaluate the new situation in the European Economic and Monetary Union (EMU) despite the structural break of the introduction of the euro.

Regarding the monetary policy of the ECB the German experience is of particular interest since the Deutsche Bundesbank (henceforth: Bundesbank) was the leading monetary authority in the European Monetary System, following a successful independent monetary policy focusing on money growth. Moreover, it is the largest economy in the EMU area. The aim of this study is to analyse whether the transmission of monetary policy in the euro area resembles features of the monetary transmission process in Germany. The outcome of this analysis contributes to the discussion whether the ECB should follow a monetary policy strategy where money plays a prominent role, a strategy that has adapted Bundesbank policy to cope with the uncertainties of the starting period of EMU.

It is important for the analysis of the transmission process of monetary policy to take long-run relations between fundamental macroeconomic variables in an economy as well as short-run dynamics into account. Therefore, the analysis presented here extends the multivariate approach applied to a German macroeconomic system in Hubrich (1999, 2000) employing the long-run relationships analysed there, that is a money demand relation, a Fisher relation as well as an interest rate spread, as a basis for modelling a dynamic cointegrated system for Germany. For this purpose the structural vector error correction model (S-VECM) approach suggested by Vlaar (1998), that incorporates restrictions on the cointegration vectors, will be applied to analyse the transmission of shocks in the economy. The results from the analysis of the transmission of monetary policy in Germany will be compared with analyses on the basis of aggregated European data prior to EMU, especially with Vlaar and Schuberth (1999) and Coenen and Vega (1999).

The paper is structured as follows: In the next section, the insights and problems of studies based on aggregated euro area data in contrast to cross-national comparisons are discussed. In the third section, recent literature on the German transmission of monetary policy is reviewed. The fourth section presents a discussion of some methodological issues. The initial system as well as the cointegration analysis are presented in the fifth section. Section six displays the analysis of the transmission of monetary policy within a structural vector autoregressive (SVAR) framework and section seven focuses on the comparison between Germany and aggregated euro area results. Section eight presents the main conclusions.

2 AGGREGATED EURO AREA VERSUS NATIONAL EVIDENCE

The discussion concerning the introduction of a common European currency has initiated empirical studies based on aggregated European data, e.g. studies on money demand on the European level as Monticelli and Papi (1996), Wesche (1997), Fagan and Henry (1998) and Fase and Winder (1998). Recently, Vlaar and Schuberth (1999), Monticelli and Tristani (1999) and Coenen and Vega (1999) have presented SVAR studies analysing the transmission of monetary policy for different sets of variables based on aggregated data.

Several problems and questions arise with respect to the conclusions drawn from such an analysis based on aggregated data.[1] One problem is that the structural asymmetries that exist across countries in the EMU are disregarded in aggregate analysis. Of course, the central monetary authority, the ECB, has to consider the euro area as a whole. However, information on the transmission channels of monetary policy in different countries of the euro area are also important for the monetary policy decisions of the ECB, especially as long as the economies of these countries are not fully converged. Therefore, the present study wants to shed some light on the transmission process in Germany in comparison with the aggregated results.

Another concern is that the analysis of aggregated data implies possibly invalid restrictions on the coefficients implicit in the aggregation of data across different countries. Although the specification bias of national estimations due to the omission of relevant euro area foreign variables is avoided by aggregated analysis (see e.g. Monticelli and Papi, 1996; Pesaran, Pierse and Kumar, 1989), a bias due to differences in parameters or even functional form between national specifications is likely. This is a further argument that national and aggregated analyses should be considered complementary.

One approach to analyse on the national differences in the transmission of monetary policy has been presented by Fase and Winder (1993) who compare national money demand relations across European countries. They find lower sensitivity of money demand to interest rate and inflation changes in the southern than in the northern EC countries. Furthermore, they find differences in the stability of the

[1] For a presentation of these problems within the framework of a two-country model, see Monticelli and Tristani (1999).

demand for money, specifically that German money demand is more stable than the demand for money in other countries. Wesche (1997), analysing an aggregated money demand relation for different sets of European countries, finds a stable aggregated money demand function for a group of countries including Germany, but instability is indicated if Germany is excluded from the aggregated data. She concludes that the aggregated European relation reflects the stability of German money demand.

These analyses indicate the importance of national differences in the context of the monetary policy of the ECB. The present paper extends such a comparison to other aspects of the transmission of monetary policy by comparing the monetary transmission between Germany and the aggregated euro area. In such an analysis other important aspects of monetary transmissions, such as controllability of money and a causal link between money growth and future inflation can also be considered.

Monticelli and Tristani (1999) consider monetary transmission in a small system of three variables and compare some of their empirical results based on aggregated data with the cross-country study by Gerlach and Smets (1995) based on the same set of variables and the same identification scheme. Comparing the effect of some of the shocks between single countries and the euro area provides mixed results, i.e. some shocks differ whereas some do not.

There are two studies that consider the transmission of monetary policy on an aggregated euro area level using the S-VECM approach. The first study is Vlaar and Schuberth (1999), henceforth VS, who analyse a six variable system including wealth besides real money, real output, the inflation rate and long- as well as short-term interest rates. The authors find two cointegration relations, a money demand relation and a stationary real long-term interest rate, but a stationary interest rate spread is rejected in their system. They identify six different shocks affecting the euro area economy. Regarding the monetary policy strategy the effect of a positive shock in the interest rate is of relevance. Since this monetary policy shock leads to an increase in nominal money, VS conclude that money is difficult to control on a European level.

In contrast, Coenen and Vega (1999), henceforth CV, consider a five variable system not including wealth, also employing the same S-VECM methodology. They find three stable long-run relationships. In addition to the money demand relation and the stationary real interest rate they also find a stationary spread between short- and long-term interest rates. CV identify five shocks affecting the euro area economy. They impose that real money balances are in the long run not affected by a monetary policy shock. Consequently, controllability of money is not a problem in the long run because the temporary fall in the inflation rate due to the interest rate rise decreases the price level permanently. However, their results indicate that short-term controllability is problematic.

Regarding the causal link between money growth and inflation, neither VS nor CV find convincing evidence for a leading indicator role of money growth on inflation. Most increases in inflation are not preceded by an increase in money growth. The reverse causality is very prominent though.

3 THE TRANSMISSION PROCESS IN GERMANY: RECENT LITERATURE

Since the Bundesbank followed a monetary targeting strategy since 1975, lots of emphasis in the empirical studies has been on analysing whether the preconditions of monetary targeting were fulfilled in Germany. In this context, the stability of the demand for money, the controllability of the monetary aggregate by the central bank's monetary policy actions and the question whether a causal link between money and inflation, i.e. between the intermediate and final target, exists, are of interest.

Especially after German reunification the question has been raised whether the Bundesbank's strategy of monetary targeting was still appropriate since the stability of the demand for money might be impaired. A number of single-equation studies, for example Issing and Tödter (1995) and Wolters, Teräsvirta and Lütkepohl (1998), among others, indicated that German money demand is still stable if German reunification is modelled including dummy variables.

The analyses of a German monetary system presented by Juselius (1996, 1998), Hubrich (1999, 2000), Lütkepohl and Wolters (1998) and Beyer (1998) have also shown that the structural break embodied by German reunification can be modelled by dummy variables. Covering different sample periods and seasonally unadjusted as well as seasonally adjusted data, these studies, except for Juselius (1996, 1998), find a stable German money demand relation.

Juselius (1996, 1998) finds a structural break in 1983 and she concludes that this break marks the liberalisation of capital markets in Europe. However, the fact that capital markets in Germany have largely been liberalised at the beginning of the 1970s (see also Issing, 1997), raises doubts about the plausibility of this finding.

Besides studying the stability of money demand, some of the systems analyses cited above have also tested and found stationarity of the spread between short-and long-term interest rates as well as the real interest rate, both relevant for the transmission of monetary policy into the economy and its predictability. The stability of these long-run relationships will also be analysed in this study and will be taken into account with respect to the transmission of monetary policy in Germany.

In addition to the stability of the demand for M3 further conditions have to be fulfilled, for a monetary targeting strategy to work. Therefore, the controllability of the monetary aggregate by the central bank has been analysed by Cabos, Funke and Siegfried (1999). Employing Markov-Switching Models they analyse the link between monetary policy actions and inflation and find that control problems with respect to money are slightly higher in a monetary targeting strategy than in an inflation targeting regime.

The causal link between money and prices is one main focus of the analysis by Lütkepohl and Wolters (1998). On the basis of a system taking a long-run money demand equation derived in a single-equation procedure into account, an impulse response analysis to investigate dynamic interdependencies between the variables as well as the transmission mechanism is carried out. They find no strong influence of money growth on inflation, but considerable effects of shocks in the inflation rate on money growth. This main result of the study allows some doubt about the strength of the causal link between money growth and inflation that is a precondition for a strategy of monetary targeting.[2]

Clarida and Gertler (1996) and Bernanke and Mihov (1997) have presented SVAR studies of the transmission process in Germany. However, both studies focus on the monetary policy reaction function of the Bundesbank. Bernanke and Mihov (1997) raise the question whether the policy of the Bundesbank can actually be characterized as monetary targeting and conclude that the Bundesbank can rather be classified as an inflation targeter. Also the fact that in the majority of cases the realised money growth was not in accordance with its target attributes to this finding. If it is true that the Bundesbank has not reacted strongly to changes in money growth, this raises additional doubts regarding the feasibility of monetary targeting for the Bundesbank.[3]

4 METHODOLOGICAL ISSUES

A large body of literature has evolved following the criticism of classical simultaneous equation models (SEMs) by Sims (1980), focusing on (S)VAR analysis. (S)VAR analysis, in contrast to SEM approaches, does not make a distinction between endogenous and exogenous variables. Constraints are imposed on the variance-covariance matrix of the residuals of the reduced form model. Different ways to impose identifying restrictions that result in uncorrelated shocks have been introduced in the literature. One way to identify the system is to carry out a Choleski decomposition. This procedure has been criticised for

[2] Benkwitz, Lütkepohl and Wolters (2000) come to a similar conclusion presenting also the confidence bands for the impulse responses of the analysed system.

[3] In a single-equation analysis of the Bundesbank monetary policy reaction function Schächter and Stokman (1995) also find that the Bundesbank responds rather to deviations of the inflation rate from its target than to deviations of money from its target. In contrast, Brüggemann (1999) finds that expected money growth relative to target is more important for the setting of the policy instrument by the Bundesbank than expected inflation.

producing empirical results depending on the order of the variables in the system. A further strategy developed by Blanchard (1989) is to impose contemporaneous restrictions, i.e. restrictions on the contemporaneous relationships between variables. Economic theory might suggest that some variables are affected by a shock with a lag due to wage and/or price rigidities or because of informational and decisional lags. Furthermore, long-run restrictions might be imposed since economic theory suggests that some shocks do not have long-run effects on certain variables. This approach to identifying the system has been pioneered by Blanchard and Quah (1989) and King, Plosser, Stock and Watson (1991). Gali (1992) suggested to employ a combination of short- and long-run restrictions to identify the VAR system.

Since the whole branch of cointegration literature has been focussing on long-run relationships between variables these have been incorporated in the identification strategies of SVARs recently, extending the ideas by Stock and Watson (1988) and Mellander, Vredin and Warne (1992) who suggest to decompose multivariate series into permanent and transitory components.[4] For instance, Vlaar (1998) suggests a very general procedure (see Appendix C) commencing in two steps starting with a cointegration analysis in the first step. In the second step contemporaneous as well as long-run restrictions can be imposed to identify the shocks that affect the economy.[5] Moreover, Vlaar (1998) derives the correct asymptotic distribution of the confidence bands in case of long-run restrictions for identifying the VAR using an idea proposed by Mittnik and Zadrozny (1993). This approach is chosen in the present paper.

It has been criticised that SVAR studies do not sufficiently check for misspecification of the model. Misspecification is specifically a serious problem in the SVAR framework since the residuals are interpreted as shocks from a certain source, but they might capture effects of some omitted variable in case of misspecification (see e.g. Ericsson, Hendry and Mizon (1998) and Rudebusch (1998)). Therefore, this paper puts relative strong emphasis on misspecification testing and testing for a structural break.

5 DATA AND COINTEGRATION ANALYSIS

The empirical analysis in this paper is based on German data. The results are compared with other studies based on aggregated euro area data. The initial system for Germany includes five variable: real money, real output, short- as well as long-term interest rates and the inflation rate.

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[4] For further approaches taking cointegration relations into account, see e.g. Lütkepohl and Reimers (1992), Gonzalo and Ng (1996) and Fung and Kasumovich (1998).

[5] The long-run restrictions are on structural parameters in contrast to Paruolo (1997) who proposes to impose restrictions on the long-run impact matrix.

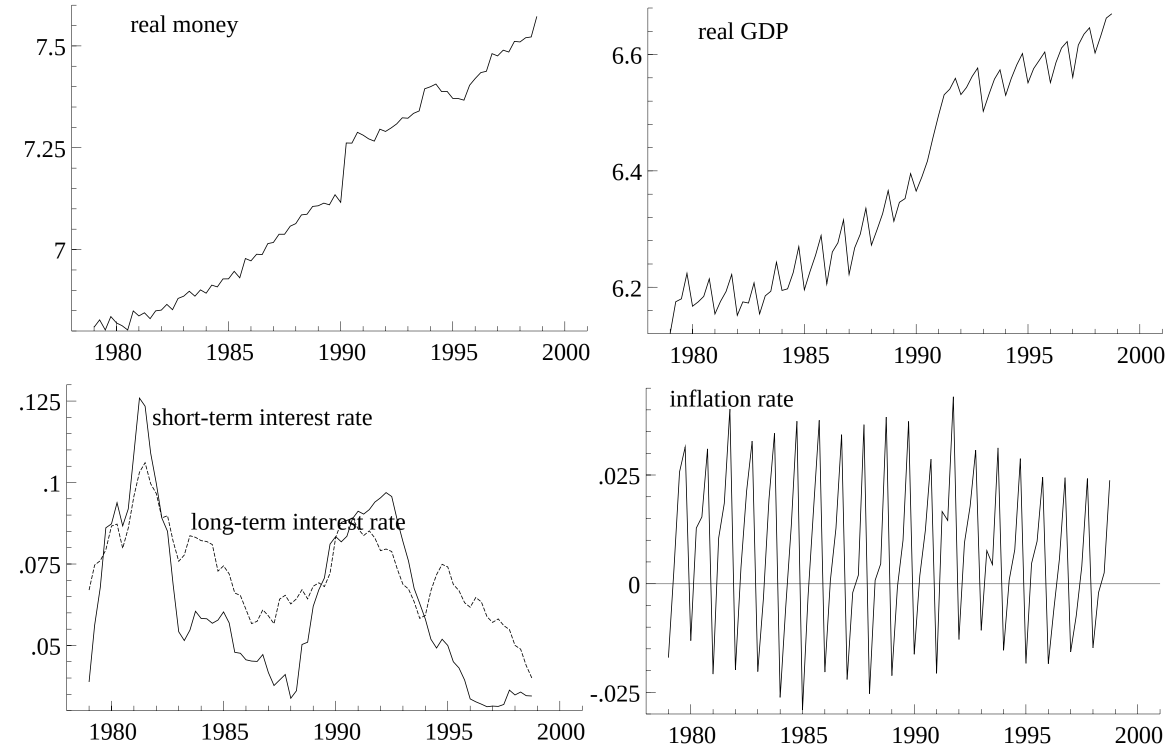

Figure 1 Data

Real money is represented by the broad monetary aggregate M3 (m^r), output is approximated by GDP (y^r), the short-term interest rate is the three-months money market rate (r^s) and the long-term interest rate is the interest on 10 year government bonds (r^l). The inflation rate is represented by the change in the GDP deflator (Δp).[6] The data employed in the paper are depicted in Figure 1. The data on M3 and output display a clear structural break around 1990 which is due to the German unification.

The system includes the impulse dummy variables *D*902 and *D*911, that are one in 1990(2) and 1991(1), respectively, and zero otherwise, to model the structural break of German reunification in the money and GDP series, respectively.[7] Additionally, the impulse dummy *D*9334, which is one in the third and fourth quarter of 1993 and zero otherwise, enters the system to account for the turbulence in the EMS that led to a widening of the currency band to +/- 15% in autumn 1993. The impulse dummy *D*944 (1 in 1994(4) and zero otherwise) accounts for an extraordinary decrease in money in the end of 1994 due to the authorisation of money market funds in that year.

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[6] m^r and y^r are measured in logarithm, inflation is the change in the logarithm of the GDP deflator whereas interest rates are presented in decimals. For more detailed information on the data used the reader is referred to Appendix D.

[7] Hubrich (2000) has found for a similar data set and the sample period 1979(1) to 1997(4) that a step dummy for German reunification is not significant. Since this indicates that there has been no change in the velocity trend in Germany due to reunification, we did not include a step dummy in our system.

A VAR order of two has been chosen for the model according to the Hannan Quinn order selection criterion. The Schwarz criterion selected a VAR order of one but this resulted in significant residual autocorrelation. Moreover, the F-form of a likelihood ratio test rejected the reduction of the VAR(2) to a VAR(1) with a *p*-value of 0.003. The model has been tested for stability employing a one step Chow test as well as a breakpoint Chow test (see Appendix A). The tests indicate reasonable stability of the model on a 5% significance level.[8]

The cointegration rank was fixed at three based on both economic and statistical arguments (see Appendix B). As in Hubrich (1999, 2000) the three cointegrating relations are identified as a money demand relation, an interest rate spread and a stationary real interest rate. As the term spread and real interest rates are stationary themselves, their influence on long-run money demand can not be determined. In order to identify the system, we arbitrarily restricted the influence of interest rates to be zero, but any other linear combination of the three cointegration relationships could represent the money demand relationship as well. The model implies four overidentifying restrictions on β. These restrictions have been simultaneously tested and have not been rejected (see Table 1). The income coefficient (larger than one) and the inflation coefficient in the money demand relation are significant with standard errors of 0.026 and 0.978, respectively. The economic implication is a downward trend in the velocity of money for Germany.

Table 1 LR Test of Simultaneous Restrictions on β

			m^r	y^r	r^s	r^l	Δp		*p*-value
H_1^*	$\beta_1' =$	(	1	-1.25	0	0	17.74	)	
	$\beta_2' =$	(	0	0	1	-1	0	)	0.47
	$\beta_3' =$	(	0	0	0	1	-4	)	

Note: the *p*-value corresponds to the LR test of the simultaneous restrictions; the values with modulus unequal to 1, 0 or 4 are freely estimated

6 THE TRANSMISSION OF MONETARY POLICY IN GERMANY

6.1 **Identification Restrictions**

A structural vector error correction model (SVECM) is estimated using the methodology suggested by Vlaar (1998). Based on the system with five endogenous variables the transmission of five shocks to the economic variables are considered, i.e. a technology shock, an institutional shock, an aggregate

[8] There is no sign of instability on a 1% significance level.

demand shock, an interest rate shock, as well as an exchange rate shock. In line with the common trends literature and given the cointegration rank of three, only two shocks are assumed to drive the system in the long run. These are the technology shock, that affects only real variables in the long run, and an institutional shock, that affects all variables. Moreover, it is imposed that the technological shock does not affect prices contemporaneously. This overidentifying restriction is not rejected by the data on the basis of an LR test (p-value: $p = 0.42$). The aggregate demand, interest rate and exchange rate shocks are assumed only to have transitory effects. Identification is achieved by assuming that aggregate demand shocks are accommodated by the monetary authorities in such a way that the real short-term interest rate is not affected contemporaneously. The interest rate shock is not restricted contemporaneously. These assumptions are in line with VS. Furthermore, the exchange rate shock is restricted not to affect output and short-term interest rates contemporaneously. The restrictions are summarised in Table 2.

Table 2 Identifying restrictions of the structural model

	technological	institutional	aggregate demand	interest rate	exchange rate
			Contemporaneous restrictions		
m^r					
y^r					0
r^s			x		0
r^l					
Δp	0		4x		
			Long-run restrictions		
m^r			0	0	0
y^r			0	0	0
r^s			0	0	0
r^l			0	0	0
Δp	0		0	0	0

Note: The contemporenous short-term interest rate effect is assumed to exactly compensate for the rise in inflation in case of an aggregate demand shock.

The effects of these five shocks are depicted in three different forms. First, Figure 2 depicts the impulse response functions. These dynamic multipliers show the impact of a one time one standard deviation shock on the model variables during the first 20 quarters. Second, Figure 3 provides the forecast error variance decompositions. These graphs show the relative weight of the five shocks in explaining forecast errors at various horizons. Finally, Figure 4 gives the cumulative effect of all the historical shocks, from 1979 onwards, on the five model variables. These historical graphs enable us to compare the structural shocks with other information regarding the German economy.

Figure 2   Impulse Response Functions

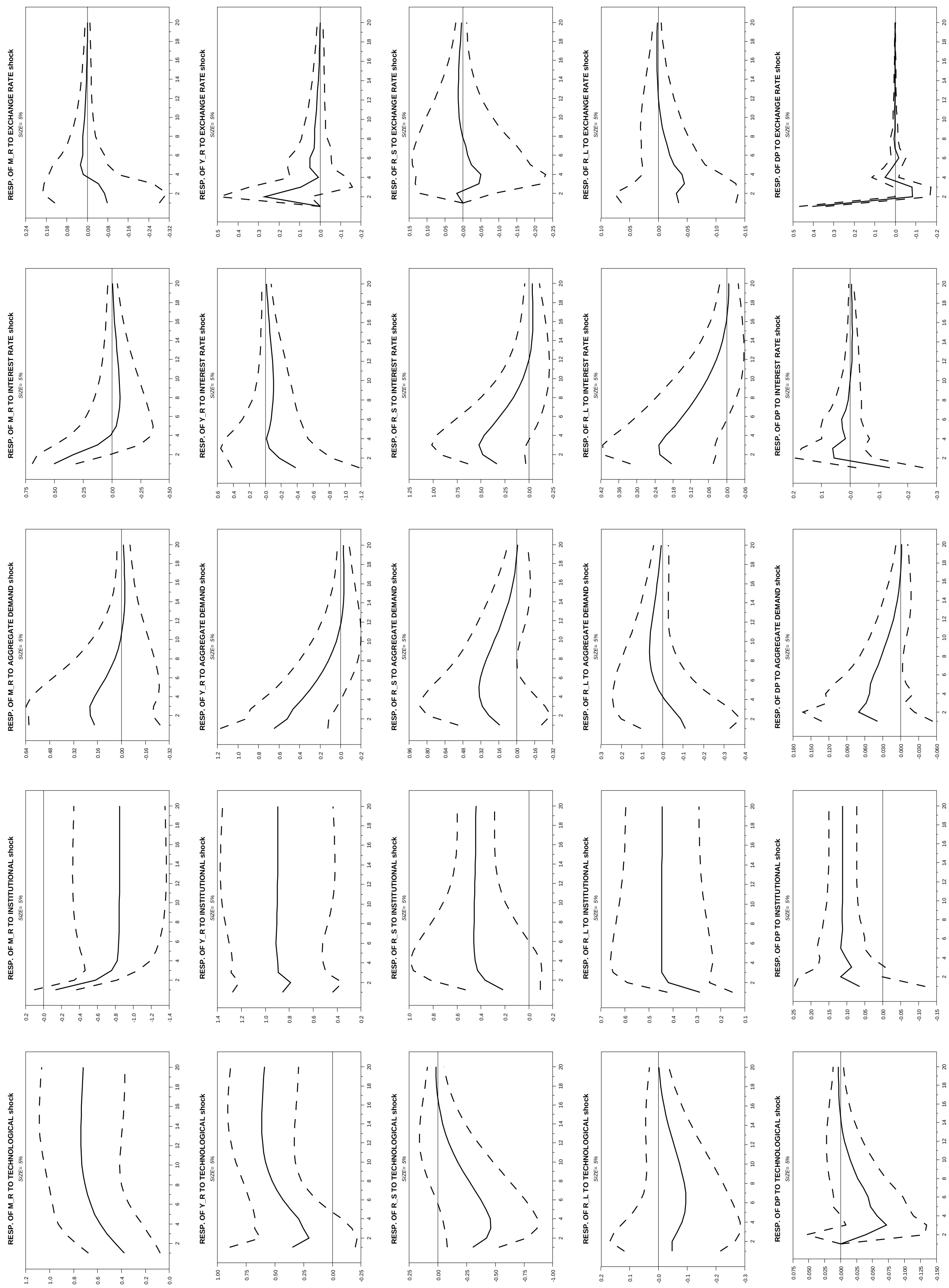


Figure 3   Forecast Error Variance Decompositions

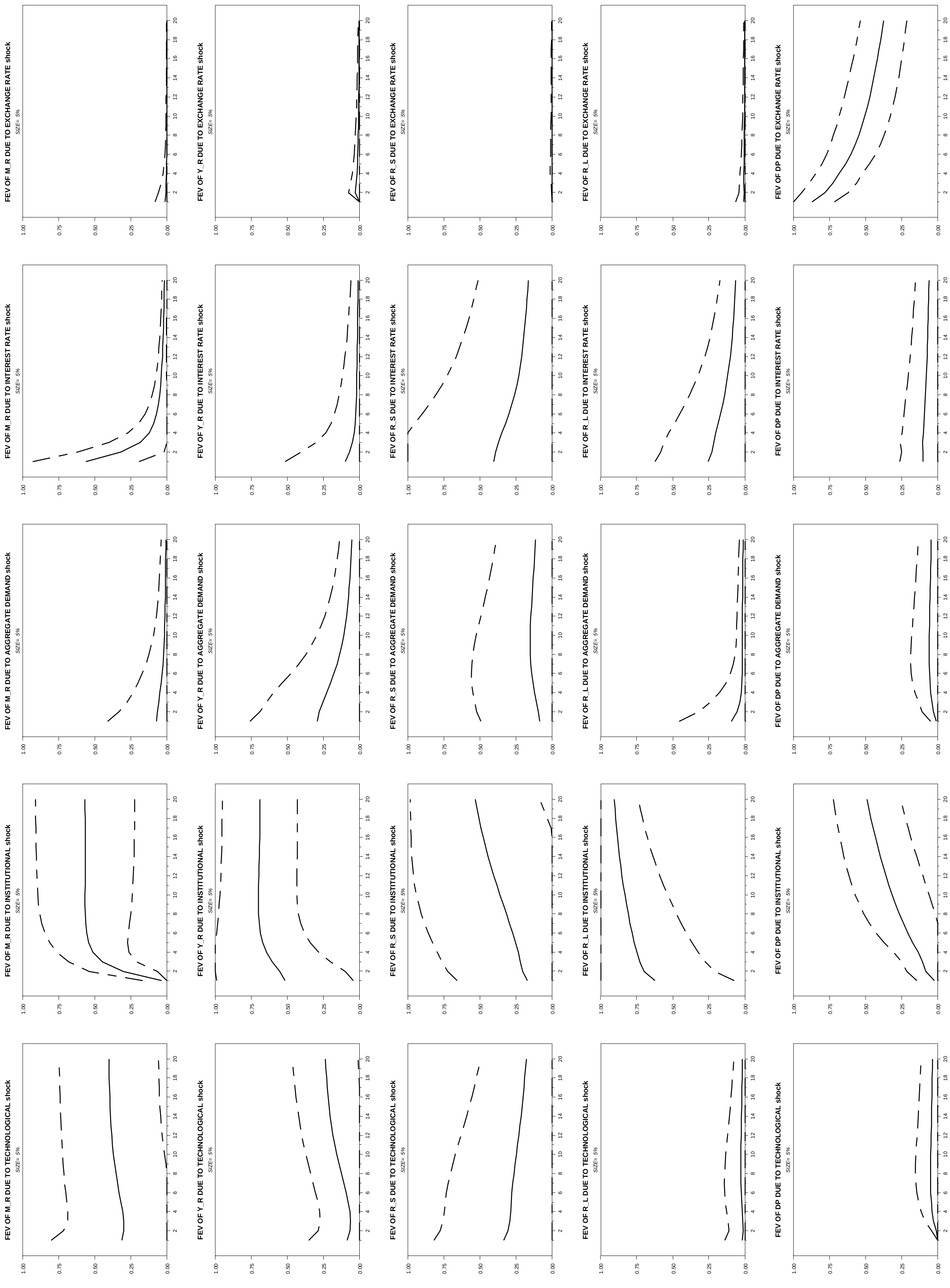
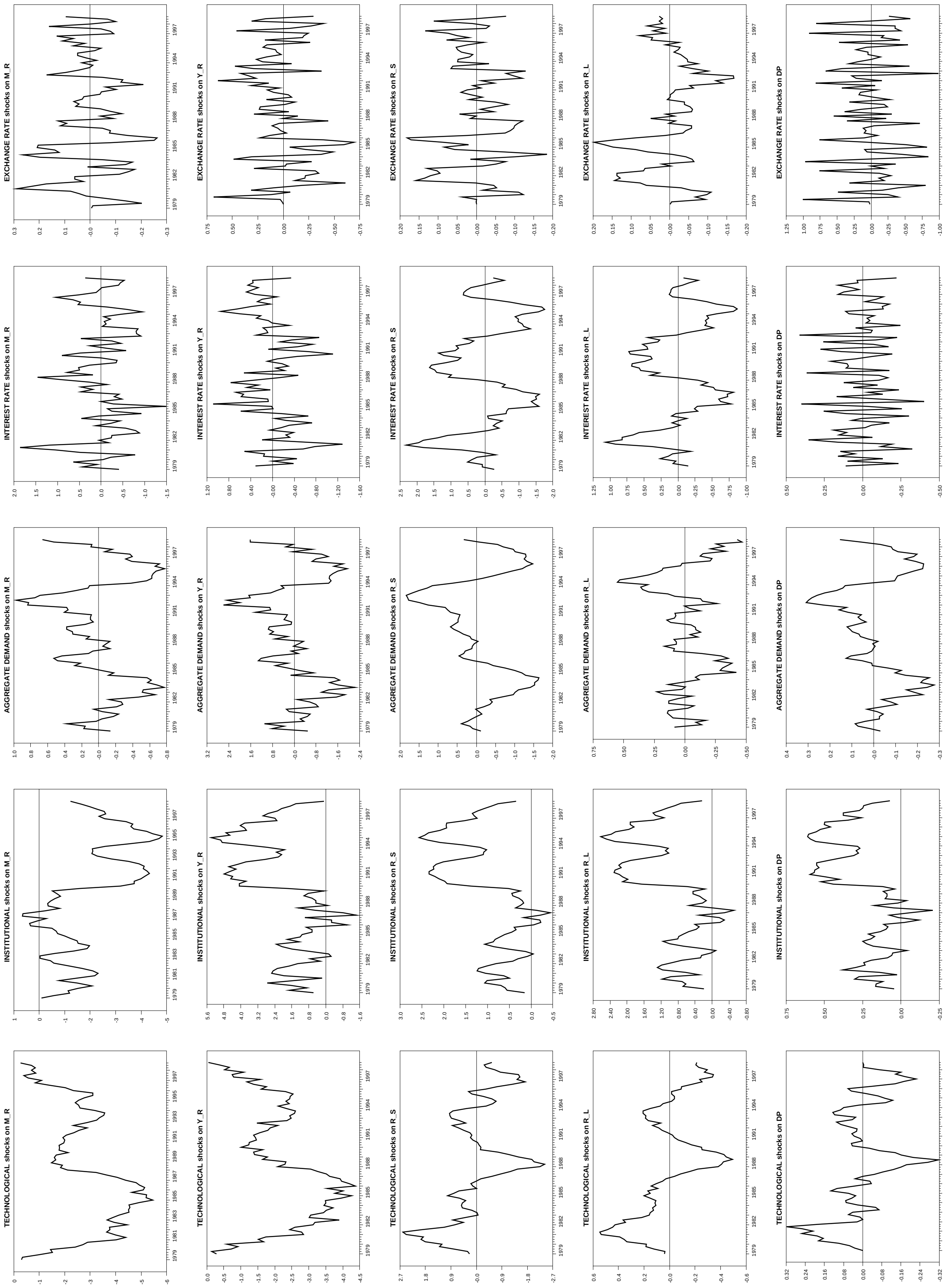


Figure 4   Cumulative Effects Historical Structural Shocks



6.2 Interpretation of the structural shocks

One important shock affecting the economy is the **technological shock**, causing an increase in productivity and thereby lower cost of production. A positive technology shock (Figure 2, Column 1) has a highly significant positive impact on real output, leading to a highly significant positive effect on real money. About 40% of the variance in real money and, depending on the horizon, 10 to 25% in the variance of output can be contributed to this shock (Fig.3, Col.1). The increase in output also invokes a decrease in the inflation rate. Whereas real output and real money increase permanently, inflation returns to its initial level (as imposed). The fall in inflation is accompanied by a decrease of short-term interest rates reflecting an easing of monetary policy.

Contrary to the studies on European data mentioned before (Vlaar and Schuberth, 1999; Coenen and Vega, 1999), we were not able to split the common trends in either having only nominal or only real effect in the long run. The shock that permanently decreases inflation also decreases the output level permanently.[9] If this shock were to be interpreted as an inflation objective shock, as in the European studies, a disinflationary policy would have permanent real effects in Germany. However, changes in the inflation target are probably not as important for Germany as for other European countries since it has a long tradition of low inflation. The inflation target of the Bundesbank has only shifted from four to two percent over our sample. We contribute the changes in the inflation rate to **institutional shocks**. As the positive correlation between output and inflation indicates important Phillips curve effects, this shock is probably related to all kinds of changes in the economy that affect the supply or demand of labour. Given the permanent impact, especially shocks that affect the structural unemployment rate, for instance due to labour market rigidities, e.g. to the duration and coverage of unemployment benefit programs (e.g. Burda, 1991, p.413) or to the increased demand for employment in the service sector, seem to matter here. On the labour supply side, one can for instance think of an increase in unemployment benefits relative to wages (the replacement rate). On the one hand this will lead to lower labour supply and thereby lower output. On the other hand the higher unemployment rate might reduce wage increases and thereby inflation. Regarding labour demand, especially the reduced need for unskilled workers seems to be an important element. According to the International Monetary Fund (1999) the high reservation wage of unskilled workers, coupled with insufficient wage differentiation are main factors in explaining high German unemployment.[10]

Since effects of shocks are symmetric in this methodological framework, one can also consider the effect

[9] Restricting the effect of this shock on output to zero was rejected.

[10] Further empirical research is needed with respect to the causes of unemployment in Germany taking into account German Reunification. One empirical study has been presented by Burda and Sachs (1988) who find that wage rigidity in the service sector has caused high unemployment in Germany in the 80's.

of an institutional shock to permanently increase inflation.

If indeed the cause for permanent inflation changes does not originate from a change in the inflation objective, one may wonder why the Bundesbank did not respond more powerful. The implicit assumption seems to be that the Bundesbank either could not or would not fight inflation more rigorously. Indeed, the inflation targets of the Bundesbank during periods of relatively high inflation before 1984 were presented as the "unavoidable rate of price rises" (König, 1996, p.113), and not as the desired rate.[11] The inevitability might be due to structural factors in the labour market, for instance due to prevailing wage contracts. Although very large increases in interest rates might have reduced inflation more – at the cost of a recession – monetary policy is certainly less effective to fight a cost-push inflation, for example if inflation originates in the labour market.[12] However, the inflationary impact is only small in Germany compared to inflation histories in other countries.

According to the historical decomposition of structural shocks, by far the most important event causing the institutional shock was the German unification (Fig.4, Col.2). The steep rise of the cumulative effects of this shock starting the last quarter of 1989 is apparent. The fall of the Berlin wall in November 1989 caused a consumption and investment boom leading to higher output (especially in western Germany), higher interest rates and higher inflation. One important factor driving inflation was also the increase in nominal wages, in East Germany due to desired convergence towards West German wage levels and in West Germany due to the anticipation of the expected boom as well as increased income taxes due to reunification. These effects are not fully captured by the unification dummies as the structure of the economy was already affected in 1989. After a few years, the unemployment rate increased, especially for lower skilled labour, and the difficulties to increase the productive capacity of East German industry became apparent.

A positive institutional shock positively affects output, interest rates and inflation, and decreases real money holdings (Fig.2, Col.2). Especially long-term interest rates are dominated by this shock. The decrease in real money holdings despite the increase in output is explained by the higher opportunity costs of holding money. According to the forecast error variance decompositions, institutional shocks dominate in the long run, especially with respect to long-term interest rates, output and real money balances (Fig.3, Col.2).

The positive **aggregate demand shock** (Fig.2, Col.3) has a significant positive effect on output and a positive, although not significant, effect on inflation. Higher inflation is reflected in an increase in nominal interest rates. By assumption, all effects are transitory for this shock. In the short run about 25%

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[11] Since 1985 the Bundesbank has included a "normative" inflation rate of 2 per cent in its strategy.

[12] See also Tödter and Ziebarth (1997, p.10) on the costs of disinflationary policy in a low inflation regime.

of the variance of output can be explained by the demand shock. As this shock is transitory, in the long run the contribution is negligible.

A **shock in the interest rate** can be interpreted as the transitory and unexpected element of monetary policy. A positive interest rate shock leads to an increase in nominal short- and long-term interest rates and therefore invokes an immediate drop in the inflation rate and a small but insignificant decrease in output (Fig.2, Col.4). The immediate price reaction might be explained by an instantaneous appreciation of the DM. The negative inflation effect only lasts for one quarter however. Real money balances increase initially even though output decreases and long-term interest rates increase. Apparently, the short term interest rate, which represents the own interest rate of the interest bearing items in M3, is more important for money demand in the short run. As the increase in real money balances is much bigger contemporaneously than the decrease in prices, controllability is problematic in the short run. In the long run both real money balances and the price level are hardly affected. For real balances that has been imposed, but not on the price level. Therefore, we find no convincing evidence that money was controllable by the Bundesbank.

The fifth shock identified is interpreted as an **exchange rate shock** (Fig.2, Col.5). This might for instance be due to foreign interest rate changes. The influence of domestic interest rates on the exchange rate is modelled already in the previous shock. Inflation shows a sharp increase in the first period. This might be due to a price rise of primary commodities for which the law of one price might be a reasonable approximation. Already after one quarter inflation turns negative again. Output is positively affected by the depreciation after one quarter. However, according to the variance decompositions, the size of this effect is negligible. Only prices are significantly affected by this shock. In the short run, it even explains almost 90% of inflation variability. According to the historical decompositions (Fig.4), the exchange rate shock is quite volatile. Maybe this shock also embodies other transitory volatile price movements due to for instance changes in seasonal patterns or harvest conditions.

Regarding the causal link between money and inflation, our results do not provide any evidence of a leading role for money. In a monetary targeting strategy, the growth of the money stock as such is considered to be indicative of future inflation, irrespective of the underlying reason for this growth. Consequently, in principle all shocks should be considered in order to judge the leading indicator role of money. The two shocks that affect money most are the technology and the institutional shock. For both shocks there is a clear *negative* relation between money growth and subsequent inflation. For the aggregate demand shock, there is a positive relation between real money and inflation, but also for this shock money growth does not lead inflation. For the other two shocks either the impact on money or the one on inflation is negligible. Consequently, we find no evidence of a leading role for money with respect to inflation.

6.3 **Robustness of the results**

In evaluating the results of structural VAR analysis the literature has focussed on the sensitivity of the findings (see e.g. Christiano, Eichenbaum and Evans, 1998). Therefore, this section discusses the robustness of the impulse responses presented for Germany.

First, it has been analysed whether the results are sensitive regarding the inclusion of a different short-term interest rate. The day-to-day interest rate that should be more closely related to the policy rate of the Bundesbank (the repo rate) has been included instead of the 3-months money market rate. It turns out that the impulse responses are robust towards the inclusion of the day-to-day interest rate.

An analysis of the sensitivity of the results towards changing the identification scheme shows that the results depend on the restriction that inflation is not affected by the technological shock in the long-run. However, the imposition of this restriction is based on economic considerations. Furthermore, this over-identifying restriction, that separates the technological from the institutional shock and that results in two interpretable shocks with significant permanent impact, is not rejected. The results for the transitory shocks depend on the contemporaneous restrictions imposed. Especially the exchange rate shock could be given a different interpretation if other restrictions were imposed. However, the interpretation as an exchange rate shock appeared to be most plausible from an economic point of view.

Finally, the lag order of the model has been changed imposing the restrictions on a VAR(4). The impulse responses of the model where a cointegration rank of three and three cointegration relations have been imposed display much more volatility than for the VAR(2). The general results do not change, however.

7 COMPARISON: EURO AREA AND GERMANY

Comparing the findings of the present analysis with aggregate euro area studies, the process of identification shows that to a large extent a similar pattern of shocks influences the German economy as in the euro area as a whole. Regarding the common trends, the responses to the technological shock are similar to the ones to a supply shock in the aggregated euro area, except for the development of prices which adjust later in Germany than in the euro area.

Probably the most important difference between the German and the aggregated European system is that only for the latter the common trends can be split to have either nominal or real effects in the long run.

For Germany, a permanent decrease in inflation is accompanied by a permanent lower output level. As explained, the absence of an output neutral monetary policy objective shock for Germany could be due to the fact that the monetary policy objective hardly changed over our sample. Consequently, this shock is not important for Germany. Nevertheless, given the dominance of the institutional shock in Germany in the long run as shown by the variance decompositions, it is surprising that for the euro area no shock occurs that implies both nominal and real effects. The importance of the long run positive correlation between inflation and output in Germany might partly be explained by the German reunification. In addition, the fact that Germany was the anchor country for inflation during the EMS period is probably important. Being the leading country higher (or lower) inflation in Germany was sustainable without affecting output due to the fact that many other countries implicitly adjusted their inflation target to the German outcome. Consequently, real exchange rates were hardly affected. For most other EMS countries the external target of a fixed D-mark rate probably helped in reducing wage pressure during a tense labour market. Finally, institutional shocks might be less prominent in the aggregated data because they partly cancel between countries if they operate in a asynchronous fashion.

The euro area will probably feature elements of both the German and of the aggregated European data. As the inflation target for the ECB is not likely to change, the inflation objective shock as identified for the aggregated European data is probably not relevant for EMU. The relevance of shocks that affect both output and inflation permanently probably depends on the extent to which these structural shocks will be synchronous. Although the euro area as a whole does not have an external target, the individual countries will certainly look at each other. As far as the shocks that permanently affect output are asynchronous, the inflationary impact will probably be limited. Synchronous shocks on the other hand might affect inflation somewhat, provided that there is some flexibility in the price stability target of the ECB.

The contemporaneous increase in output due to a positive aggregate demand shock is about twice as large for Germany than for the euro area. The response pattern of the variables looks similar in Germany and the euro area (Coenen and Vega, 1999). Real money holdings are hardly affected in Germany whereas for the euro area CV find a positive and VS find a negative response of money holdings which they explain by lower precautionary saving in an economic upswing.

The response pattern of the variables to an interest rate shock in Germany looks also similar to the ones found for the euro area by CV. They found a similar large contemporaneous inflation effect that was reverted after one quarter. However, in their system the long run overall price effect is slightly negative, although insignificantly so, whereas we find a negligible positive price effect. Consequently, controllability of the nominal money stock might even have been more problematic for the Bundesbank than it will be for ECB.

Also with respect to the causal link between money growth and inflation the results for Germany alone are at least just as negative as for the European aggregates. Whether this means that money is not a useful indicator remains to be seen.

8 CONCLUSIONS

This paper has analysed the transmission of monetary policy in Germany for a sample covering the EMS period from 1979(1) to 1998(4) and compared the results to studies analysing constructed aggregated euro area data for the pre-EMU period using the same methodological framework.

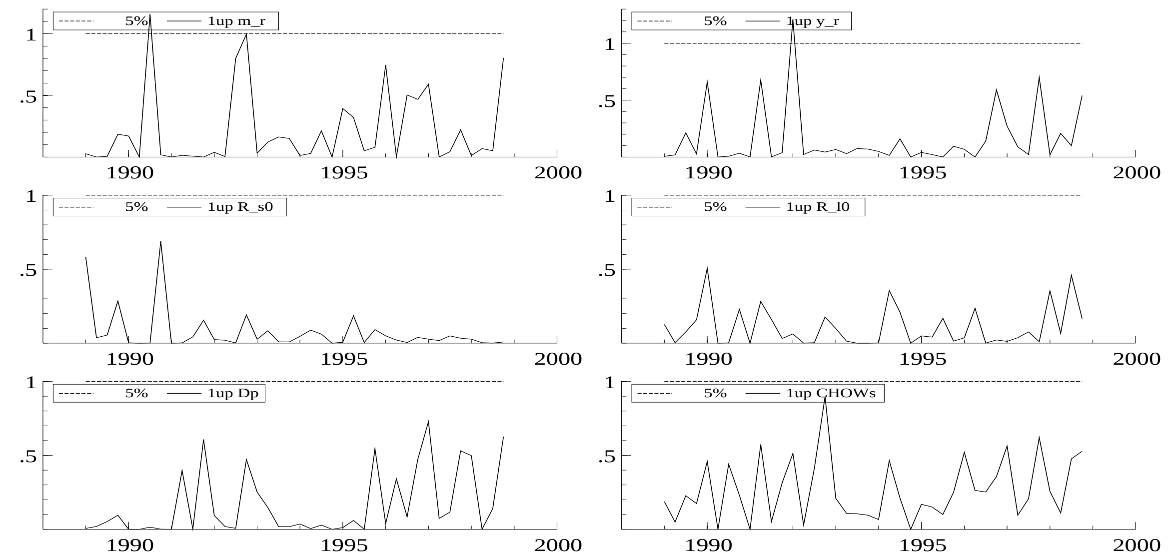
The results for Germany appear to a large extent similar to the response patterns found for aggregated euro area data, even though the identification restrictions differ to some extent. However, important differences also arise. The main difference between the European and the German system is that for Germany one common trend involves both nominal and real effects in the long run, whereas for Europe a distinction could be made between nominal and real shocks. This combined shock results in a positive correlation in the long run between the output level and inflation. We contribute this shock to institutional changes, primarily related to the structural unemployment. Consequently, we assume that the permanent changes in the inflation rate in Germany originated in the real economy and were not due to a change in monetary policy objectives, given the low inflation culture of the Bundesbank. The underlying assumption is that monetary policy is less effective during labour market pressure.

It can be argued that, at least in spirit, the environment under which the ECB has to operate is more similar to that of the Bundesbank (low inflation, no exchange rate target) than that of the European average. On the other hand competition in terms of unit labour cost between euro-members that was probably an important factor in a successful disinflationary policy before is likely to become even more important now the individual currencies are irrevocably linked. Consequently, further research is needed in order to shed light on the cost of disinflation in Europe.

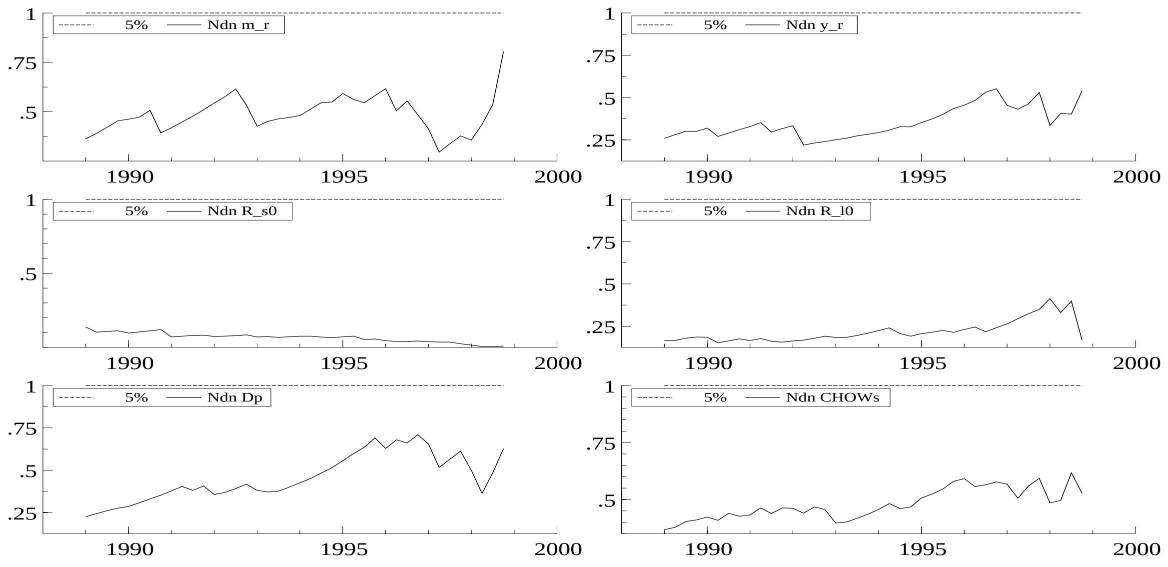
Regarding a monetary targeting strategy, we did not find empirical support for this strategy for Germany. Controllability of nominal money is seriously impaired in the short run, whereas in the long run money is hardly affected by interest rate shocks. In this type of analysis the model endogenizes the monetary policy rule, i.e. anticipated policy actions of the monetary authorities are implicit in the system analysed. However, some of the structural shocks result in deviation of money from its target and we find that this deviation can not be corrected by unanticipated monetary policy actions. Moreover, in accordance with results for the European aggregate, we do not find a leading role for money in predicting inflation for Germany. This result suggests that the high credibility of the Bundesbank might have played an important role in the success of the monetary targeting strategy of the Bundesbank.

The results presented in this paper indicate differences in real effects of disinflation between Germany and other euro area countries pointing at the difficulties of a common monetary policy in the euro area. Thus, although aggregated euro area analysis might be helpful as a benchmark against which to evaluate the new situation in EMU, it is necessary to also draw attention to differences of national experiences between euro area countries.

APPENDIX A STABILITY TESTS



(a) 1 step Chow test (1.0: 5% significance level)



(b) Break-point Chow Test (1.0: 5% significance level)

APPENDIX B COINTEGRATION ANALYSIS

Unit root tests have been carried out for the data (see Table 3). For money and output the Perron (1989) (model A, level shift) test has been used to take account of the level shift in these variables due to the German unification. For the other variables the augmented Dickey Fuller test is used. All variables appear to be I(1).

Table 3 Perron Test / Augmented Dickey Fuller Test

variable (in log)	auxiliary regression	k	t-statistic	critical value (5%)
m^r	$c, t, D902, SD$	1	-2.17	$-3.76^{(1)}$
y^r	$c, t, D911, SD$	5	-1.93	$-3.76^{(1)}$
r^s	c	5	-2.78	-2.90
r^l	c	4	-1.81	-2.90
Δp	c, SD	4	-2.31	-2.90
Δm^r	$c, D902i, SD$	5	-4.60^{**}	-2.90
Δy^r	$c, D911i, SD$	4	-3.93^{**}	-2.90
Δr^s	c	1	-4.91^{**}	-2.90
Δr^l	c	3	-3.71^{**}	-2.90
$\Delta\Delta p$	c, SD	4	-9.31^{**}	-2.90

Notes: k : is the number of lagged differences included in the DF/ADF test (according to the highest significant number of lags with a maximum of 5 lags); ** and *: significance at a 1% and 5% level; critical values from MacKinnon (1991), sample period 1979(1)-1998(4), except for (1): critical value of Model(A) in Perron (1989), $\lambda = 0.60$, c: constant, t: linear trend, $D902$, $D911$: step dummies (1 after 1990(2) and 1991(1) respectively, 0 otherwise, $D902i$,$D911i$: impulse dummies (1 in 1990(2) and 1991(1) respectively), SD: seasonal dummies

Johansen's likelihood ratio (LR) trace test has been applied to test for the cointegration rank of the five variable system.[13]

The test indicates a cointegration rank of $r = 4$ on a 5% significance level.[14] In our five variable system without trend, a rank of four would imply stationary interest rates, inflation rate and a relation between

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[13] For a review of different cointegration rank tests, see for example Hubrich, Lütkepohl and Saikkonen (2000) and also Hubrich (1999) focussing on the small sample performance of different systems cointegration tests.

[14] The largest cointegration rank tested is $r_0 = n - 2 = 3$ because a linear trend in the data is allowed by the specification of the model. This excludes the possibility of $n = r$, i.e. n stationary variables. Therefore, $r_0 = n - 1$ is not a reasonable null hypothesis (see also Saikkonen and Lütkepohl, 2000).

Table 4 Johansen's LR Test, 5-dimensional VAR(2), Det. Terms: Constant, *SD*, *D*902, *D*911, *D*9334 and *D*944, Estimation Period: 1979(1)-1998(4)

H_0: rank=r_0	*LR* trace statistic	95% critical values
$r_0 = 0$	122.2	68.5
$r_0 = 1$	47.9	47.2
$r_0 = 2$	30.5	29.7
$r_0 = 3$	16.1	15.4

Note: critical values are the 95% quantiles of the asymptotic distribution: Johansen (1995).

money and output.[15] Since interest rates and inflation are clearly indicated to be I(1) variables according to the Dickey Fuller test statistics, a rank of four seems unlikely. Figure 8 shows the stability of the cointegration rank for our system. Only for the system including the last quarter, a rank of four is supported. For a sample until 1997 however - might be reasonable to consider because relations are probably distorted for 1998 shortly before the start of EMU - the cointegration rank is $r = 3$. For shorter samples a rank between one and three is indicated. Given the intuitive economic interpretation, and in line with Hubrich (1999, 2000) for a similar set variables in a shorter sample period, a rank of three was imposed.

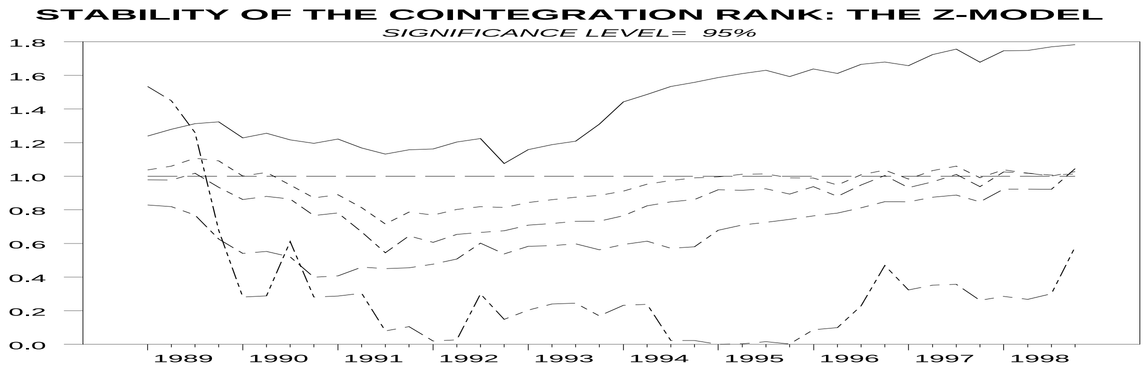

Figure 5 Recursive cointegration rank

[15] If a restricted trend is included, the cointegrating rank would be only one. However, both under a rank of one and under a rank of four, the null hypothesis that the restricted trend can be excluded is not rejected employing an LR-test (see Johansen (1995, p.162)).

APPENDIX C S-VECM METHODOLOGY

This section provides a brief summary of Vlaar (1998). Let x_t be a $n-$dimensional vector of variables which is generated by an unrestricted vector autoregressive (VAR) process of order k

$$x_t = \mu + A_1 x_{t-1} + \ldots + A_k x_{t-k} + \varepsilon_t \tag{1}$$

where μ is a vector of constants, A_is are $(n \times n)-$dimensional coefficient matrices and where the vector of innovations ε_t has covariance matrix $E(\varepsilon_t \varepsilon_t') = \Sigma$. If x_t is cointegrated of order (1,1) with cointegrating rank r, then, according to the Engle/Granger representation (see Engle and Granger (1987) or Johansen (1995)), the data generating process has two equivalent representations:

a) the vector error correction representation

$$\Delta x_t = \mu + \alpha\beta' x_{t-1} + \Gamma_1 \Delta x_{t-1} + \ldots + \Gamma_{k-1} \Delta x_{t-k+1} + \varepsilon_t \tag{2}$$

where α, β are $(n \times r)-$dimensional full column rank matrices and Γ_is represent $(n \times n)-$dimensional coefficient matrices, and

b) the vector moving average representation

$$\Delta x_t = C(L)(\mu + \varepsilon_t) \tag{3}$$

where $C(L) \equiv I_n - \sum_{i=1}^{\infty} C_i L^i$ is a matrix polynomial of infinite order in the lag operator L, and $C(1) = \beta_\perp \left(\alpha'_\perp (I_n - \sum_{i=1}^{k-1} \Gamma_i)\beta_\perp\right)^{-1} \alpha'_\perp$. The $C(1)$ matix, which has rank $n - r$, gives the ultimate effect of a shock to the reduced form innovations on the level of the endogenous variables.

The structural vector error correction model (S-VECM) method is a two stage procedure. In the first stage the reduced form vector error correction model (Equation 2) is estimated. The second step comprises in the identification of the structural model. Thereto it is assumed that the reduced form disturbances ε_t are linearly related to an $n-$dimensional vector of orthonormal structural innovations e_t:

$$\varepsilon_t = B_0 e_t \qquad \text{with} \qquad E(e_t e_t') = I_n \tag{4}$$

where B_0 is a non-singular $(n \times n)$ matrix. In order to identify the structural model, restrictions have to be imposed on the B_0 matrix. From the relationship between the variances of the reduced form residuals and the structural innovations it follows that $B_0 B_0' = \Sigma$. This relationship imposes $n(n+1)/2$ independent restrictions on B_0, leaving $n(n-1)/2$ elements free. Consequently $n(n-1)/2$ additional independent restrictions have to be imposed in order to exactly identify the structural model.[16] Once at least $n(n-1)/2$

[16] One might also impose more restrictions, in which case the model will be over-identified.

independent restrictions have been imposed, the B_0 matrix can be estimated by maximum likelihood. Assuming the restrictions are all linear zero restrictions, this boils down to maximizing:

$$logl = -\frac{T}{2}\log\left(|B_0|^2\right) - \frac{T}{2}\mathrm{tr}\left(B_0'^{-1}B_0^{-1}\hat{\Sigma}\right) \quad \text{subject to} \quad R\mathrm{vec}(B_0) = 0 \tag{5}$$

where $\hat{\Sigma}$ denotes the estimated covariance matrix of the residuals of the first step, R denotes a $(g \times n^2)$ matrix, imposing the g independent restrictions on B_0 and vec() denotes the column stacking operator. In the case of only contemporaneous restrictions, the R matrix is a selection matrix with only nonzero elements for the restricted elements of B_0. Long run restrictions are related to the $C(1)$ matrix. If the j^{th} structural innovation is supposed to have no impact on variable i in the long run, this can be achieved by restricting the i, j element of $B_\infty \equiv C(1)B_0$ to be zero.

Given the rank of $n-r$ for $C(1)$, at most $(n-r)(r+(n-r-1)/2)$ independent long run restrictions can be imposed. Consequently, at least $r(r-1)/2$ contemporaneous restrictions are needed. In the common trends representation (see Stock and Watson (1988)), only $n-r$ structural shocks (the common trends) are supposed to drive the system in the long run, whereas the impact of the other r structural shocks (the transitory shocks) dies out in the long run. In our model this structure can be imposed by restricting r columns of B_∞ to zero. As the rank of $C(1)$ is $n-r$, this implies $r(n-r)$ independent restrictions. The mutual identification of the common trends can subsequently be achieved by imposing either contemporaneous or long-run restrictions. For the identification of the transitory shocks, only contemporaneous restrictions can be used.

The asymptotic distribution of the impulse response functions in case of only contemporaneous restrictions is given in Lütkepohl and Reimers (1992). The introduction of long run restrictions considerably complicates the distribution however, as these restrictions on B_0 are functions of the VECM parameters. As a consequence, the convenient block-diagonality of the covariance matrix of model parameters with the parameters of the mean on the one hand and those of B_0 on the other hand is destroyed. In Vlaar (1998) it is shown that the asymptotic distribution of the impulse responses can still be computed from the covariance matrix that neglects the stochastic nature of these restrictions however, provided that a correction is computed related to the partial derivative of B_0 with respect to the VECM parameters.

APPENDIX D DATA

The data analysed in this paper are quarterly, not seasonally adjusted time series for the period 1979(1) to 1998(4). Sources are as follows:

– The nominal M3 time series are obtained from the data bank DATASTREAM and are originally obtained from the *Deutsche Bundesbank*. The time series is given in billion DM. The value of the last month of each quarter represents the quarterly value. The structural break of German reunification is in 1990(2).

– The GDP data are in constant prices with 1991 as the basis year. East-Germany is included from 1991(1) onwards. The data are from DATASTREAM, originating from the Quarterly National Accounts of the OECD.

– Prices are represented by the deflator of GDP (1991=100) derived from Bundesbank data offered in DATASTREAM, i.e. GDP in current prices (in billion DM) divided by GDP in constant prices.

– The long-term interest rate is the long-term interest rate on 10 year government bonds from DATASTREAM originally provided by the BIS. These data are quarterly averages.

– The three-months short-term interest rate is the euro market rate from DATASTREAM, originally provided by the BIS. These data are quarterly averages.

– The day-to-day interest rate is taken from DATASTREAM, originally provided by the Deutsche Bundesbank. These data are quarterly averages.

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