Further VAR Evidence for the Effectiveness of a Credit Channel in Germany

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August 2002

In this paper, the empirical relevance of the credit channel for the explanation of monetary policy transmission in Germany during the period of monetary targeting from 1975 to 1998 is analyzed. While existing studies of the credit channel rely mostly on the analysis of monetary policy effects on balance sheet items, both quantities and financing costs are considered here. Using vector autoregressive models, impulse response analysis and forecast error variance decompositions, strong empirical evidence for the effectiveness and relevance of a credit channel in Germany can be reported.

JEL classification: C32, E44, E52.

Keywords: Credit channel, monetary policy transmission, money channel, vectorautoregressive models.

* I thank Imke Brüggemann, Ralf Brüggemann and Jürgen Wolters for commenting on an earlier version of this paper. I am also grateful for comments and suggestions that were made during presentations at the Freie Universität Berlin and at the joint Econometrics Seminar of the Humboldt-Universität zu Berlin and the Freie Universtität Berlin. Financial support from the Deutsche Forschungsgemeinschaft, SFB 373 (TP C3) at the Humboldt-Universität zu Berlin, is gratefully acknowledged.

1 Introduction

While it seems to be consensus in macroeconomics that monetary policy has real effects – at least in the short run – it is still an open question how monetary policy is transmitted to real variables. The stylized facts of the monetary transmission mechanism that are widely accepted can be described as follows: the effects of a contractionary monetary policy impulse are (Favero, 2001, p. 97) "(1) the aggregate price level initially responds very little; (2) interest rates initially rise; (3) aggregate output initially falls, then follows a j-shaped response with a zero long-run effect of the monetary impulse." The purpose of this paper is to contribute to the empirical investigation of the "black box" (Bernanke and Gertler, 1995) through which monetary policy effects are transmitted to real variables like prices and output. Following the monetary policy research program characterized by Christiano et al. (1999), further knowledge about this black box is necessary for the development and evaluation of structural theoretical models of the transmission mechanism. Theoretical models usually form the basis for the assessment of monetary policy effects on welfare and should therefore reflect the relevant structural relationships of the respective economy. Concentrating on Germany and the period of monetary targeting by the Bundesbank from 1975 to 1998, it is demonstrated here that the money view is not able to explain the transmission of monetary policy exclusively. Moreover, empirical evidence for the effectiveness of a credit channel is presented. Since Germany is the largest Euro area country (31% of Euro area GDP in 2000), these results are highly relevant for the analysis of monetary policy transmission in the Euro area. Modeling the credit channel with aggregated historical Euro area data seems not to be a promising approach at this stage because the financial structure of the respective countries have been and are still heterogeneous, see for example Kashyap and Stein (1997) or de Bondt (2000).

The methodological approach followed in this paper is to analyze the effects of monetary policy shocks in vector autoregressive (VAR) models. Monetary policy shocks are defined as that part of variability in the monetary policy instrument that cannot be explained by a monetary policy reaction function. This approach is motivated and explained in Christiano et al. (1999) who propose (p. 68) to analyze the effects of monetary policy shocks and not simply of monetary policy actions "because monetary policy actions reflect, in part, policy makers' responses to nonmonetary developments in the economy. A given policy action and the economic events that follow it reflect the effects of *all* the shocks to the economy."[1]

The credit channel is one possible explanation of the transmission mechanism among numerous other theories about the transmission of monetary policy.[2] The main arguments for a credit channel to be operative are: Due to market imperfections like informational problems and transaction costs, agency costs play an important role on credit markets and influence the decision whether expenditures are financed internally, for example by retained earnings of firms, or externally by raising credit. The credit market is characterized by the existence of financial intermediaries, especially banks, which contribute to the efficient allocation of resources. Therefore, credit can be raised directly, for example by emitting shares or bonds, or indirectly by borrowing from banks. According to the credit view, monetary policy does systematically affect the conditions on the credit market and therefore the ability of firms and households to finance expendi-

[1] Citing the finding of Clarida et al. (1998) that shocks are only responsible for 1.9% of the variance of the monetary policy instrument in Germany (1.6% in the U.S. and 3.0% in Japan), McCallum (1999) offers a critical discussion of this approach.

[2] An overview can be found in the 1995 fall issue of the Journal of Economic Perspectives, where Mishkin (1995) distinguishes between interest rate channel (money channel/view), exchange rate channel, other asset price effects, and credit channel.

tures. The theoretical foundations of the credit channel are reviewed in section 2. Two versions of the credit view are considered in this paper: the bank lending channel, which stresses the importance of banks, and the broad credit channel, which is more general and relies solely only the existence of agency costs. Whether such a credit channel has been operative in Germany in the period from 1975 to 1998 and how relevant it is for the explanation of the transmission mechanism is analyzed empirically in section 3. By considering not only quantities but also financing costs in terms of interest rate spreads it can be shown that credit channel elements have been important in the monetary policy transmission chain in Germany up to 1998. Conclusions that follow from the empirical evidence are drawn in section 4.

2 Theoretical Foundations of the Credit Channel

2.1 Credit Market Imperfections

Only the most important aspects that are relevant for the empirical analysis in section 3 are reviewed here.[3]

An important function of the credit market is to support the efficient allocation of savings and investment. Two forms of credit can be observed: direct credit and indirect credit via financial intermediaries. Reasons for the existence of financial intermediaries are credit market imperfections like incomplete and asymmetric information as well as transaction costs. The informational problems on credit markets can be divided into adverse selection, moral hazard, monitoring costs (or costly state verification), and agency costs, see Walsh (1998, chapter 7). Due to these informational problems, external financing is more expensive for a firm than internal financing using retained earnings. The cost differential is called external finance premium (EFP).

Given these credit market imperfections, the existence of financial intermediaries can be explained with the availability of a technology reducing the negative impact of these imperfections together with economies of scale or scope, see de Bondt (2000, p. 3). Following Bhattacharya and Thakor (1993), financial intermediaries fulfill two functions: firstly, they match borrowers and lenders without changing the characteristics of the credit contract (brokerage) and secondly, they transform risk and/or maturity (qualitative asset transformation). Therefore, financial intermediaries play an important role for the efficient allocation of resources. In Germany, the average share from 1975 to 1998 of financial intermediaries in gross value added is about 5%. Lending from banks has an average share of 24.5% in total financing and of 67.5% in external financing.

In the following, more details about two distinct versions of the credit channel – the bank lending channel and the broad credit channel – are provided. They have in common that the simplifying assumption made in models of the interest rate channel or money view that it is sufficient to consider only two financial assets, money and non-money (mostly named bonds), is relaxed.

[3] More details can be found in these studies: Gertler (1988) reviews the interdependence of financial structure and aggregate economic activity, Bernanke and Gertler (1995) analyze the sequence of effects within the credit channel, Freixas and Rochet (1997) give a broad and detailed overview of the microeconomics of banking, and Walsh (1998, chapter 7) stresses macroeconomic consequences of credit market imperfections.

2.2 *Bank Lending Channel and Broad Credit Channel*

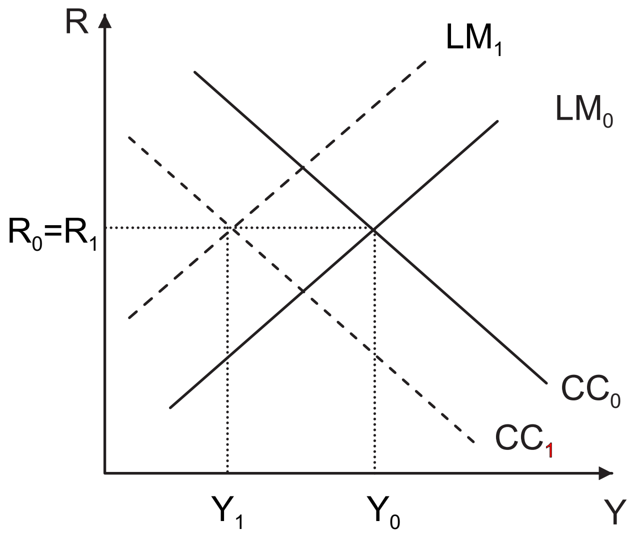
A standard model describing the bank lending channel is the model of Bernanke and Blinder (1988). It is an extension of the well known IS-LM model. While the traditional IS-LM model consists of three markets (bonds, money, goods), the model of Bernanke and Blinder comprises the bank lending market as an additional market, that is, credit equals bank lending (loans). Being an extension of the IS-LM model, the Bernanke and Blinder (1988) model describes only the demand side of an economy with given price level. However, this model can be augmented by an aggregate supply equation like the usual IS-LM model.

In the Bernanke and Blinder (1988) model, the supply of loans depends negatively on the interest rate on bonds, R, positively on the interest rate on loans, R^L, and on the amount of deposits not needed to fulfill the reserve requirement. The demand for loans depends negatively on the interest rate on loans, and positively on the interest rate on bonds, and positively on the scaling variable income, Y. In this framework, it can be shown that the interest rate on loans depends positively on income and the interest rate of bonds, and that restrictive monetary policy increases the interest rate on loans and decreases income. A graphical representation of this model can be found in figure 1. The LM-curve shifts to the upper left in case of a restrictive monetary policy shock. Due to increasing financing costs, the CC-curve (credit and commodities), which corresponds to the IS curve in the IS/LM model, is shifted downwards by restrictive monetary policy. Therefore, restrictive monetary policy is followed by a decrease in income. The effect on the interest rate of bonds, R, is not clear a priori, but in contrast to the IS/LM model it is well possible that R does not change at all or does increase to a lower extent than in the IS/LM model. This would imply that the spread between the interest rate on loans and the interest rate of bonds, $R^L - R$ is increasing.

The effectiveness of the bank lending channel depends on three conditions: (1) Loan supply has to react on monetary policy actions. (2) Non-banks have no perfect substitutes for bank loans. (3) Expenditures of firms and households depend on loan supply. These conditions are analyzed empirically in section 3.

The Bernanke and Blinder (1988) model has been extended in several respects. Kashyap et al.

Figure 1: Effects of Restrictive Monetary Policy in the Bernanke and Blinder (1988) Model



(1993) consider explicitly the financing decision of firms and Bårdsen and Klovland (2000) augment the model by a supply side equation as well as a foreign sector.

While the bank lending channel focuses on the importance of bank lending, the broad credit channel stresses all kinds of external finance. The broad credit channel is modeled by Bernanke et al. (1996, 1999), for example. They specify a dynamic stochastic general equilibrium model with nominal rigidities, monopolistic competition, and a credit market with heterogenous agents. Firms have the possibility to borrow from banks or to finance their investments by internal financing. In the Bernanke et al. (1999) model, the external finance premium depends on net wealth of the borrower: the larger net wealth, the smaller are the creditor's monitoring costs and the difference between external and internal financing costs. As a consequence, the external finance premium follows movements in net wealth which is reduced by restrictive monetary policy: if interest rates increase due to restrictive monetary policy, interest payments increase and present values of collateral decrease. The variation in the external finance premium enlarges the effects of monetary policy and is therefore also called financial accelerator.

A broad credit channel is operative if (1) monetary policy has a systematic impact on the external finance premium and if (2) the external finance premium does systematically affect aggregate output. The empirical relevance of these conditions is studied in section 3.

It should be noticed that the existence of a credit channel has also microeconomic implications. Under the assumption that the external finance premium of different borrowers is not affected to the same extent, monetary policy does not only change the aggregate level of economic activity but also the income distribution. It is for example reasonable to assume that the monetary policy effect on the financing costs of households and small firms is stronger than on the financing costs of big firms. These microeconomic aspects are not considered here.

3 Empirical Analysis of the Credit Channel

3.1 General Aspects and International Evidence

The majority of contributions to the empirical analysis of the credit channel are concerned with U.S. data. Bernanke (1983) analyzes the role of credit markets during the Great Depression, Kashyap and Stein (1994, 1995, 2000) study the bank lending channel in the USA, King (1986) investigates credit rationing, Kashyap et al. (1993), Bernanke et al. (1996), Friedman and Kuttner (1992, 1993, 1998) and Oliner and Rudebusch (1996) explore the broad credit channel. Overviews are given by Gertler and Gilchrist (1993) and Hubbard (2001). The empirical results are far from being unambiguous but the majority of the cited studies finds evidence that the credit channel plays an important role in the transmission of monetary policy. The main problem that is discussed in the empirical literature on the credit channel is the identification of supply and demand side effects on credit markets. While building on a decrease in credit supply, a decrease in the quantity of credit after a restrictive monetary policy action is neither necessary nor sufficient for the existence of a credit channel. It is not necessary because the decline in credit supply can solely result in an increase in the interest rate on credit without affecting its quantity. This would be the case if the demand for credit was perfectly unelastic. A decline in the quantity of credit is not sufficient because it can also be totally demand determined, this would be compatible with the traditional money view. Different approaches to distinguish between supply and demand effects on the credit markets have been proposed. Kashyap et al. (1993) assume that a change in the demand for credit affects all kinds of external finance, that is, indirect borrowing from banks (loans) and direct borrowing on capital markets (commercial papers) in the same way while supply side effects should only reduce the supply of loans. Therefore, they interpret a decrease in the loan-paper ratio as a decrease in loan supply. Bernanke et al. (1996) make use of the distributional aspects mentioned above in order to identify supply side effects. According to this view, different reactions of lending to heterogenous borrowers indicate supply effects assuming that the reaction of credit demand is identical across borrowers. Friedman and Kuttner (1993) stress that not only changes in quantities but also changes in prices should be analyzed in order to identify supply and demand side effects. This suggestion is followed here in a way that is described in section 3.

3.2 Institutional Framework and Evidence for Germany

External financing had approximately a share of 37% in total financing of German firms from 1975 to 1998. The share of external financing tends to increase in recessions (early 80s and early 90s). As a consequence, interest payments of firms have increased in these periods, too. This had a negative impact on cash flow. As mentioned before, lending from banks has an average share of 24.5% in total financing and of 67.5% in external financing.

The role of external finance and the existence of a credit channel in Germany is analyzed in studies by Guender and Moersch (1997), Worms (1998), Ehrmann and Worms (2001), von Kalckreuth (2001), Hülsewig et al. (2001) and Küppers (2001), for example. International comparisons are conducted by Kashyap and Stein (1997) and de Bondt (2000). Guender and Moersch (1997) apply three vector autoregressive (VAR) models using monthly data from 1969 to 1994 to analyze the existence of a bank lending channel in Germany. Their main finding is that short-term bank lending does increase after a restrictive monetary policy shock. This response is rationalized by the so-called *Hausbankbeziehung* between German banks and firms. However, an increase in the share of short-term lending in response to increasing interest rates is not surprising: if borrowers expect that interest rates will decrease again it is only rational to borrow at short maturities. Furthermore, it is total credit that is relevant for the credit channel not only short-term lending. Additionally, Guender and Moersch (1997) have chosen a sample period including the structural change of monetary policy in 1975, which is not considered in their empirical analysis. Similar results are reported by Worms (1998) who states that the bank lending channel is only of secondary importance. Ehrmann and Worms (2001) do also support this view. They analyze the response of bank loans with respect to the size of the bank. Only for small banks that are not organized in credit cooperatives or the savings banks sector a negative response of loans to restrictive monetary policy shocks is found. This group of banks, however, has only a share of 2.9% in total bank lending (Ehrmann and Worms, 2001, table 2). Big banks and banks that are organized in credit cooperatives or the savings bank sector respond to a restrictive monetary policy shock not by decreasing loans but by decreasing net foreign assets. All these results are based on the analysis of banks' balance sheet items without considering interest rates on loans. An alternative approach is followed by von Kalckreuth (2001) who specifies an autoregressive distributed lag model for investment spending. His results also indicate that the credit channel is only of minor importance compared to the interest rate channel. Evidence that is supportive for a credit channel is reported by Hülsewig et al. (2001), Küppers (2001) and Worms (2001). Hülsewig et al. (2001) estimate a cointegrated VAR and identify the demand for and supply of loans as cointegrating vectors, Küppers (2001) uses heterogenous groups for identification, and Worms (2001) conditions his panel data study on the ratio of short-term interbank deposits to total assets.

De Bondt (2000, chapter 5) compares financial structure and monetary policy transmission in six countries of the European Union. He estimates vector error correction models for quarterly data from 1980 to 1996 using gross domestic product as demand proxy and total private wealth as supply proxy. The impulse responses reveal that loans and wealth react immediately after a monetary policy shock while GDP reacts with a lag of approximately one year. Therefore, the reaction of loans is interpreted as supply effect supporting the credit view.

Kashyap and Stein (1997) describe the financial structure in the countries participating in the European Monetary Union. An important result is that the financial structure in these countries is still quite different. Therefore, it can be assumed that the relevance of the credit channel varies across countries which has to be considered by the European Central Bank when conducting a single monetary policy for the Euro area.

3.3 A Benchmark Model of the Interest Rate Channel

Before addressing the bank lending channel and a broad credit channel in Germany, a benchmark model of the traditional money view, i.e. the interest rate or money channel, is discussed. This view can be described with an IS-LM model augmented by a supply side. This class of models is characterized by the assumption that money and bonds are the only relevant financial assets. The stylized transmission process according to this view is as follows. Monetary policy actions change the nominal short-term interest rate by changing the nominal money supply. This change is transmitted to the real long-term interest rate that is relevant for investment decisions of firms as well as for certain consumption decisions (durable goods, for example). A restrictive monetary policy shock that increases the nominal short-term interest rate increases the real long-term rate. Subsequently, investment and consumption spending decrease and total output decreases, too.

The conditions for the money channel to be effective are, see also Hubbard (2001):

1. There are no perfect substitutes for base money such that the central bank can influence the development of the nominal money stock by increasing or decreasing the amount of base money. This condition has been satisfied in Germany from 1975 to 1998 due to the reserve requirement.
2. The central bank is able to control not only the nominal short-term interest rate but also the real short-term interest rate. This condition can be considered as satisfied because prices are supposed not to react instantaneously on monetary policy.
3. Changes in the real short-term interest rate are transmitted to the real long-term interest rate. A long-run equilibrium relationship between the short-term and the long-term interest rate in Germany is not observable. The spread is non-stationary like the short-term and the long-term interest rates themselves, see Hassler and Nautz (1998) and Wolters (1995). Nautz and Wolters (1999), however, show that an instationary spread does not necessarily contradict the expectations theory of the term structure and that innovations in the short-term rate do systematically affect the long-term rate. The non-stationarity of the spread could possibly be the consequence of a non-stationary liquidity premium.
4. Output is elastic with respect to the real long-term interest rate. Von Kalckreuth (2001) shows that investment spending in Germany decreases by approximately 4% after an increase in the nominal interest rate of 1%. The impact of the real rate, however, is not clear. Furthermore, the interest rate sensitivity of total output can also not be considered as known. This is still an open question.

An overview of VAR models of monetary policy transmission in Germany is given in table 1. The core endogenous variables in all these models are output, price level or inflation rate, and a short-term interest rate as monetary policy instrument. Different other endogenous variables like money stock, exchange rates, additional price indices, or long-term interest rates are included. Some models also consider exogenous variables that describe the development of the world economic situation, for example U.S. GDP or the Federal Funds Rate. In order to specify a benchmark model of the interest rate channel, a general-to-specific approach is followed here. The benchmark model includes seven endogenous variables (x_t): world export price index (epi), industrial production (ip), consumer price index (cpi), short-term money market rate (i), spread between long-term interest rate and money market rate ($\rho = R - i$), money stock M3 (m), and real effective exchange rate (ex). All variables except for the interest rates are measured in logarithms. The data are described and depicted in the data appendix. In addition to the world export price index and real effective exchange rate, international economic effects are taken into account by including the following exogenous variables (z_t): Federal Funds Rate (fr), U.S. spread ($R^{US} - fr$), and U.S. industrial production (ip^{US}). The VAR model can be written as

$$x_t = \mu_t + \sum_{i=1}^{12} A_i x_{t-i} + \sum_{i=0}^{12} B_i z_{t-i} + u_t,$$

$$x_t = (epi_t, ip_t, cpi_t, i_t, \rho_t, m_t, ex_t)', \qquad z_t = (fr_t, R_t^{US} - fr_t, ip_t^{US})' \tag{3.1}$$

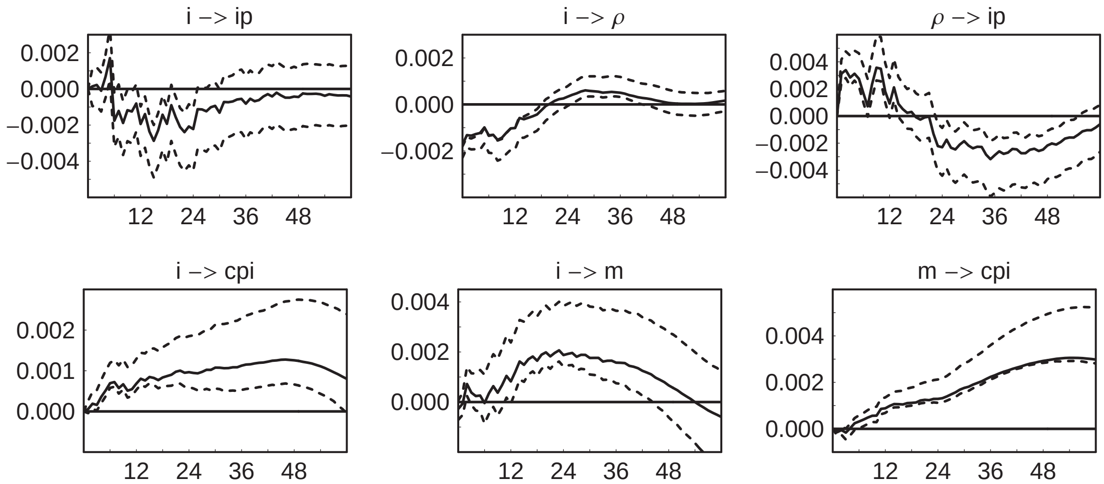
where u_t is normally distributed with a zero mean vector and covariance matrix Σ_u, and μ_t contains a constant and centered seasonal dummies. The sample period is 1975-1998 covering the period of monetary targeting by the Deutsche Bundesbank. The lag length is chosen according to lag exclusion Wald tests which indicate that lags up to twelve should be included. The relatively high lag order is necessary because the data is not seasonally adjusted and seasonal dummies are not able to describe all seasonal effects. Using seasonally adjusted data would probably reduce the lag length but could possibly also distort the short-run dynamics of the data in which we are interested here. The dynamic effects are analyzed by investigating impulse response functions and forecast error variance decompositions. For this purpose it is not necessary to determine the integration order of the time series and to identify possible cointegration relations explicitly. The VAR in levels can be estimated consistently with OLS, see Breitung (2000), and appropriate confidence intervals for the impulse responses can be obtained by using a suitable Bootstrap procedure, see Benkwitz et al. (2001), e.g. This technique is applied here. However, a possible problem is the large number of coefficients to be estimated. The number of variables shall not be decreased here because we are explicitly interested in the elements of the transmission channel and not only in the overall effect of monetary policy shocks on output and prices. Therefore, the following subset VAR procedure is employed: in the first step, the complete VAR is estimated by OLS. In the subsequent steps, the regressor with the lowest absolute t-ratio is deleted in the respective equation. The procedure stops if all remaining regressors exhibit an absolute t-ratio of at least 1.28, which is the 90% percentile of the standard normal distribution implying that the nominal significance level for the two-sided t-test for zero restrictions is about 20%. At this significance level, the probability of wrongly eliminating regressors can supposed to be acceptable. The efficiency of the estimation could be improved by applying a generalized least squares (GLS) technique that considers the contemporaneous correlation between the error terms given by an estimate of Σ_u. Because contemporaneous residual correlation is low in the considered VAR models and a comparison of OLS and GLS results has revealed that they do not differ substantially, OLS is applied in the following in order to keep the calculation time in the bootstrap procedure within an acceptable range. The subset procedure excludes on average more than one half of the regressors per equation such that the remaining

Table 1: VAR Models of Monetary Policy Transmission in Germany

Authors	Methodology	Variables	Sample	Effects of Restrictive MP Shock
Kim (1999)	SVAR (non-recursive contemporaneous restrictions)	money call rate, money (M1 + quasi money), CPI, IP, CMPI	1965:3-1997:5 (monthly)	IP: negative, CPI: insignificant (one std.err. bands)
Dedola and Lippi (2000)	SVAR (Cholesky decomposition)	IP, CPI, CMPI, 3-months money rate, M3, real effective exchange rate	1975:1-1997:3 (monthly)	IP: short-run positive, long-run negative, CPI: positive
Ehrmann (2000)	SVECM (King et al. (1991) type restrictions)	3-months money rate, IP, ΔCPI, DM/USD exchange rate, CMPI	1979:3-1997:4 (quarterly)	IP: negative after four quarters, ΔCPI: short-run negative
Kim and Roubini (2000)	SVAR (non-recursive contemporaneous restrictions)	money call rate, M1, CPI, IP, OPI, FFR, DM/USD exchange rate	1974:7-1992:12 (monthly)	IP: negative, CPI: slightly negative (one std.err. bands)
Brüggemann (2001)	SVECM (Gonzalo and Ng (2001) type restrictions)	Real M3, GDP, ΔCPI, money call rate, long-term interest rate, DM/USD exchange rate	1975:1-1983:12 and 1984:1-1998:12 (monthly)	GDP: short-run negative, ΔCPI: short-run negative
Mojon and Peersman (2001)	SVAR (Cholesky decomposition)	GDP, CPI, 3-months money rate, real effective exchange rate (endogenous) and CMPI, GDP USA, FFR (exogenous); additionally models with bank loans and retail loan rate	1970:1-1998:4 (quarterly)	GDP: negative, CPI: negative (the so-called MP shock has only an insignificant positive impact on the interest rate)
Lütkepohl and Wolters (2001)	SVECM (contemporaneous restrictions)	Real M3, GNP, Δ(GNP Deflator), long-term interest rate, money call rate, import price index	1975:1-1998:4 (quarterly)	GNP: negative, ΔGNP Deflator: negative

Abbreviations: SVAR (structural VAR Model), SVECM (structural vector error correction model), IP (industrial production), CPI (consumer price index), GDP (gross domestic product), GNP (gross national product), CMPI (commodity price index), OPI (oil price index), FFR (federal funds rate), MP (monetary policy), std.err (standard error).

Figure 2: Selected Impulse Responses in the Interest Rate Channel Model



Notes: The figure shows impulse responses that are calculated from a Subset VAR in levels with initially twelve lags assuming a recursive identification scheme. Endogenous variables are in the ordering used to identify the monetary policy shock: $(epi, ip, cpi, i, \rho, m, ex)_t$. The data are adjusted for the structural break due to the German unification, see data appendix. A constant, centered seasonal dummies, and impulse dummies di8406, di8512, di8807, di9110, di9212 are included. Dotted lines are 95% Hall-Bootstrap confidence bands (2000 replications).

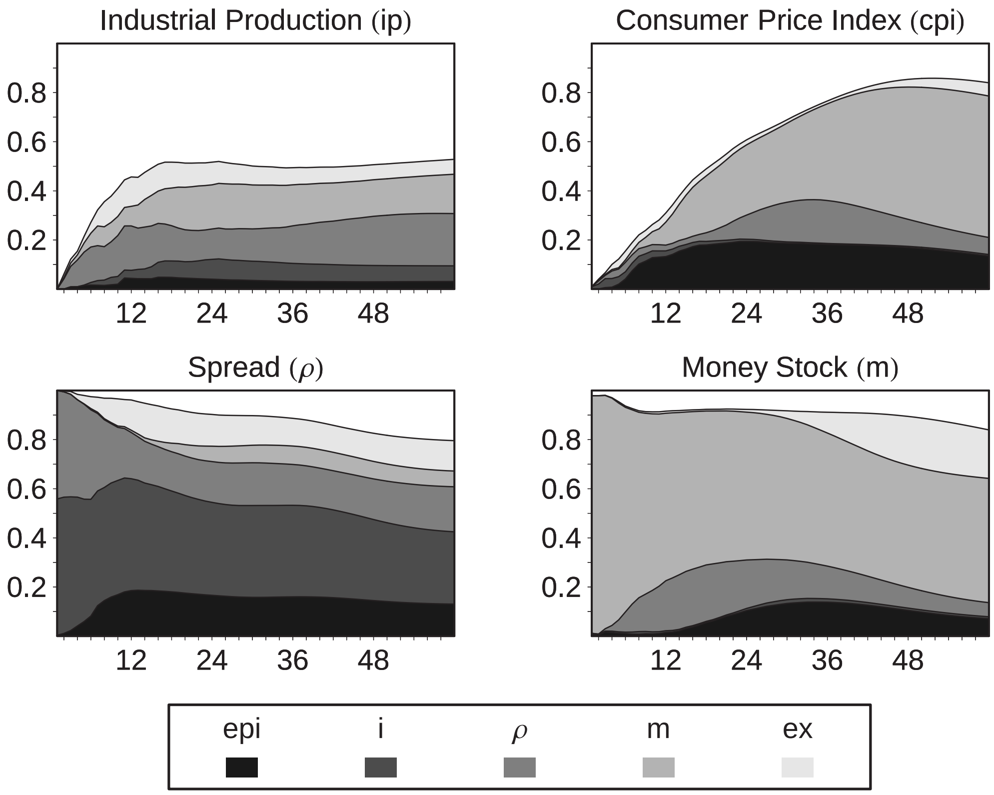
number of coefficients to be estimated is well balanced with the number of 288 observations per variable. Diagnostic tests for all equations are reported in the appendix.

A recursive identification scheme is applied to identify monetary policy shocks.[4] The ordering of the variables is $(epi, ip, cpi, i, \rho, m, ex)$. This ordering corresponds to the ordering in Dedola and Lippi (2000) and Mojon and Peersman (2001) and is based on the following structural assumption: first, the central bank observes the status of the real world (epi, ip, cpi); second, the central bank sets the nominal short-term interest rate (i) that has no contemporaneous effect on the real world but an impact in subsequent periods; third, financial variables (ρ, m, ex) adjust to changes in the short-term rate contemporaneously. Selected impulse response functions of the benchmark model are depicted in figure 2.[5] A positive shock on the short-term interest rate is followed by a temporary decrease in industrial production and in the spread. The negative response of the spread shows that monetary policy shocks are at most partially transmitted to the long-term interest rate. Furthermore, positive innovations in the spread, which can also be interpreted as long-term interest rate shocks when the short-term interest remains constant, are followed by a positive response of industrial production. This is not compatible with the interest rate channel transmission theory but can possibly be explained by the fact that the long-term

[4] The alternative identification schemes suggested by other authors (see table 1) have also been considered. The response of industrial production to a monetary policy shock, which is the most interesting in the present context, differs not in shape but with respect to timing and extent across the different identification schemes. The recursive identification scheme has the advantage that it can be easily modified and extended, and it does not provide results substantially different from more complicated identification schemes. Similar results for the Euro area are reported by Peersman and Smets (2001).

[5] The whole set of impulse responses cannot be discussed here. However, also the other impulse responses are mainly in line with economic theory and the cited VAR models by other authors. For example, innovations in the world export price index have a positive long-run effect on the price level, innovations in the spread have a temporary negative effect on the money stock, and positive innovations in the real effective exchange rate are followed by a decrease in industrial production.

Figure 3: Selected Forecast Error Variance Decompositions in the Interest Rate Channel Model



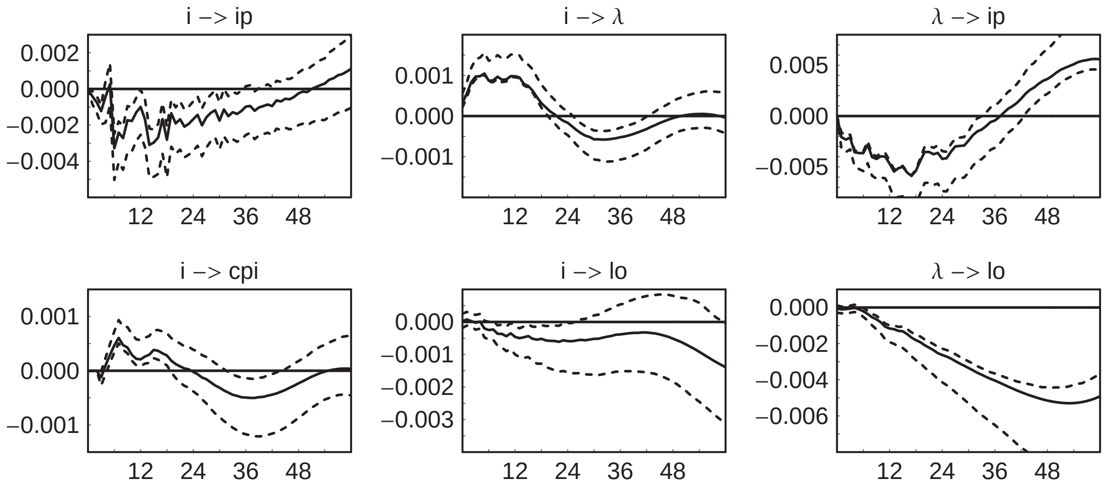
Notes: See notes to figure 2.

interest rate reflects expectations about the future economic development in terms of the real interest rate and inflation. When a positive development of the economy is expected, industrial production increases. Like in other studies, a positive response of the price level to innovations in the short-term interest rate can be observed. This phenomenon is sometimes called price puzzle. A possible explanation for the occurrence of this phenomenon is that the short-term interest rate has a positive impact on the money stock M3, which contains interest bearing assets. The money stock itself has a positive impact on the price level. Therefore, the positive impact of restrictive monetary policy on the price level can be understood in this VAR model but it remains an open task to specify a model in which the expected negative impact of restrictive monetary policy on prices is revealed.

The forecast error variance decompositions presented in figure 3 indicate that monetary policy shocks are of minor importance for the variance of industrial production. Innovations in the short-term interest rate and in the spread together have a share of about 20% in the forecast error variance of industrial production after 18 months. It can also be seen that innovations in the money stock have a large share in the forecast error variance of the price level.

Given that there seems to be evidence that the interest rate channel proposed by the money view is not very well suited to explain monetary policy transmission exclusively, the VAR is now modified in order to allow for a bank lending channel.

Figure 4: Selected Impulse Responses in the Bank Lending Channel Model



Notes: Endogenous variables are in the ordering used to identify the monetary policy shock: $(epi, ip, cpi, i, \lambda, lo, ex)_t$. Further notes see figure 2.

3.4 A Model of the Bank Lending Channel

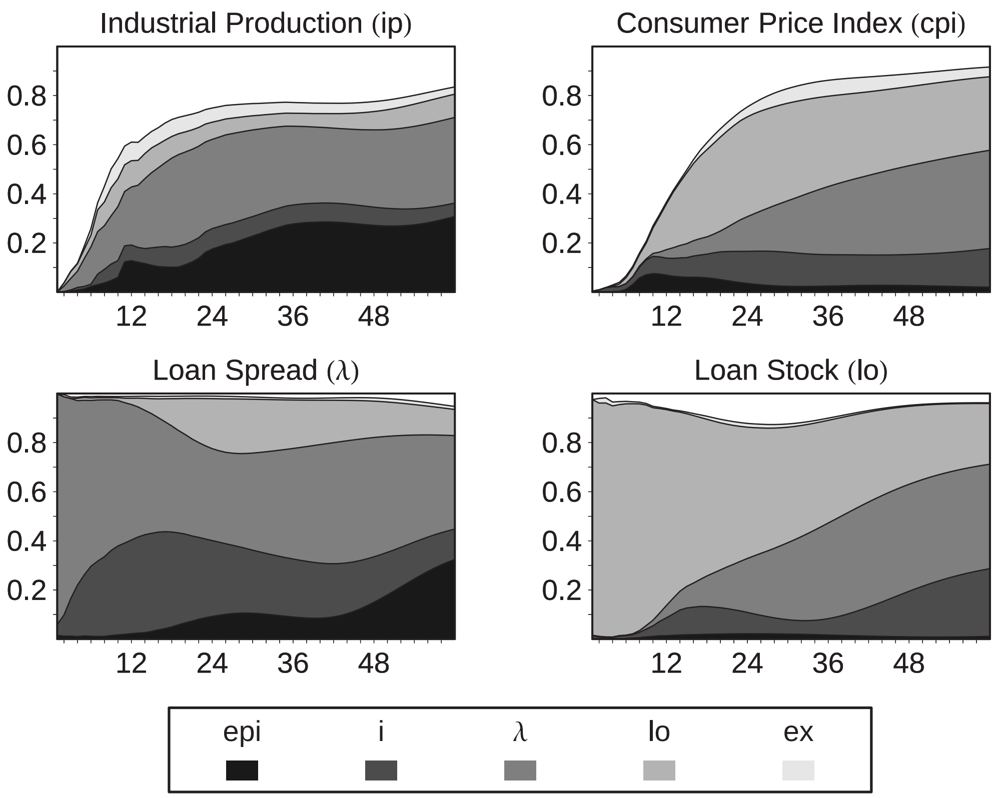
In section 2, the Bernanke and Blinder (1988) model has been presented as a simple model capturing the bank lending channel. This model builds the theoretical foundation for the empirical bank lending channel model that is specified in this section. It has to be stressed that it is not sufficient to add only the loan stock as an additional variable to the VAR. As explained before a negative response of loans to a restrictive monetary policy shock is neither necessary nor sufficient for the existence of a bank lending channel. The purpose here is not to explicitly identify loan supply and demand effects. However, it is intended to investigate the prediction of the Bernanke and Blinder (1988) model that the spread $\lambda = R^L - R$ between the interest rate on loans and the interest rate on bonds increases in response to a restrictive monetary policy shock, and that economic activity decreases if the interest rate on loans increases.

The variables included in the VAR analysis are now:

$$x_t = (epi_t, ip_t, cpi_t, i_t, \lambda_t, lo_t, ex_t)', \tag{3.2}$$

where lo_t is the nominal loan stock. Lag length, exogenous variables (z_t) and deterministic specification are like before. Selected subset VAR impulse responses for the bank lending channel model can be found in figure 4. Again, a hump-shaped negative effect of a restrictive monetary policy shock on industrial production can be observed. The bank lending channel version of the transmission mechanism is confirmed empirically: The spread $\lambda_t = R_t^L - R_t$ increases in response to a restrictive monetary policy shock, and the spread itself has a negative impact on the loan stock and on industrial production. There is also weak evidence that the loan stock decreases in response to a restrictive monetary policy shock. Together with the increasing spread this can be interpreted as evidence for a negative impact of restrictive monetary policy on loan supply. The responses to the spread should describe mainly supply effects because credit demand effects should also affect the bond rate and not only the bank lending rate. Additionally, a demand effect would be indicated by a decreasing loan stock accompanying a decreasing inter-

Figure 5: Selected Forecast Error Variance Decompositions in the Bank Lending Channel Model



Notes: See notes to figures 2 and 4.

est rate on loans.[6] Furthermore, the price puzzle is not observed in this model. The restrictive monetary policy shock has a significant negative impact on the price level after about two and a half years.

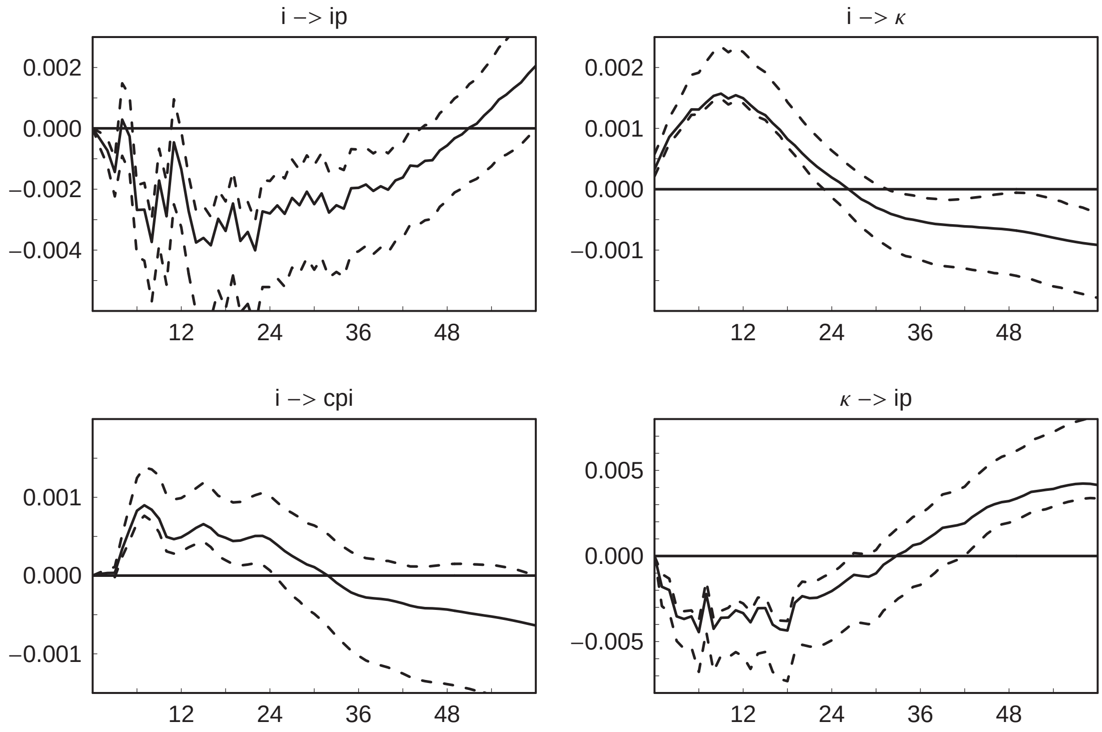
According to the forecast error variance decompositions, see figure 5, the impact of monetary policy on industrial production is much larger than in the interest rate channel model. Monetary policy shocks are responsible for a considerable part of the variance in the loan spread, and innovations of the short-term interest rate and the loan spread have together a share of about 45% in the forecast error variance of industrial output after 18 months. The price level is also strongly affected by bank lending variables.

This analysis shows that conditions (1) – reaction of loan supply on monetary policy – and (3) – reaction of production on loan supply – for the effectiveness of a bank lending channel in Germany can be considered fulfilled in the sample period. Condition (2) – the absence of short-run substitution possibilities for bank loans – cannot be tested explicitly in a time series analysis because appropriate data are not available. The institutional setting in Germany, however, seems to support the assumption that condition (2) is also fulfilled.[7]

[6] Responses to innovations in the loan stock are not depicted here. The price level responds positively in the long-run and industrial production exhibits a hump-shaped negative response.

[7] See Kashyap and Stein (1997) for a discussion of institutional settings on financial markets in European countries.

Figure 6: Selected Impulse Responses in the Broad Credit Channel Model



Notes: Endogenous variables are in the ordering used to identify the monetary policy shock: $(epi, ip, cpi, i, \kappa, ex)_t$. Further notes see figure 2.

3.5 A Model of the Broad Credit Channel

The main argument of the broad credit channel is that restrictive monetary policy increases the external finance premium, lowers the firms' and households' ability to borrow and does therefore reduce aggregate output. This effect can be analyzed in a VAR with the endogenous variables

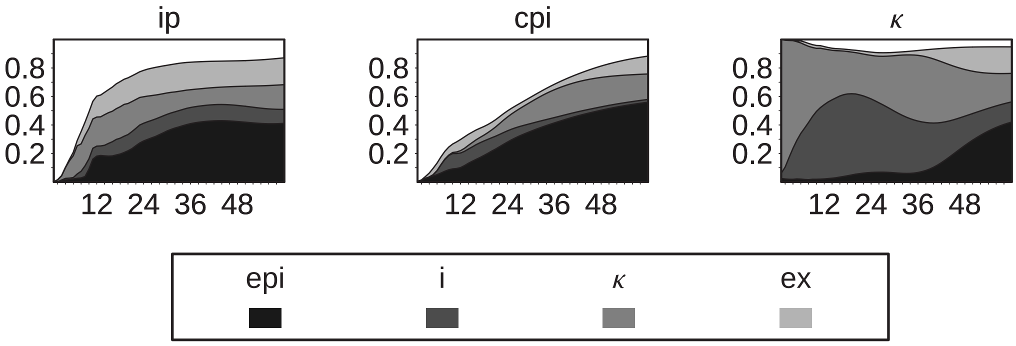
$$x_t = (epi_t, ip_t, cpi_t, i_t, \kappa_t, ex_t)', \tag{3.3}$$

where κ_t is the external finance premium. Lag length, exogenous variables (z_t) and deterministic specification are like in models (3.1) and (3.2). Notice that a monetary aggregate like loans or money is not included. Following Friedman and Kuttner (1992) the spread between the interest rate on loans and the yield on government bonds is used as external finance premium. This spread is in general positive because of a risk premium and a liquidity premium. These two terms are not constant and are presumably affected by monetary policy. The external finance premium is therefore measured in the following as:

$$\kappa_t = R_t^L - R_t^{\mathrm{Gov}}, \tag{3.4}$$

where R_t^{Gov} is the yield on government bonds. The mean of this spread from 1975 to 1998 is 1.8 percentage points and the standard deviation is 1.5. It should be mentioned that κ_t is very similar to λ_t. In figure 6 it can be seen that positive innovations in the short-term interest rate increase the external finance premium, and shocks to the external finance premium have a hump-shaped and significant negative impact on industrial production and a significant long-run negative impact on the price level (the latter impulse response is not depicted). The response

Figure 7: Selected Forecast Error Variance Decompositions in the Broad Credit Channel Model



Notes: See notes to figures 2 and 6.

of the price level to a restrictive monetary policy shock is non-negative like in the interest rate channel model.

The forecast error variance decompositions can be found in figure 7. Monetary policy shocks have a much larger impact on the forecast error variance of industrial production than in the interest rate channel model but less than in the bank lending channel model. Monetary policy shocks are responsible for a big share of the variance in the external finance premium, and innovations in the short-term interest rate and in the external finance premium have a share of about 34% in the forecast error of industrial production after 18 months. The omission of a monetary aggregate has the consequence that a major share of the forecast error variance of the price level is now explained by innovations in world export prices.

3.6 Interpretation of the Empirical Evidence

The empirical evidence reported in this paper has been intended to explore the relevance of a credit channel of monetary policy transmission in Germany during the period from 1975 to 1998. Separately estimated VAR models of the interest rate channel, the bank lending channel and the broad credit channel have revealed some problems of the interest rate channel. Further, predictions of bank lending and broad credit channel models are compatible with impulse response functions derived from the VAR models. Unfortunately, a direct evaluation of the relative importance of the respective transmission channels is not possible in the presented framework. For this purpose, a model that includes interest rate channel variables like long-term interest rate and money stock as well as credit channel variables like interest rate on loans, loan stock and external finance premium is necessary. Due to the high degree of interaction between these variables, the recursive identification scheme seems not appropriate for the identification of shocks in such a system. However, the foregoing results have shown that the interest rate channel reveals only incomplete information about monetary policy transmission. Further insights are provided by considering the credit channel of monetary policy transmission: real economic activity is affected significantly by monetary policy shocks via refinancing costs. Neglecting these effects leads to severe underestimation of the impact of monetary policy shocks on real economic activity. It can also be stated that inclusion of a monetary aggregate in the model is important for the explanation of effects on the price level.

4 Conclusions

The empirical analysis of the monetary policy transmission mechanism stands in the center of attention of this paper. As reviewed in section 2, the credit channel with its two forms bank lending channel and broad credit channel offers a theoretically well founded explanation of the monetary policy transmission mechanism. The empirical evidence reported in section 3 shows that the traditional interest rate channel should not be considered as an exclusive explanation of the transmission mechanism. While inflation can be assumed to be a monetary phenomenon in the long run, the impact of monetary policy on output can be explained to a considerable extent by the credit view. Restrictive monetary policy tends to increase refinancing costs, i.e the loan spread in the bank lending channel model and in the external finance premium in the broad credit channel model. In both credit channel models, a hump-shaped response of output to innovations in the variable reflecting the financing costs can be observed. Additionally, monetary policy shocks explain a larger share in the variance of industrial production in the credit channel models than in the interest rate channel model. These results are encouraging for research on structural theoretical models of the transmission mechanism that are necessary to evaluate the welfare effects of monetary policy.

There remains still a number of open questions. While in this paper the dynamics in terms of impulse response functions are addressed, it would also be interesting to identify the long-run relationships (cointegration vectors) between the considered variables. Furthermore, it would be of major interest to specify a model that allows for an interest rate channel and a credit channel simultaneously and to explore the relative importance of the two channels in more detail. Of course, the analysis has to be extended to the Euro area when time series of appropriate length have become available.

Appendix A. Data Description

Consumer Price Index (cpi): Logarithmic consumer price index, OECD Main Economic Indicators (125241K).

Federal Funds Rate (fr): Federal funds rate, fractions, OECD Main Economic Indicators (426217D).

Industrial Production (ip): Logarithmic industrial production, OECD Main Economic Indicators (122027K).

Industrial Production USA (ip^{US}): Logarithmic industrial production USA, OECD Main Economic Indicators (422027K).

Interest Rate on Loans (R^L): Average interest rate on current account credit (DM 1 million and more but less than DM 5 million), fractions, Deutsche Bundesbank (SU0004).

Loans (lo): Logarithmic loan stock (bank lending (balances and advances) to residential non-banks), Deutsche Bundesbank (OU0085), adjusted for German unification by regressing first differences on seasonal dummies and an impulse dummy which is one in 1990:6. Autoregressive errors are considered. The coefficient of the impulse dummy (0.0715) is added to level data before 1990:6.

Long-term Interest Rate (R): Yields on bonds outstanding, fractions, Deutsche Bundesbank (WU0017).

Long-term Interest Rate USA (R^{US}): Interest rate on US government composite bonds ($>$10 years), OECD Main Economic Indicators (426279D)

Money Stock (m): Logarithmic money stock M3, Deutsche Bundesbank (TU0800), adjusted for German unification by regressing first differences on seasonal dummies and an impulse dummy which is one in 1990:6. Autoregressive errors are considered. The coefficient of the impulse dummy (0.1387) is added to level data before 1990:6.

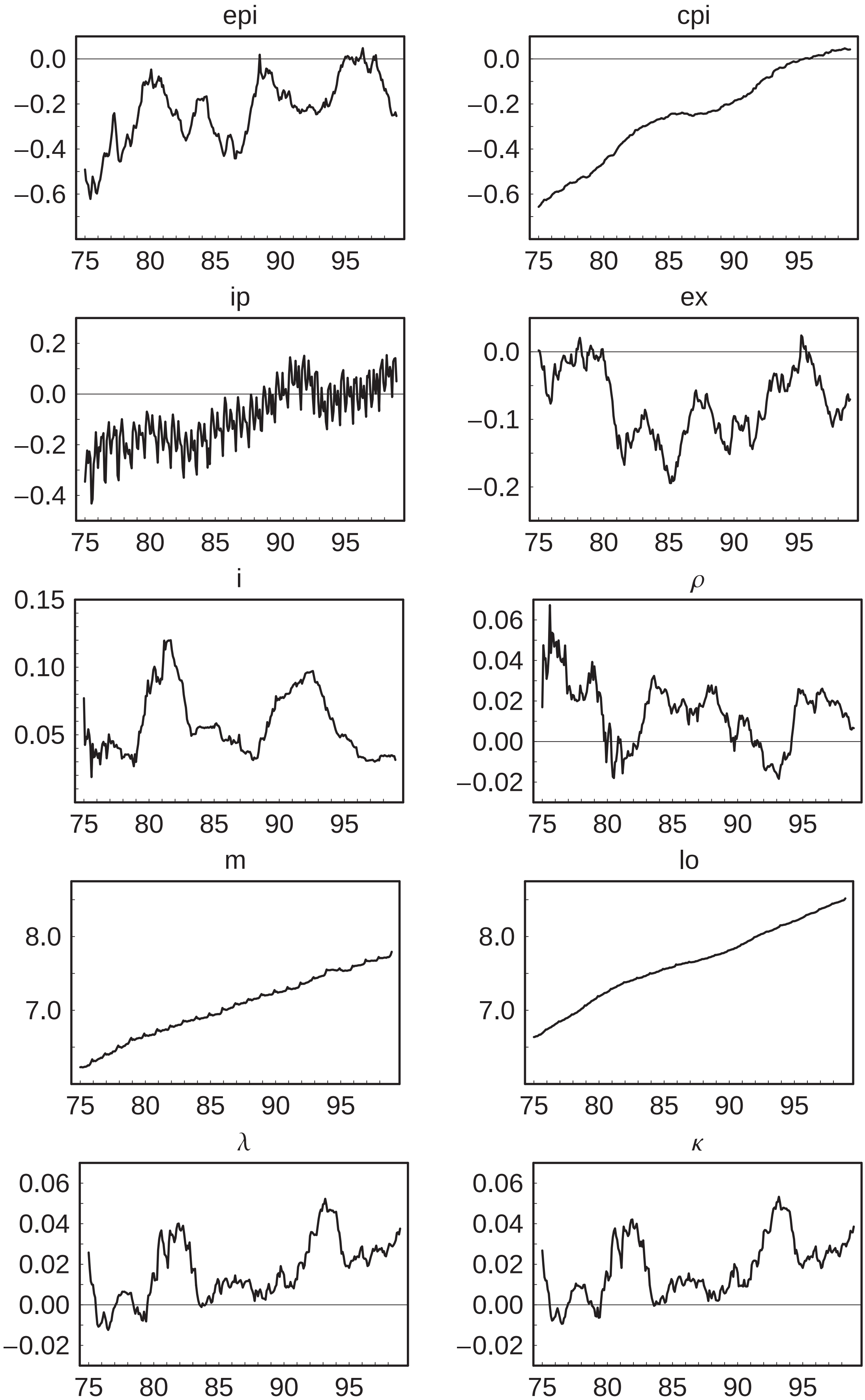
Real Effective Exchange Rate (ex): Logarithmic real effective exchange rate, OECD Main Economic Indicators (127001K).

Short-term Interest Rate (i): Money market rate reported by Frankfurt banks, day-to-day money, fractions, Deutsche Bundesbank (SU0101).

World Export Price Index (epi): Logarithmic world export price index, IMF (001 76AXD).

Yield on Government Bonds (R^{Gov}): Yields on bonds outstanding, public bonds, fractions, Deutsche Bundesbank (WU0004).

Figure 8: German Data



Appendix B. Diagnostic Tests

The diagnostic tests in table 2 are the following: JB denotes the Jarque-Bera test for normality, LM(k) the Lagrange multiplier test for serial correlation of the residuals (k lagged residuals included), ARCH(k) the Lagrange multiplier test for autoregressive conditional heteroskedasticity, and RESET(1) the Regression Specification Error Test considering the second powers of the fitted values from the original regression. The values given are the corresponding p-values. All models include a constant, centered seasonal dummies and exogenous variables $z_t = (fr_t, R_t^{US} - fr_t, ip_t^{US})'$. Further, impulse dummies di8406, di8512, di8807, di9110, di9212 which have value one in the respective month and zero otherwise are included in all cases in order to correct for large outliers. However, there remain still some outliers leading to rejection of the normality hypothesis in some cases.

Table 2: Diagnostic Tests: p-Values, Sample Period: 1975:1-1998:12

Eq.	JB	LM(1)	LM(12)	ARCH(1)	ARCH(12)	RESET(1)
Interest Rate Channel Model (3.1): $x_t = (epi_t, ip_t, cpi_t, i_t, \rho_t, m_t, ex_t)'$						
epi	0.00	0.04	0.02	1.00	0.97	1.00
ip	0.99	0.01	0.08	0.76	0.09	1.00
cpi	0.00	0.34	0.00	0.88	0.51	0.00
i	0.00	0.29	0.12	0.44	0.22	1.00
ρ	0.33	0.37	0.06	0.80	0.10	1.00
m	0.08	0.02	0.01	0.01	0.10	0.04
ex	0.01	0.21	0.83	0.27	0.43	0.54
Bank Lending Channel Model (3.2): $x_t = (epi_t, ip_t, cpi_t, i_t, \lambda_t, lo_t, ex_t)'$						
epi	0.00	0.05	0.31	0.76	0.94	1.00
ip	0.08	0.11	0.68	0.49	0.26	1.00
cpi	0.00	0.65	0.12	0.61	0.99	0.00
i	0.00	0.84	0.00	0.95	0.01	1.00
λ	0.23	0.90	0.10	0.13	0.94	1.00
lo	0.00	0.79	0.16	0.93	0.95	1.00
ex	0.05	0.21	0.17	0.57	0.40	1.00
Broad Credit Channel Model (3.3): $x_t = (epi_t, ip_t, cpi_t, i_t, \kappa_t, ex_t)'$						
epi	0.00	0.19	0.11	0.48	0.96	0.84
ip	0.81	0.06	0.15	0.65	0.24	1.00
cpi	0.00	0.73	0.71	0.66	0.95	0.00
i	0.00	0.46	0.18	0.34	0.00	0.74
κ	0.15	0.18	0.23	0.59	0.53	1.00
ex	0.02	0.45	0.72	0.88	0.35	0.00

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