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Monetary Transmission, Asset Prices, and The Business Cycle Indicator in Germany

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“ However, the effects of our policy instruments, such as the short-term interest rate, on these goal variables are indirect at best. Instead, monetary policy actions have their most direct and immediate effects on the broader financial markets, including the stock market, government and corporate bond markets, mortgage markets, markets for consumer credit, foreign exchange markets, and many others.”

Ben Bernanke (2003).

“The Bank of England's Monetary Policy Committee today voted to raise the Bank's repo rate by 0.25 percentage points.After slowing at the start of the year, growth in the United Kingdom has picked up and credit growth remains strong. Business surveys suggest the recovery is becoming more broad-based. Neither household spending nor the housing market have slowed by as much as the Committee expected.”

Bank of England, November 6, 2003.

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Abstract

We analyze monetary transmission in Germany and focus on two elements. First, we address the role of asset prices in monetary transmission, especially the role of housing and equity. We show that including assets helps in understanding the monetary transmission process. Housing is found to be more important in Germany than equity. Next we emphasize the role of business cycle indicators in VAR-models. Knowing that asset prices signal future economic development it seems to be consistent to include contemporaneous or even leading indicators as GDP-measures. Inclusion of the IFO-Climate indicator leads to more rapid impact of interest rates and asset prices on economic activity and inflation.

1 Introduction

The effectiveness of monetary transmission depends on the rigidity of prices and wages and on the transmission into real expenditure categories. Traditionally the so-called interest rate channel is held responsible for transmission of monetary policy shocks. Nowadays the working of the whole financial system is believed to be relevant. Due to informational problems the credit market has a special role in propagating monetary shocks (see Bernanke and Blinder, 1988). But revaluation of all assets and liabilities (resulting in net wealth positions) seems to determine the ultimate impact. The financial structure, like described by Tobin in his general equilibrium view on the financial sector, is crucial in transmission (see also the financial accelerator approach by Bernanke et al., 1999).

As Lettau et al. (2002) show for the US, equity, housing, and liquidity are considered to be the three key financial markets in transmission (apart from the money and credit markets). Liquidity in various forms is essential to consumption and investment decisions. Lettau et al. argue that the housing market is essential in transmission. Probably an interest rate increase will increase the costs of mortgages. But the fall in demand for housing will reduce collateral value of existing houses, lower borrowing capacity for its owners and so start a downturn in a credit cycle (see Kiyotaki and Moore, 1999). The direct wealth effects of housing market crashes are well known and by far more substantial than any other revaluation effect. Equity markets have a leading role in expected future growth and inflation forecasting. The informational contents of equity are relevant to forward-looking decisions. As Bernanke (2003) argues monetary economists need to understand how strong monetary policy changes affect equity prices (the equity price-interest rate elasticity is believed to be about 3 to 6 for the US) and more important, why equity prices are influenced. Knowing this one can analyze transmission of asset price changes into real decisions and infer consequences for monetary policy in its turn again.

If all, asset prices contain more information than any other economic variable. This leading property has two major consequences. First, monetary authorities will use asset price information to derive future inflationary expectations. The Bundesbank is believed to pursue a monetary strategy focused on inflation (see Bernanke and Mihov, 1997), so will be eager to follow asset price inflation. Secondly, private agents will use asset prices (or revaluations) into their decisions. So the leading informational contents of

asset prices might change our view on the effectiveness of monetary policy completely. If we observe that central banks care about expectations, it seems to be weird to avoid any information with respect to future real developments. Are central bankers interested in lagged real growth or output gaps in steering monetary policy or do they take care of expected business cycle developments? We advocate the latter in this paper and combine the role of the role of asset prices and expected output developments in our model.

We take Germany as an example. The main argument doing so is twofold. First of all, the German financial system and the role of the housing market are special. Germany is known for being a bank-based economy (see e.g. Kakes and Sturm, 2002). This leads to the expectation that housing price transmission maybe important. With the Netherlands Germany has the highest share of mortgage loans to GDP in the EU. This could lead to vulnerability to interest rate shocks. Moreover, the term of the mortgage contracts is typically long (25 to 30 years, as in Austria and The Netherlands). On the other hand the owner occupation rate in Germany is relatively low (40 percent, while 63 for the EU) while the private rental occupation rate is high. So it remains an empirical problem to establish the precise effects. Secondly, we take Germany as an example since it has a consistent historical experience in using business cycle indicators. We turn back to this issue later on in discussing the data we use.

There are several interesting issues to be addressed. First, how is the monetary transmission mechanism affected by asset prices? Does neglecting asset price developments lead to the 'wrong' conclusions with respect to output and inflation-sensitivity to monetary policy changes? Secondly, how big is the impact of asset price shocks on GDP? How should we cope with a contemporaneous measurement of GDP, knowing that official publication of GDP lags at least one year? And thirdly, did monetary authorities respond to asset price changes in the past? We don't go into the problem how central banks should respond to asset price changes. The latter problem requires the specification of a social welfare function, which is out of scope of this paper.

In the next section we very shortly describe the theoretical context of our study. Our main argument in this section is that it is generally believed that positive asset price shocks should stimulate real expenditure, but there might also be arguments to doubt so. In Section 3 we very briefly compare the German housing and equity markets to those in France, Italy, Japan, the UK

and US. We show that housing is relatively important. We proceed in Section 4 by reviewing the literature on Vector AutoRegression (VAR) models. We describe the methodology, the major results on monetary policy identification, and VAR-models that focus on Germany and/or asset prices. Next we specify our VAR model for two benchmark cases: without and with equity and house prices. We compare the major findings of the two models in terms of structural factorizations of impulse response functions. After that we compare the use of actual GDP and the IFO climate indicator in the use of output in the VAR. In Section 7 we summarize and conclude. It will be shown that the housing market plays a central role in transmitting monetary policy.

2 Theory

The literature on the theory of monetary transmission is enormous (see Walsh, 2003), so we focus on a special element: asset prices in general, and house and equity prices in particular. Housing and equity differ in two important aspects. First, housing provides direct consumer services and enters the utility function (see e.g. Aoki et al., 2002). Second, price changes of housing can be observed less frequently. This implies that the informational content of housing prices is typically less than the one carried by equity.

Standard monetary theory focuses on the *interest rate channel*. In the tradition of Wicksell (1907), a lower banking rate (below the natural rate of interest) has an impact on spending (investment in particular) which will lead to higher output if prices are sticky. Starting with Bernanke and Blinder (1988) the *credit channel* has become an important second mechanism. Informational asymmetries in the credit market will lead to equilibrium rationing and so transmit initial monetary shocks via credit to output. In the same spirit Bernanke and Gertler (1995) extended the credit channel to a credit view by allowing the so-called *financial accelerator*: revaluation of assets affects spending categories.

How should we treat asset price changes in this respect? First, since asset prices reflect expected discounted future payoff streams, an adjustment of a (stochastic) discount factor will lead to a revaluation. To what extent precisely monetary policy changes affect these stochastic discount factors (are risk premia embedded) is unknown, but a positive shock to money market rates is likely to have a negative direct revaluation of assets. If asset prices change, how will this influence real expenditure? Here we can think of four basic mechanisms (see Chirinko et al., 2003).

First, there is the classical Modigliani life-cycle model, which leads to the *wealth channel*. Higher asset values will increase lifetime wealth and therefore positively affect e.g. private consumption. It is an empirical matter to what extent various assets will (temporarily) affect lifetime wealth. Equity price changes might be transitory and interpreted in this way, while house price changes for instance might be considered to be more permanent (or sticky at least). Moreover, an asset like housing provides direct consumer

services and enters a utility function (see e.g. Aoki et al., 2002). If asset components and consumption are substitutes, an increase in e.g. housing wealth, might lead to substitution out of consumption. So the wealth channel is not completely clear about the impact of asset price changes on real expenditure.

Second, in relation to the financial accelerator we have the *balance sheet channel*. Both consumers and firms can be exposed to financing constraints, due to informational problems. If external finance is more expensive than internal sources of finance it is likely that financial structure of households or firms is relevant. Positive revaluation of assets can alleviate these constraints (see Hubbard, 1998).

Third, positive shocks to e.g. equity prices might lower the equity financing costs (and to some extent the same argument holds for housing). If the current equity price falls below the fundamental value, equity financing gets cheap. This so-called *equity-financing channel* might not lead to a positive impact on real expenditure, if managers use the proceeds from emissions to invest in financial transactions. So the sign of the equity channel is not clear a priori.

Fourth, in the spirit of Brainard and Tobin (1968) there might be an *allocation channel*. If there is an initial shock to some asset price, imperfect substitutable assets will be exchanged, leading to revaluation of other assets. It will be hard to align market and fundamental values, which might lead to misallocation. This misallocation might even stretch out to real investment.

The bottom line of these four channels is that it is likely that there will be positive impact of a policy interest rate decrease, but there is no absolute guarantee. It remains an empirical issue to what extent asset price changes will affect real expenditure.

3 The German equity and housing markets in a birds-eye view

The German financial system is different from the U.K. or U.S. equivalents (see Allen and Gale, 2000). We don't discuss this general feature in detail, but provide Table 1 with some basic key indicators for France, Germany, Italy, Japan, the UK and US (from the World Bank source on Financial Structure Indicators). Here we can observe the relative overhang to bank loans in Germany opposed to the more equity markets based Anglo-Saxon economies. Knowing this general feature of the German financial system, we provide a little more detail on housing and equity markets. Table 2 provides information of the relative shares of equity and housing values in some key economies (using our database EUROMON, produced by De Nederlandsche Bank). Here we can observe that housing wealth is relatively large in Germany. Equity markets are relatively larger by this measure in the UK and US (as one would expect from Table 1). The wealth components are computed from the capital stock of the corporate sector and the general stock price index for the equity variable and the stock of owner occupied houses and the general housing price index for the housing variable. From Table 2 we conclude that the role of the housing market is relatively important in the German case.

For both markets it is interesting to know a little more about ownership. Ownership is relevant to transmission. For the equity market it is hard to get an idea of the ownership structure though. La Porta et al. (1999) provide some information on the ownership of listed firms for both medium-sized and large publicly traded firms. We give the data for the six economies of interest in Table 3. From this table it can be seen that German equity holdings are not that publicly as in the more market-based economies. Medium-sized firms are relatively more owned by the controlling families. Large firms are relatively more owned by financial institutions and the government.

Finally, we provide some institutional data on the housing market (see Giuliadori, 2003) in Table 4. In this table we provide information on the ownership structures in the upper panel. We can observe that relatively few houses are occupied by owners in Germany. There is more rental activity. In principle this will complicate a housing price channel, but it is not said that house-owners will not transmit revaluation into rental tariffs. In the lower

panel we give some mortgage system information. Germany has a relatively large fraction of mortgage loans, the contracts are typically longer, but the mortgage loan costs are comparable to the foreign equivalents.

4 Literature

4.1 The history of VAR-methodology

Vector autoregressions have become an important tool since Sims (1980) criticized large-scale macroeconometric models for assuming unfounded identifying restrictions. One of the main issues in the analysis of the properties of vector autoregressions is the (use of theory in order to come to) identification of so-called structural shocks (this leads to a structural vector autoregression, SVAR). Sims suggested solving the identification of the contemporaneous structure of the model by using a recursive (orthogonalized) structure. This implies that there is no contemporaneous feedback from the variables mentioned at the end of the ordering on the variables on top. Although theory can play a role in such a recursive scheme, the lack of simultaneity led Bernanke (1986), Blanchard and Watson (1986), and Sims (1986) to propose a larger role for economic theory in formulating plausible restrictions on contemporaneous interactions among variables. This implies that the recursivity can be replaced by other more simultaneous structures (at least conserving the number of identifying restrictions). After that Blanchard and Quah (1989) and Gali (1992) suggested to impose so-called long-run restrictions on impulse response functions to allow for instance for inflation not to have an impact on output. As Faust and Leeper (1997) argue, imposing long-run restrictions of this type requires the VAR to satisfy strong dynamic restrictions.

Pesaran and Shin (1998) criticized the orthogonal impulse-response analysis (Cholesky-decomposition) and advocated to use so-called generalized impulse-response analysis. These generalized impulse responses from an innovation to the j -th variable are generated by applying a variable specific Cholesky factor computed with the j -th variable at the top of the ordering. These impulses therefore do not depend on the initial ordering of the variables. A major disadvantage of the generalized impulse response analysis is that the results are completely a-theoretical and lack any obvious interpretation in principle. The major advantage is that the shock patterns observed appeal more to historical data and covariations.

Following the Granger representation theorem vector autoregressions can easily be transformed into a so-called Vector Error Correction model (see Garratt et al., 2003). In a VECM apart from the standard lagged differenced

dependent vectors, stationary linear combinations of the levels of the variables are added. These cointegrating vectors describe the long-run equilibrium of the model. It is obvious that economic theory is needed to identify these long-run vectors. Garratt et al. show that it is possible, at least in principle, to combine long-run VECM restrictions and short-run theoretical restrictions in the so-called SVAR.

There is a debate on the use of cointegrating relations in VAR-models. As Sims et al. (1990) showed, a VAR model of I(1)-variables can be estimated unrestricted (at least asymptotically) if there are sufficient cointegrated relations. Estimating a VECM with ill-specified (or arbitrarily chosen) long-run vectors will lead to biased impulse-response functions. Estimating the VAR in first-differenced stationary variables leads to a loss of information though.

4.2 Identifying monetary policy shocks

Identifying monetary policy shocks using times series information is not simple. It would be easy to simply look at actions of monetary policy makers (e.g. policy interest rate increases), but policy makers respond to non-monetary developments. If demand for goods increases and supply is fixed (as will be likely in the short run), an interest rate increase will reflect this demand change and not so much a step towards monetary contraction. So one needs to know the structure of the economy in order to understand and interpret monetary shocks.

As Christiano et al. (1999) argue the literature explores three general strategies to isolate monetary policy shocks. The first uses economic identification to estimate central banks' feedback rules. Here one assumes that the monetary policy instrument, e.g. the policy interest rate, is well known and accepted, that the contemporaneous determinants of this policy rate are known, and that the dynamics of interaction between the policy rate and the other variables can be traced. One can directly estimate a forward-looking monetary policy reaction function, like Rudebusch (1998) does for a Taylor-rule, or estimate a prototype VAR. Identification of monetary policy shocks can be performed by assuming orthogonalized shocks or by imposing structure in a SVAR (see Sims and Zha, 1995, or Bernanke and Mihov, 1998). A second way to identify monetary policy shocks is to look at data like board meetings to try to distillate policy shocks (see Romer and Romer, 1989). A third method to identify shocks is to assume that they don't affect

real variables in the long run (see Gali, 1992). As explained above, this approach has been criticized. In long-run models, like VECM's, no attention to monetary shocks is given.

4.3 VAR-models and asset prices

There are numerous VAR-studies on monetary transmission. The basic interest in VAR-models indeed originated from the interest in monetary transmission and the Lucas-critique on large-scale structural modeling (all the references given above apply to this field). As Christiano et al. (1999) argue the models can be classified according to the specification of the monetary reaction function. Central banks can focus on monetary aggregates (M2, M3), interbank aggregates (like (non)-borrowed or total reserves, see Bernanke and Mihov, 1998), interest rates (like the Taylor-rule, Taylor, 1993) or even on the interaction between interest and exchange rates (see for instance Kim and Roubini, 2000, Cushman and Zha, 1997, and Clarida and Gertler, 1997).

In general terms one can argue that misspecification is a common theme in VAR-models. Misspecification can originate from a wrong interpretation of the art of monetary policy to the lack of including relevant variables. One of the common features of monetary VAR-models is the so-called price puzzle. In lots of postwar business cycles a rise in inflation was preceded by an increase in interest rates and commodity prices (see Eichenbaum, 1992). Leaving commodity prices out or ignoring indicators of future inflation leads to substantial price puzzles in numerous VAR-models. Barth and Ramey (2000) argue that the cost channel may be an important part of the monetary transmission mechanism. They argue that if working capital is an essential component of production and distribution, monetary contractions can affect output through a supply channel as well as the traditional demand-type channels. An increase in the interest rate will increase production costs and lower output. So, generally spoken, modern VAR-studies are not so much troubled by the price puzzle (after controlling for other demand and supply shocks).

Here we concentrate on a special element of VAR-models, namely the interest in the role of asset prices. Rapid changes in asset prices can lead to real effects. For instance Lettau et al. (2002) report a strong wealth effect on consumption in the US using an SVAR-model. The IMF (2002) reports a robust international wealth effect, especially via equity prices in market-

based economies. Bernanke et al. (1999) present a theoretical model that includes a so-called financial accelerator that can support the empirical findings. This model is extended with an equity market in Bernanke and Gertler (1999), while Aoki et al. (2002) include a housing market.

Besides the broad establishment of wealth effects there is also a lively debate on the role of asset prices in monetary policy. The general notion in favor of including asset price fluctuations in monetary policy rules is that an asset price bubble is socially unwanted. The disruptive effects of the bursting of the bubble lead to real effects of various kinds (economic growth, investment, income distribution, soundness of the financial system), which should be avoided by a central bank. There are disadvantages of using monetary policy in trying to avoid bubbles though. As Dornbusch (1999) argues there are two major disadvantages. First, there is a tendency towards an asymmetric response to asset price changes. A sudden widespread slump in assets prices will lead to a large provision of liquidity. A central bank is concerned about trust in the financial system and wants to provide stability. An asset price boom should then lead to an increase in interest rates, but the general public will typically not appreciate this. Knowing the likely reaction of central banks, there will be a moral hazard problem that leads to overly risky investment, possibly creating a bubble. Secondly, the credibility of a central bank might be lowered. Asset prices are volatile and typically hard to predict. Responding on a day-to-day basis may reduce credibility.

The following items seem to be relevant in this discussion:

1. Should measures of the general price level include asset prices?
2. Should there be target levels for asset prices?
3. Should asset prices be included as indicators in a direct inflation strategy?
4. Should monetary policy makers react stronger to asset prices than item 3 prescribes?

The majority of opinions says no to the first two items. It is very hard to estimate the true value of individual stock for instance, so how could a central bank be able to value all assets appropriately? In the System of National Accounts it is common to measure price indices based on flow transactions in goods. Including prices of stocks or assets would blur this system. Moreover, one could argue that if asset prices were relevant, they would be leading indicators in decisions. Moreover they can be leading indicators without being included in the indicators of the current general price level.

The empirical research on the second two items can be divided into two competing views. On the one hand, papers by Bernanke and Gertler (1999, 2001) argue that a central bank should not respond to asset price fluctuations. On the other hand, Cecchetti *et al.* (2002) and Filardo (2001) come to the opposite conclusion. Bernanke and Gertler analyze the role of an exogenously determined flexible inflation-targeting rule in a sophisticated dynamic new-Keynesian model with credit market frictions. Their main idea is that if asset price changes are important they should translate into changes in expected inflation and via that channel have their impact on monetary policy. A central bank should not try to target asset prices. Cecchetti *et al.* argue that one should use an optimal monetary policy rule that takes into account all information. Ignoring asset price changes will lead to sub-optimal outcomes. But a central bank should be able to distinguish asset price bubbles in the Cecchetti *et al.* model. Filardo (2001) argues that a central bank should respond to asset price movements as long as they provide some information about inflation or output, even if the prices are driven by bubbles or not. It should be clear though in the Filardo-model how asset price fluctuations affect real variables. If this is not clear, the expected costs of responding to asset price changes might be too high.

So both wealth effects and monetary policy reactions to asset price changes are found to be relevant and could possibly lead to better specifications of VAR-models. In principle three assets are used in empirical studies: equity, housing, and liquidity. We don't focus on liquidity here, but review some of the results found for equity transmission and housing market studies.

Ludvigson and Steindel (1999) analyse the impact of wealth on consumption. Using a VAR-model they find that there is a contemporaneous impact from wealth on consumption. Lettau *et al.* (2002) construct an SVAR for the US and include household asset wealth in a consumption model. They conclude that the impact of shocks to the Federal Funds Rate via wealth components is not so strong, but direct interest rate effects are. Asset values can be influenced by other sources (like price increases or upturn of the business cycle) and can be amplified into consumption.

Lastrapes (2002) estimates the dynamic response of aggregate owner-occupied housing prices to money supply shocks and interprets these responses using a dynamic equilibrium model of the housing market that relies on the asset view of housing demand. Money supply shocks are

identified empirically from a vector autoregression. Using monthly data, he finds that money shocks have real effects on the housing market: both real housing prices and housing sales (new starts and existing homes) rise in the short-run in response to positive shocks to the money supply. Giuliadori (2003) gives an extensive overview of the role of house prices in the Euro-countries. He estimates SVAR-models for several countries (Belgium, Finland, Ireland, Italy, the Netherlands, Spain, Sweden, and the UK) and links the results to facts of financial structure (like Cecchetti, 1999). Giuliadori includes inflation, GDP, real house prices, the interest rate and the exchange rate as the key variables. Iacoviello (2000) estimates VAR-models for six European Economies to explain house price movements. He finds a substantial impact of monetary policy on house prices. Using a sample of France, Germany, Italy, Spain, Sweden, and the UK) Iacoviello specifies a five-dimensional VAR with output, real house prices, real money, a short-term interest rate and inflation. He finds that a contractionary monetary policy has a negative impact on real house prices (to a similar extent as output), especially in the UK and Italy (while moderate effects appear for Germany).

There are not so many VAR-studies that include equity prices. Goodhart and Hofmann (2001) is an exception. They assess the role of asset prices as information variables for aggregate demand conditions and in the transmission of monetary policy. By looking at reduced form coefficient estimates and VAR impulse responses Goodhart and Hofmann derive Financial Conditions Indices, a weighted average of the short-term real interest rate, the effective real exchange rate, real property and real share prices, for the G7 countries. They find that house and share prices get a substantial weight in such an index and that the derived Financial Conditions Indices contain useful information about future inflationary pressures. Elbourne and Salomons (2003) estimate an 8-variable VAR for EU-countries and find no substantial equity wealth effects (except for the UK and the outside Japan).

4.4 VAR-models of Germany

Many VAR-models for Germany have been developed. We limit ourselves here to SVAR-models and models that focus on monetary transmission. In an early study Weber (1996) analyzes the determinants of the post-unification downturn in Germany using an SVAR-model. The results suggest that German business cycles were not all alike. Whilst adverse

supply shocks clearly matter before unification, it is primarily adverse aggregate demand shocks and a too tight monetary policy, which dominate the German post-unification decline in output growth rates. Bernanke and Mihov (1997) apply a structural VAR to determine the historical optimal indicator of German monetary policy and find that the Lombard rate has historically been a good policy indicator. Peersman (2002) estimates an SVAR-model that links short and long run interest rates in Germany. He finds a positive correlation after a supply and demand shock and a negative correlation after a monetary policy shock. Kakes and Sturm (2002) analyze monetary policy transmission according to the credit channel by assuming heterogeneity between banks. Banks hold important positions in the German economy, which justifies such an approach.

There have been a number of VAR-studies on the EU-level that include the German case. In the Monetary Transmission Network of the European Central Bank Mojon and Peersman (2003) review VAR-models for 10 EU-countries. They classify the countries according to their monetary integration with Germany. Apart from the first class, Germany itself, there are core-Germany countries, like the Netherlands or Austria, and other EU-countries. Mojon and Peersman find output effects from a tighter monetary policy, falling prices and a rather common pattern across countries. Peersman and Smets (2001) estimate an area-wide identified VAR for the euro area. They find for the EU similar effects as have been found in the analysis of US monetary policy. On the G-7 level Canova and De Nicrolo (2002) examine the importance of monetary disturbances for cyclical fluctuations in real activity and inflation. They employ a novel identification approach, which uses the sign of the cross-correlation function in response to shocks to assign a structural interpretation to orthogonal innovations. They find that identified monetary shocks significantly contribute to output and inflation cycles in all G-7 countries.

5 Vector Autoregression

5.1 A basic VAR-model

Data are taken from the EUROMON-source, produced by the Dutch central bank (see for a description of the data the appendix). First we estimate a basic five-variable VAR-model of the German economy for the 1978.4-2000.4 sample (with quarterly data). This period covers the basic EMS-period and the start of the euro-area. This VAR model includes reference series like GDP, the CPI, domestic credit to the private sector (CR, as the indicator of monetary stance), the nominal trade weighted exchange rate (EX), and the short-term money market interest rate (RS). We use the latter variable as the indicator of monetary policy. Identified shocks to the interest rate will be interpreted as monetary policy changes. Officially, this might not have been the monetary strategy of the Bundesbank, but de facto interest rate was used in the EMS-period as monetary policy variable (see also Bernanke and Mihov, 1997).

The dependent vector is [GDP, CPI, CR, EX, RS]. All variables, except RS, are in logs. We tested for stationarity of the series. All series are found to be of order $I(1)$, although the first difference of the log of the price level is found to be a borderline case (see Table 1). We use the Sims et al. (1990) principle and do not investigate co-integrating relations in the VAR (using the Johansen-test we find two co-integrating relations). Including misspecified co-integrating relations would lead to spurious impulse-response findings, while estimating the model in first differences would lead to a loss of information in the levels. We included three exogenous variables in the VAR in order to capture world economic development: relevant world trade (WT), a world commodity price index (PC), and the US short-term interest rate (RUS). Although Germany is a large economy, it will be dependent on world developments. Moreover, we might reduce the so-called price puzzle including a world commodity price index. As Barth and Ramey (2000) show, the price puzzle might be due to the ignorance of the so-called cost channel of monetary policy. The costs of working capital are the crucial variable in this respect. We tested for normality of the residuals of the equations in the VAR, since we include the reunification period.

The ordering of the variables is relevant in a Cholesky factorization of the variance-covariance residual matrix. We assume that shocks to output are basically driven by supply elements, that prices are rather sticky, credit

largely dependent on output changes and the single asset price, the exchange rate, endogenous to a large extent. The policy interest rate is assumed to be responding to all other variables in the system.

Experimenting with the lag structure we found three lags. It is good to note that the lag-length criteria did not hint at one specific lag length due to the flatness of the optimization surface. As explained above, there are various ways to represent the analysis of shocks in a VAR-model:

- one can compute the orthogonalized impulse response functions. This is the solution offered by Sims (1980) and is labeled the Cholesky decomposition.
- One can impose theoretical structure on the short-run contemporaneous impact and restrict the A-matrix to an identified matrix. This approach is known as the SVAR (see Bernanke, 1986).
- One can impose theoretical structure on the long-run impact of contemporaneous shocks. This is the approach proposed by Blanchard and Quah (1986) and Gali (1992), but criticized by Faust and Leeper (1997).
- One can impose 'realistic' shocks by so-called Generalized Impulse Response functions (see Pesaran and Shin, 1998). Realistic shocks are taken from the estimated variance-covariance matrix of the residuals. Using GIR's the ordering of the variable in the VAR becomes irrelevant.

Inspecting the variance-covariance matrix of the estimated residuals the covariance of the interest rate residuals with all other variables are rather large (especially the exchange rate residuals). This implies that imposing a structure on the A-matrix will change the IRF's. We will rely mainly on theoretical explanations of the shocks. For the specification of the SVAR we need to apply standard economic theory. We assume that output is fully determined by supply shocks:

$$e_Y = a_1 u_Y \tag{A.1}$$

and so is inflation:

$$e_P = a_2 u_P \tag{A.2}$$

Credit is determined by the demand for credit due to transactions and a price motive:

$$e_C = a_3 u_Y + a_4 u_C + a_5 u_R \quad (\text{A.3})$$

While the exchange rate is determined by output and interest rate shocks:

$$e_E = a_6 u_Y + a_7 u_E + a_8 u_R \quad (\text{A.4})$$

Finally we assume that the Bundesbank responded to shocks in output, assets, and inflation (via a so-called Taylor rule, see Taylor, 1993):

$$e_R = a_9 u_Y + a_{10} u_P + a_{11} u_C + a_{12} u_E + a_{13} u_R \quad (\text{A.5})$$

Summarizing in a contemporaneous matrix:

	u_Y	u_P	u_C	u_E	u_R
e_Y	a_1				
e_P		a_2			
e_C	a_3		a_4		a_5
e_E	a_6			a_7	a_8
e_R	a_9	a_{10}	a_{11}	a_{12}	a_{13}

Estimation of the SVAR yields estimated values of the matrix above. We do not give an interpretation to the parameters, since the estimation itself cannot identify precise values in such a simultaneous system (it should be noted that the overidentification test rejects the restrictions imposed. We know that these overidentification tests hold asymptotically only and are too restrictive in smaller samples). So we proceed by analyzing the IRF's for this model. For our base model we present three sets of outcomes in Figures 1 and 2. Figure 1 illustrates a monetary shock. This shock leads both to an output and a prize puzzle in the above-mentioned Cholesky decomposition, which troubles the interpretation. Figure 2 presents the SVAR-impulse responses to a monetary shock. Here we observe that there is a significant contraction of output after 2 quarters. So imposing structure on the contemporaneous matrix matters to the interpretation of the shocks. Variance decomposition analysis shows that fluctuations in output and credit are substantial in the explanation of shocks in the interest rate (inflation shocks are no prominent components).

5.2 Extending the model with housing and equity prices

Knowing the properties of the base model we next extend the VAR-model with two additional variables: the real house price index PH and the equity price PEQ. Both housing and equity will affect consumption and investment behavior (which we will roughly proxy here by GDP). So we extend our dependent vector to: [GDP, CPI, CR, PH, PEQ, EX, RS]. We treat housing and equity similar to the asset price included in the model: the exchange rate. The other model properties remain the same: we use three lags, include the world commodity price index, the world trade index and the US interest rate as exogenous variables. We again estimate the model in levels using the 1978.4-2000.4 sample. Testing for integration of the real asset prices leads to the conclusion that both are stationary after differencing. Testing for co-integration reveals possibly four co-integrating vectors, but again we rely on the Sims et al. (1990) result to proceed in an unrestricted VAR.

In the SVAR we again assume (A.1) to (A.5): for the interest rate we extend the responses to asset price changes accordingly. Moreover we add symmetrical equations for the shocks in housing and equity as for the exchange rate:

$$e_{PH} = b_1 u_Y + b_2 u_{PH} + b_3 u_R \quad (A.6)$$

and

$$e_{EQ} = b_4 u_Y + b_5 u_{EQ} + b_6 u_R \quad (A.7)$$

In Figure 3 we plot the IRF's from the SVAR impulse-response functions for the monetary shock. From Figure 3 we observe that there is a significant short-run output decrease, with the peak effect after one and a half year. The price puzzle is insignificant, while real credit contracts and the real housing price falls.

What about shocks to the housing and the equity markets? How do these shocks affect output and the monetary response? Figures 4 and 5 contain plots for the SVAR-model for shocks to the housing and the equity prices. Figure 4 shows that a housing price shock (labeled by shock4) has an impact

on the general price level and so on monetary policy responses. Equity price shocks (labeled by shock5) virtually have no impact on real development.

Finally, we derive the impact of all structural shocks to unexplained variance of the monetary policy instrument equation: the short-term interest rate. Knowing the sources of this unexplained variance might help in deriving insight into the monetary policy reactions to shocks of various natures. Table 6 gives the contributions of the various shocks to the explanation of interest rate unexplained variance for various quarters. We observe that in the short run housing shock variance is important. In the longer run real GDP and equity price shocks become more relevant. There is no serious evidence that e.g. inflation has a large impact on monetary policy. Compared to the model without asset prices (see the previous section) we find that credit loses its role to housing and equity.

One of the basic issues in monetary VAR-models is the role of expectations. How does the central bank assess inflationary conditions and use its monetary policy instruments to correct any unwanted developments? It is generally believed that asset prices add more information on future output and inflationary developments (see Bernanke, 2003). Suppose that, as Bernanke and Mihov (1997) argue, the Bundesbank indeed followed an inflation targeting approach. In that case it is likely that it will have used not only inflationary forecasting devices, but also indicators of real economic activity, like the output gap. Following Taylor (1993) central banks are believed to respond on output gap and inflationary developments (the latter being more important in the German setting than in e.g. the US). Given the information lag in (mostly revised) figures (see Orphanides, 2002) it is rather unlikely that the GDP-series takes this informational role. As Flaig and Plötscher (2001) illustrate, the IFO-indicator does carry an informational role in describing and predicting the German output gap.

If we include the interest equation as a monetary feedback rule, we therefore should use a business cycle like the IFO-climate indicator. In this section we assess the role of this indicator. Figure 6 gives the Impulse Response Functions for the base SVAR-model with the IFO-climate indicator instead of GDP. Compared to Figure 3 we observe that the output and inflation variables behave more as expected. There is a more rapid contraction of the IFO climate indicator after 3 to 4 quarters instead of two years for GDP. We also observe the expected negative impact on inflation, although the lag length seems to be rather long. Only after a couple of years a monetary shock will reduce inflation. The other impacts remain rather similar to the ones we observed in Figure 3.

Figures 7 and 8 present the model with the IFO-climate indicator and housing and equity shocks. We again observe that housing price shocks (labeled by shock4) affect inflation. The inclusion of the IFO-Climate indicator predicts a quicker response of inflation to house prices than the GDP-model. The interest rate response is also more sustained in the case of the IFO-indicator.

Finally in Table 7 we present the variance-decompositions of the monetary policy equation using the IFO-climate indicator instead of GDP. Comparing Tables 6 and 7 we observe that the IFO-climate indicator takes a larger

fraction to explain monetary policy shocks than output (as we expect).
Housing prices remain important signaling variables, but equity loses its role
(to the IFO-Climate indicator).

7 Summary and conclusions

In this paper we analyze the role of asset prices in German monetary policy. Asset prices play various roles in monetary policy. They are believed to contain large sets of information. Forward-looking monetary policy should therefore include asset price information. We present a review of the theory of asset price transmission. Moreover, we illustrate that the German case is interesting to review, especially in terms of housing. The German housing market is relatively large compared to housing markets in other economies.

Using Vector Autoregression models we analyze the impact of monetary policy and asset price shocks. We show that including asset prices helps in understanding output and inflation responses. We impose a contemporaneous theoretical structure on the economy to be able to identify the shocks. Generally we find that the expected negative impact on output and the CPI is found in the model with asset price effects (and not so much in the model without). We have some concern about the lag of the peak effects. To that extent we include the IFO Climate indicator instead of output in our model. Indeed we observe a quicker response to monetary shocks, more plausible inflation effects and qualitatively similar impact on the other variables in the model. Analyzing housing and equity shocks reveals that house price shocks have a substantial impact on inflation and so on monetary responses. This conclusion holds for the model with GDP and the model with the IFO climate indicator. Analyzing the variance decompositions of the various models shows that house prices have a serious impact on monetary policy. This impact is enforced using the IFO Climate indicator.

How should we take account of these results? First of all our results might contribute to the discussion on the use of instrument rules versus targeting rules. As Bernanke and Mihov (1997) show it seems that the Bundesbank used some kind of inflation targeting strategy. Our results basically confirm this view and point at house prices being a crucial variable. This result weakens the role of Taylor-rules, in which the full attention is given to output gaps and inflation itself in explaining momentary policy reactions.

Secondly and in line with the previous conclusion, one should have some concern about the large variety of variables influencing monetary policy in terms of the modeling strategy to analyze these effects. One cannot use a

VAR-model of 20 variables over such a short time span. A suggestion made by Giannone et al. (2002) is to use factor analysis prior to going to a VAR-model. It is rather unlikely that in a high-dimensional VAR all the shocks will be independent. So Giannone et al. advocate using the principal components of all shocks. As we show in the German case, including a housing variable as one of the key shocks seems to be relevant.

Finally, a future avenue of research would be to analyze the housing market more in depth than we do in our reduced form model. Here one can think of a model in the spirit of Aoki et al. (2002) who present a dynamic stochastic general equilibrium model. This type of model could underpin the structure to identify the shocks in the short run, but also give directions to identify likely long-run effects.

Table 1 - Financial system indicators

	France	Germany	Italy	Japan	UK	US
Private credit by deposit money banks to GDP	80.9	93.6	53.1	102.4	79.1	64.3
Concentration of banks	34.5	38.6	30.6	18.3	45.0	21.1
Net Interest Margin	3.3	2.9	3.9	2.0	2.3	4.4
Stock market capitalization to GDP	22.6	19.1	13.6	68.0	82.6	64.9
Stock market total value traded to GDP	11.1	18.3	6.5	34.7	38.0	46.0
Stockmarket turnover ratio	39.7	85.7	38.8	48.6	40.3	62.8
Private bond market capitalization to GDP	42.5	48.1	30.4	43.2	16.6	79.5
Public bond market capitalization to GDP	32.7	22.9	91.2	52.3	30.2	56.1

Source: World Bank web-page:

<http://www.worldbank.org/research/projects/finstructure/index.htm>

Financial Structure Indicators, averages over 1978-1998.

Table 2 - Housing and equity wealth indicators (percentages of GDP)

	France	Germany	Italy	Japan	UK	US
Housing	377.0	686.4	514.9	309.1	407.0	426.4
Equity	529.9	532.1	547.5	374.3	602.4	616.4

Source: EUROMON Database, De Nederlandsche Bank. The housing wealth is computed as the rebuilding value of the stock of private owner occupied houses (assuming a lifetime of 50 years). The equity wealth is computed as the value (traded and non-traded) of the capital stock (not owned by debt-holders). Here we assume an annual depreciation of 6 percent per year. The figures are averages over 1978-2000.

Table 3 - Equity ownership indicators (fractions)

	France	Germany	Italy	Japan	UK	US
Medium-sized firms						
Widely held	0	0.1	0	0.3	0.6	0.9
Family	0.5	0.4	0.6	0.1	0.4	0.1
State	0.2	0.2	0	0	0	0
Widely held financial	0.2	0.1	0	0	0	0
Widely held corporate	0	0.1	0.1	0	0	0
Miscellaneous	0.1	0	0.3	0.6	0	0
Large publicly traded firms						
Widely held	0.6	0.5	0.2	0.9	1	0.8
Family	0.2	0.1	0.15	0.05	0	0.2
State	0.15	0.25	0.4	0.05	0	0
Widely held financial	0.05	0.15	0.05	0	0	0
Widely held corporate	0	0	0.1	0	0	0
Miscellaneous	0	0	0.1	0	0	0

Source: La Porta et al. (1999).

Table 4 - House market indicators

	France	Germany	Italy	UK
Housing tenure structure				
Owner occupation rate	54	40	75	67
Social rental occupation rate	21	20	3	23
Private rental occupation rate	17	40	22	10
Other	8	0	0	0
Mortgage systems				
Residential mortgages/GDP	21	51	7	57
Typical term	17.5	27.5	10	25
Typical Loan-to-Value ratio	75	70	50	92.5
Transaction costs	7.5	7.1	7.4	1.5

Source: Giuliadori (2003).

Table 5 - Unit roots tests

	ADF-levels	ADF first differences
GDP	-0.532	-4.294
CPI	-1.988	-1.727
CR	-0.531	-2.080
PH	-1.109	-3.269
PEQ	-0.113	-7.226
EX	-2.209	-6.193
WT	0.966	-2.674
PC	-2.670	-6.167
RS	-1.022	-5.397
RSUS	-1.060	-8.138
IFO Climate	-0.301	-4.919

ADF = augmented Dickey-Fuller test: lag length selection based on Akaike.

Table 6 - Variance-Decomposition of interest rate residuals (SVAR)

Period	GDP	CPI	CR	PH	PEQ	EX	RS
1	8.93	1.27	0.00	89.41	0.03	0.02	0.34
4	36.33	0.37	1.22	49.70	6.70	4.75	0.93
8	38.66	0.32	4.03	21.37	26.45	2.25	6.93
12	31.83	2.84	5.13	14.38	36.68	1.69	7.45
20	24.37	13.16	3.69	10.83	30.65	2.55	14.75

Table 7 - Variance-Decomposition of interest rate residuals (SVAR) for the IFO-climate indicator

Period	IFO Climate CPI	CR	PH	PEQ	EX	RS	
1	0.43	1.19	0.00	98.09	0.04	0.01	0.24
4	10.17	1.40	2.50	78.34	1.24	5.09	1.26
8	45.69	4.90	4.73	31.79	2.96	3.73	6.19
12	51.35	8.95	3.77	19.38	6.87	2.33	7.35
20	39.24	13.35	5.13	15.14	12.41	1.60	13.12

Figure 1 - Impulse-Response-functions: the impact of a monetary policy shock (Cholesky decomposition) in the 5-variable model

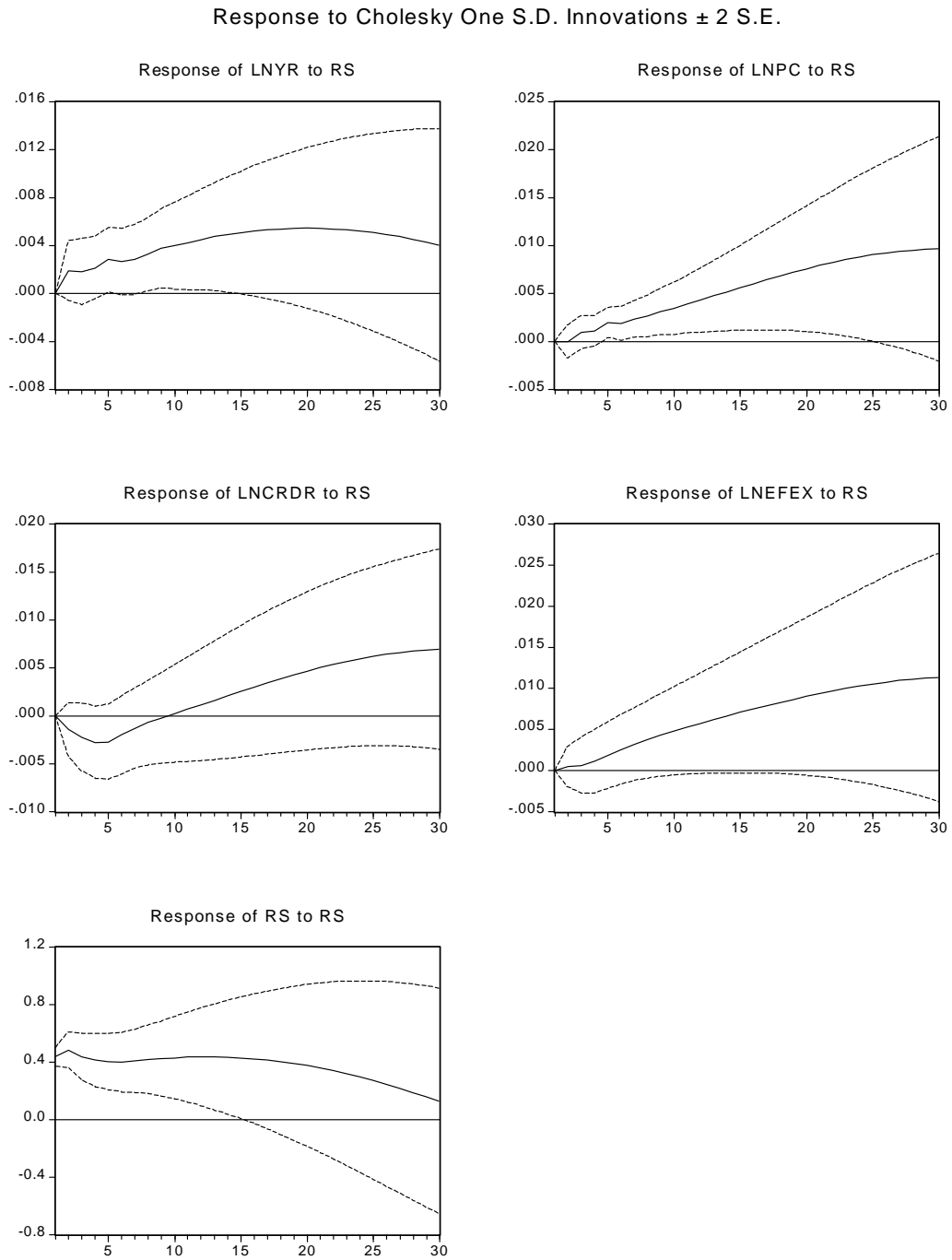


Figure 2 - Impulse-response-functions: the impact of a monetary policy shock (SVAR-factorization) in the 5-variable model

Response to Structural One S.D. Innovations ± 2 S.E.

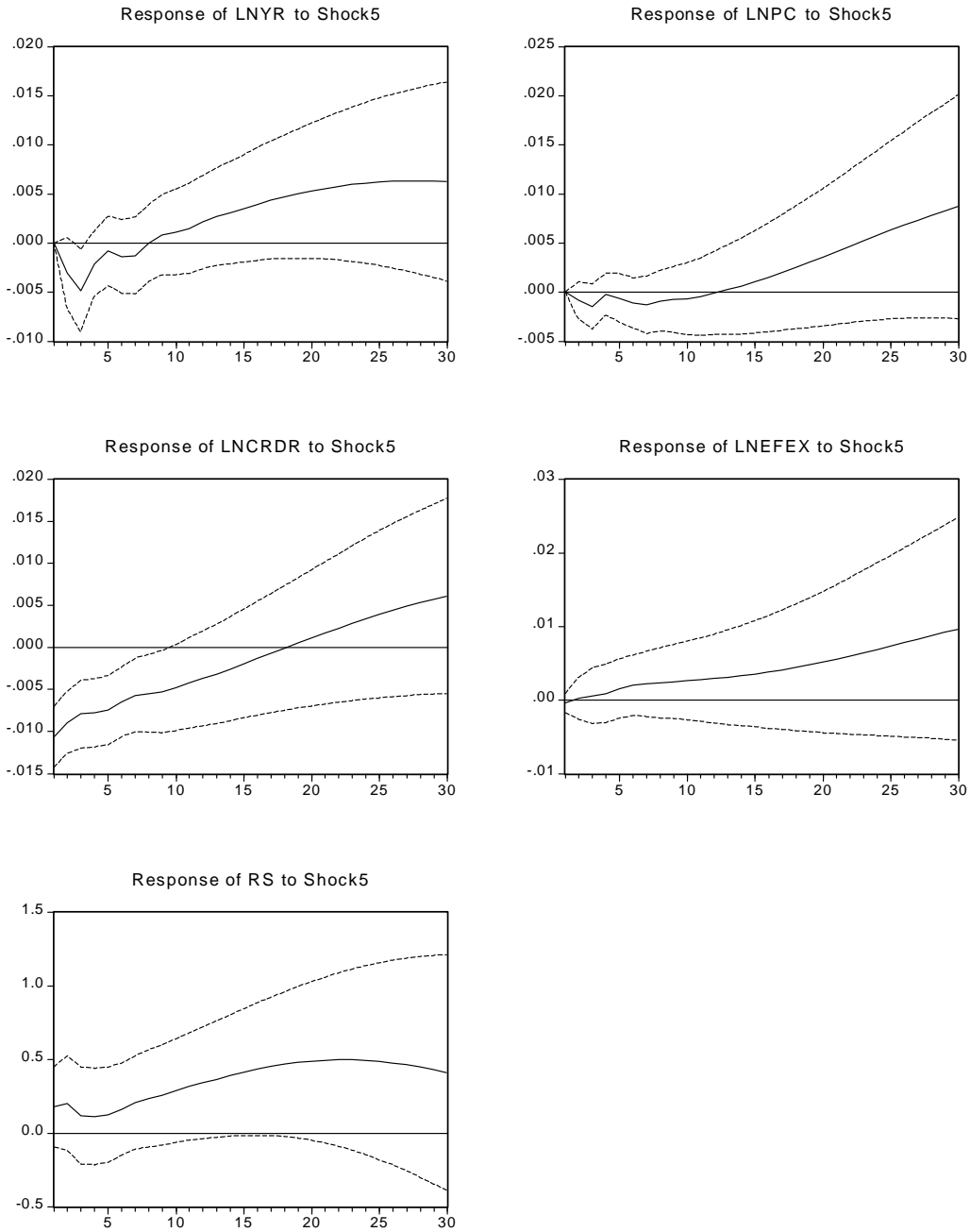


Figure 3 - Impulse-Response-functions: the impact of a structural monetary policy shock (SVAR factorization) in the 7-variable model

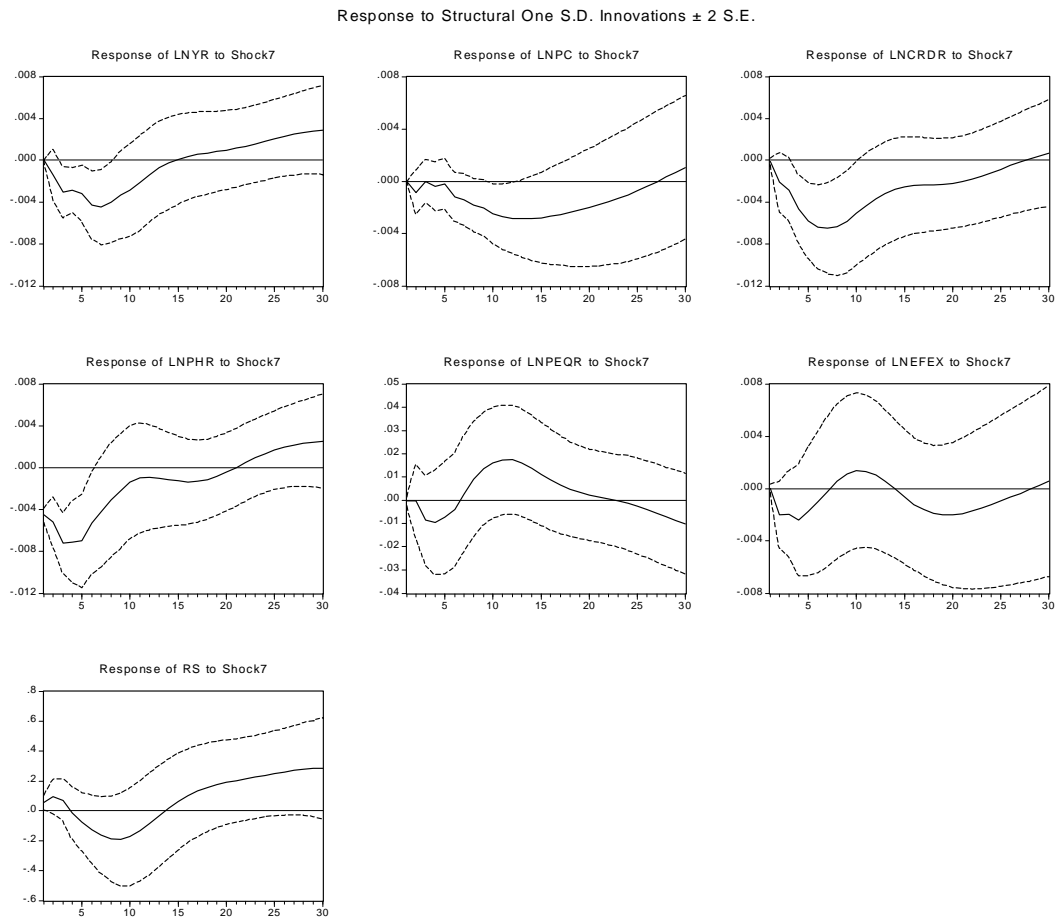


Figure 4 - Impulse-Response-functions: the impact of a structural housing price shock (SVAR factorization) in the 7-variable model

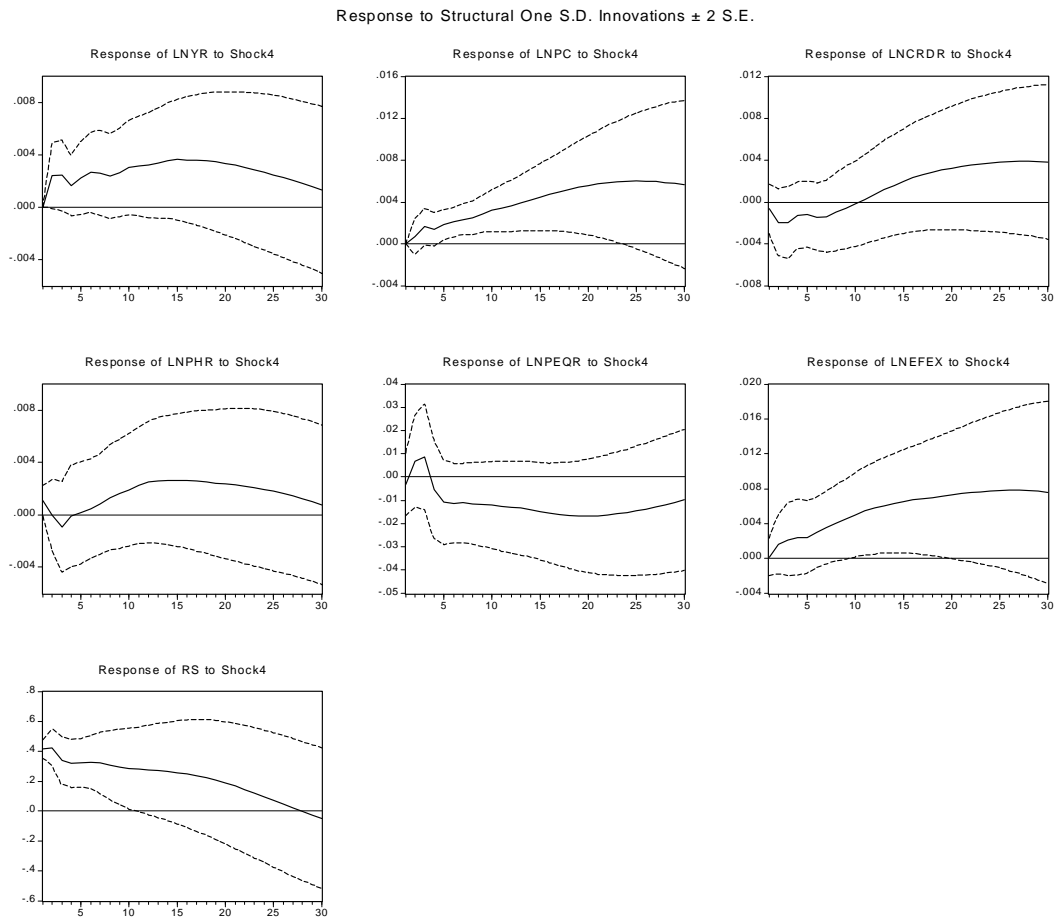


Figure 5 - Impulse-Response-functions: the impact of a structural equity price shock (SVAR factorization) in the 7-variable model

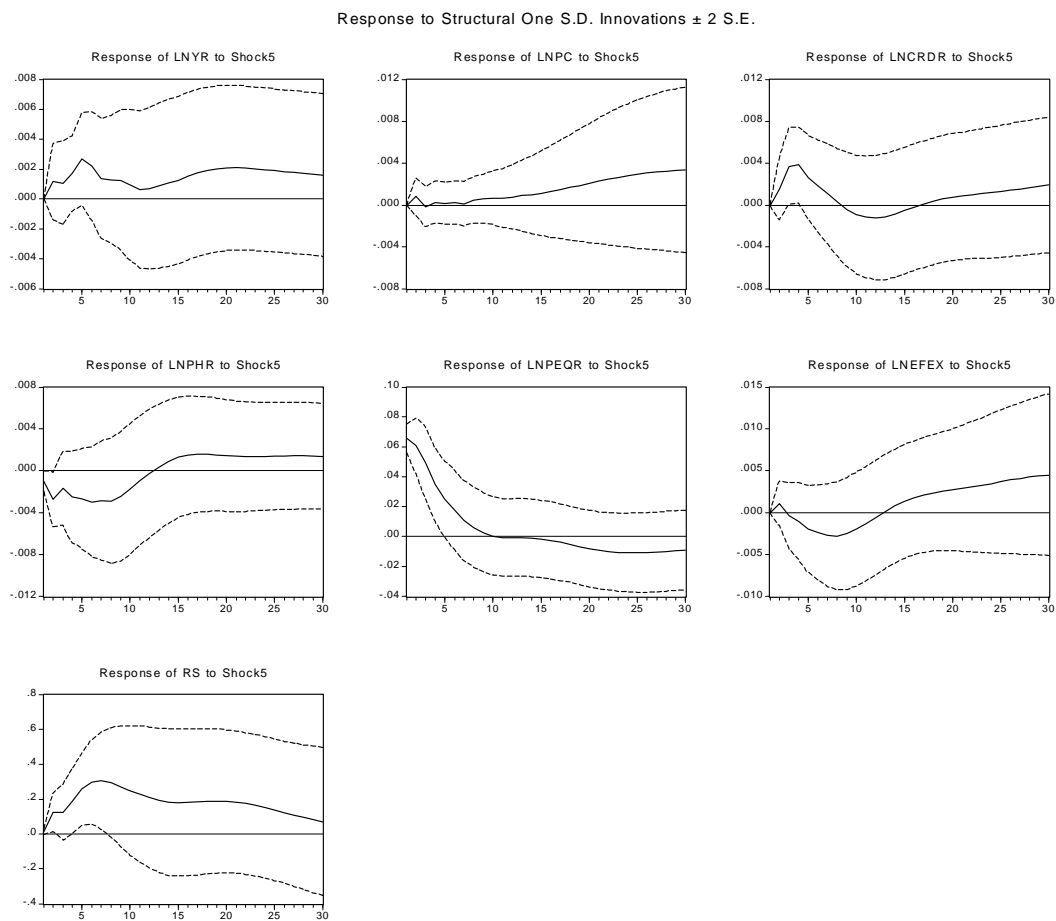


Figure 6 - Impulse-Response-functions for the model with the IFO Climate indicator: the impact of a structural monetary policy shock (SVAR factorization) in the 7-variable model

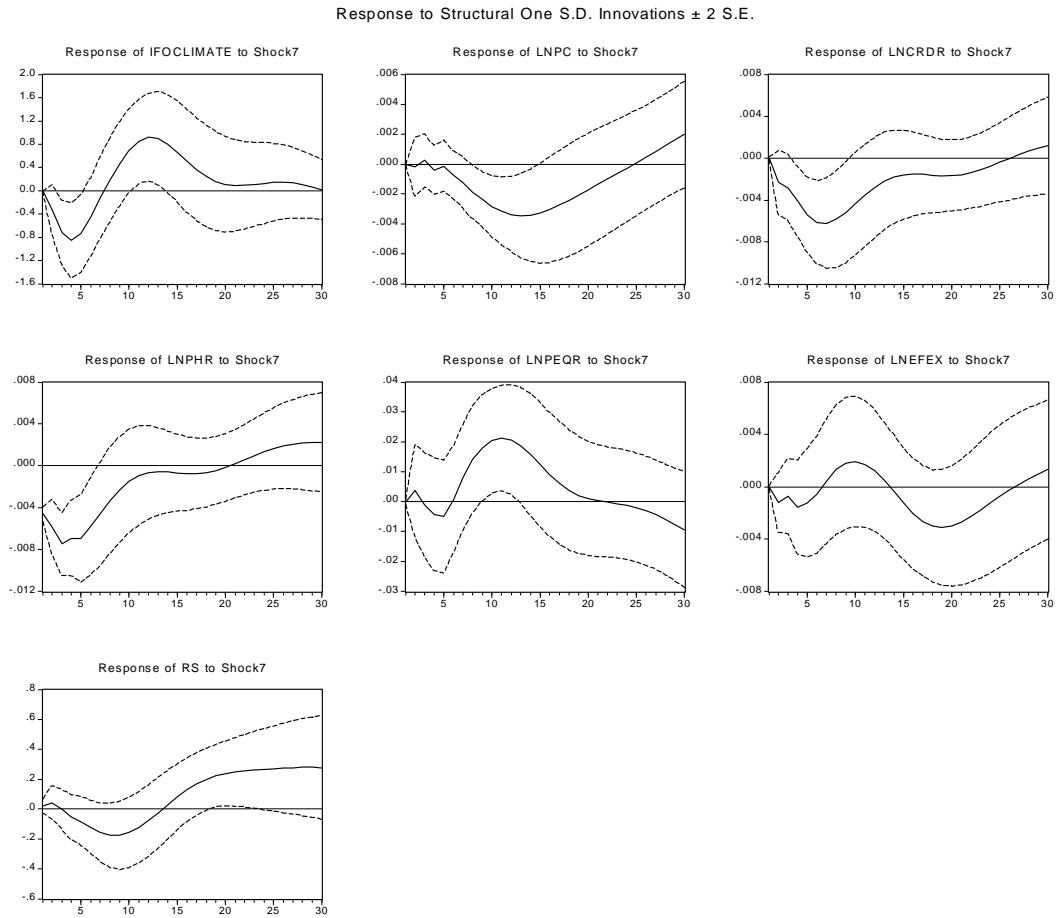


Figure 7 - Impulse-Response-functions for the model with the IFO Climate indicator: the impact of a structural housing price shock (SVAR factorization) in the 7-variable model

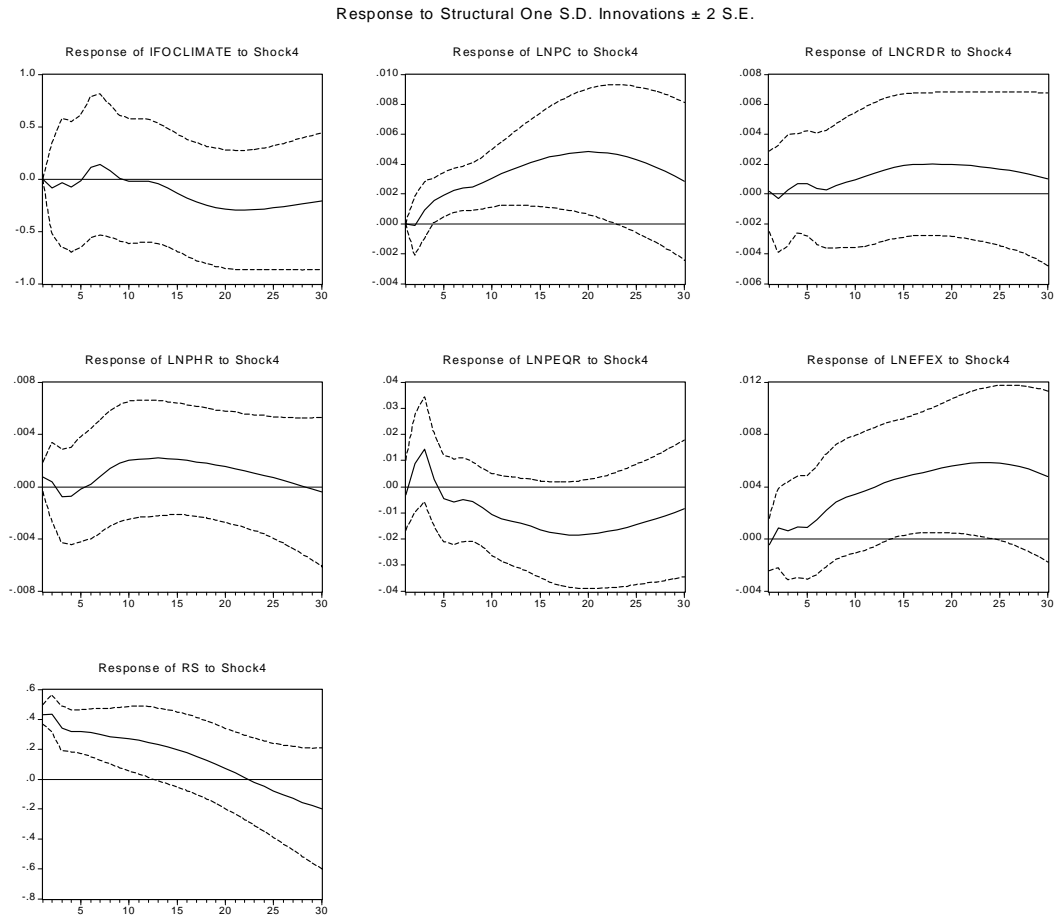
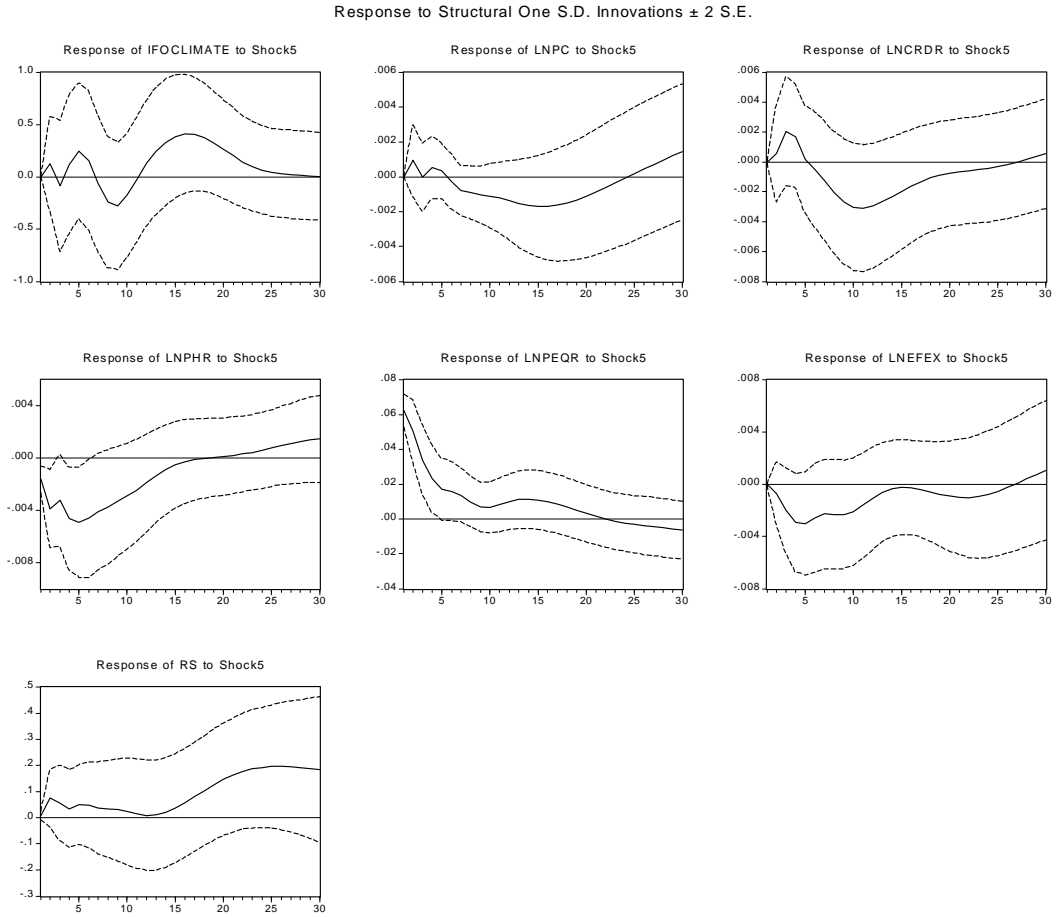


Figure 8 - Impulse-Response-functions for the model with the IFO Climate indicator: the impact of a structural equity price shock (SVAR factorization) in the 7-variable model



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Data Appendix

CR: Bank credit to the private sector.

Constant prices 1990. IMF, International Financial Statistics. Nominal figures have been deflated by the private consumption deflator.

EX: Nominal effective exchange rate.

Index 1990=100. Exchange rates from Datastream. Weighted using calculated trade weights of 1990.

MW: Relevant world trade.

Volume index 1990=100. Weighted import volumes of 12 other countries in the EUROMON dataset, using calculated trade weights of 1990.

KB: Market value of equity of the business sector.

$$KB = KBR * PEQ/100$$

KBR: Real value of equity of the business sector

$KBR = KBR(-1) + IBR - D * KBR(-1)$, where annualised depreciation rate $D = 0.06$. Starting value derived from OECD, Flows and stocks of fixed capital.

IBR: Investment in fixed assets of the business sector, constant prices 1990. Calculated as total investment in fixed assets minus residential investment and government investment. Source: OECD National Accounts and Quarterly National Accounts. We interpolated annual data for government investment and residential investment.

PEQ: Share price index 1990=100. IMF, International Financial Statistics.

KH: Market value of stock of private owner occupied houses.

$$KH = KHR * PH/100$$

KHR: Rebuilding value of stock of private owner occupied houses

$KHR = KHR(-1) + IHR - D * KHR(-1)$, where annualized depreciation rate $D = 0.02$. Starting value derived from OECD, Flows and stocks of fixed capital.

IHR: Residential investment, constant prices 1990, OECD Quarterly National Accounts. We interpolated annual data.

PH: Residential property prices, index 1990=100. Source:

Germany - Bundesbank. Interpolation of annual prices in DEM 1000 of new or existing good quality 'Reihenhaus' in West Germany.

PC: Deflator private consumption.
1990=100. OECD National Accounts

PCOM: Price of commodities.
(in own currency), index 1990=100. Pre denominated in dollars converted into national currencies using dollar exchange rates.

RS: Three-month deposit interest rate (%).
De Nederlandsche Bank, Quarterly Bulletin.

YR: Gross domestic product.
Constant prices 1990. OECD National Accounts

IFO Climate index: see www.cesifo.de