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Monetary Policy and Business Cycle Asymmetry in Germany

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I. Introduction

There exist at least two strands of theories in the literature which predict that monetary policy is more effective in a recession than during a boom. The first is based on credit market imperfections. *Bernanke* and *Gertler* (1989), for example, develop a model in which asymmetric information gives rise to agency costs in the credit market which are reflected in the external finance premium. These agency costs are supposed to be inversely related to borrower net worth. The fact that net worth moves procyclically implies that agency costs rise in recessions and fall in booms, which creates a propagation mechanism, known as the 'balance sheet channel' or 'financial accelerator'. During an expansion firms largely finance themselves with retained earnings while balance sheets are strong, which implies that the external finance premium is relatively low. Hence, monetary policy measures affecting this premium do not have much impact. In a recession, however, when cash flows are low and firms become more dependent on external finance, monetary policy measures are more likely to have an impact: a monetary contraction causes interest rates to rise which deteriorates borrowers' balance sheets, increasing interest rates even further through the higher external finance premium. *Azariadis* and *Smith* (1998) develop a theoretical business cycle model based on credit market imperfections which specifies, under certain conditions, an endogenous regime-switching mechanism between different equilibrium states.

A second class of theories build on downward nominal price rigidities. *Ball* and *Mankiw* (1994) develop a model of asymmetric price adjustment in the presence of positive trend inflation, based on menu costs. This

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approach is consistent with a convex short-run aggregate supply curve, implying that during the expansionary phase – *i.e.* at the relatively steep part of the aggregate supply curve – monetary policy measures, represented by their impact on aggregate demand, are mainly translated into changes in the price (wage) level, whereas in a recession – *i.e.* at the flat part of the aggregate supply curve – monetary policy has more real effects.[1]

Besides theoretical explanations, asymmetric effects may also be the result of monetary policy being different over the cycle. Obviously, if recessions are to be considered as 'bad' and expansions as 'good', it may simply be the purpose of the monetary authorities to be only effective during a downturn. More generally, the stance of monetary policy may be related to the business cycle.[2]

The purpose of this study is to investigate whether asymmetric effects of monetary policy over the business cycle can be established for the German economy. Most empirical studies on monetary transmission are carried out in a linear framework and ignore the fact that significant effects of monetary policy that are found may be attributed to particular periods, while monetary policy may otherwise be ineffective.

Recent studies by *Thoma* (1994), *Gertler* and *Gilchrist* (1994) and *Garcia* and *Schaller* (1995) have established business cycle asymmetries of monetary policy for the United States. More than the Fed, though, the Bundesbank is known for its commitment to pursue price stability. As this is the overriding objective of German monetary policy, while influence from politicians is restricted by formal legislation, one may expect that the relationship between monetary policy and economic growth should be weaker than in the United States. On the other hand, recent empirical work shows that in practice the Bundesbank has conducted a policy that has been more focused on the real economy than suggested by the official objective of price stability. Looking at the monetary authorities' reaction function, *Clarida* and *Gertler* (1996) conclude that the Bundesbank's policy has been similar to monetary policy in the United

1 *Evans* (1986) discusses several reasons why the aggregate supply curve may be convex in the short run. See also *Kaldor* (1961) for an early example of a theory which is consistent with a convex aggregate supply curve and *Keynes* (1936) for an early notion of downward nominal wage rigidity.

2 Interestingly, both types of theories also imply that – in either phase of business cycle – a contractionary monetary policy measure has more real impact than a monetary expansion. *Cover* (1992), *Morgan* (1993) and *Karras* (1996a, 1996b) provide empirical evidence for this asymmetry between positive and negative monetary policy shocks, which can be seen as complementary to the type of asymmetry – between recessions and expansions – that is investigated here.

States which suggests that asymmetric effects of monetary policy over the business cycle may also be relevant for Germany.

We employ *Hamilton's* (1989) two-state Markov Switching Model (MSM), which provides a natural framework to analyze time-varying aspects of monetary policy transmission. An important advantage of this method is that it is not necessary to impose an explicit time pattern of expansions and recessions: most likely switching dates between both regimes are endogenously determined in the estimation procedure.

The remainder of this paper is organized as follows. In Section 2 we discuss our methodology. The results are presented in Section 3. Section 4 concludes.

II. Methodology

In order to investigate asymmetries over the business cycle, it is necessary to use a model that can account for time-varying processes. Following *Boldin* (1994) and *Garcia* and *Schaller* (1995), we adopt *Hamilton's* (1989) MSM approach, which allows for different regimes to capture the business cycle asymmetry. The basic structure of this nonlinear model can be expressed as follows:

$$y_t = X_t \beta_{S_t} + e_t \tag{1}$$

$$e_t \sim N(0, \sigma_{S_t}) \tag{2}$$

where y_t is a measure of real activity and X_t is a matrix that consists of (lags of) explanatory variables including lags of y_t. The parameter vector β_S and standard error σ_S are specific for each regime S. In the case of only one regime the model reduces to a standard linear reduced-form equation. Throughout this paper we allow for two states ($S = 1, 2$), with the probabilities of changing from one regime to the other expressed by the following transition matrix:

$$Q = \begin{pmatrix} q_{11} & q_{12} \\ q_{21} & q_{22} \end{pmatrix} \tag{3}$$

where q_{ij} is the probability of regime j in the next period, given the current regime i. The diagonal elements of Q indicate the probability that a particular regime will persist.

Estimation of all parameters in the system, including the elements of Q, is carried out by a maximum likelihood procedure. The following likelihood function is maximized:

$$(4) \qquad L(y,\ X;\ \beta,\ \sigma,\ Q) = \sum_{S_T=1}^{2} \cdots \sum_{S_1=1}^{2} \sum_{S_0=1}^{2} \left[\prod_{t=1}^{T} f_{S,t}\, q_{S_{t-1},S_t} \right] p_{0,S}$$

which specifies every possible regime sequence, for all transition probabilities; $f_{S,t}$ is a probability density function for regime S at time t, which depends on β_S and σ_S, and $p_{0,S}$ is a probability of regime S in the initial period. The vector $p_0 = (p_{0,1}\ \ p_{0,2})$ is determined such that the elements are unconditional probabilities, *i.e.* a solution to $p_0 = p_0 Q$. For the two-state case, these probabilities are $p_{0,1} = \dfrac{1 - q_{22}}{2 - q_{11} - q_{22}}$ and $p_{0,2} = \dfrac{1 - q_{11}}{2 - q_{11} - q_{22}}$.[3]

Comparison of β_1 and β_2 may reveal important differences over the business cycle that would be ignored in a standard linear model. Furthermore, the estimated transition probabilities provide information on the persistence and average duration of each regime, the latter being $(1 - q_{ii})^{-1}$ for regime i. Presumably, the elements on the diagonal should be greater than 0.5, indicating that a regime persists over at least several periods. In addition, as post-war experience shows that expansions last longer than recessions, the diagonal element associated with the expansionary regime is likely to be greater than the corresponding probability of a recession.

With an estimated MSM model, the most likely regime sequence can be determined, as well as the probability for each observation to belong to a particular regime. The latter can be determined, using the estimated likelihood function, by applying Bayes' rule. The advantage of the MSM approach is that the regime switching dates are endogenously determined and not imposed on – possibly arbitrary – grounds.

Obviously, the MSM approach also has its drawbacks. Although the model may be suitable to capture time varying effects related to the business cycle, it is in fact a far more general approach. For example, regimes may be identified that have nothing to do with cyclical phenomena and coincide with other factors, such as a change in the monetary policy regime. We would like to stress, though, that all estimated models in this paper yield a plausible Q matrix and regime switching dates consistent with a business cycle pattern, which suggests that our approach is appropriate.

3 See *Boldin* (1992) for a more elaborate discussion of the estimation procedure that is performed in this paper, which is somewhat different from *Hamilton's* (1989) original approach.

We estimate an MSM model in which the annual growth rate of industrial production y_t is explained by its own lags and by monetary policy. We employ three different measures of monetary policy: two interest-based indicators and a qualitative indicator, the Bundesbank index. As we will argue below, each of these indicators has its pros and cons. Hence, considering them all enables us to check the robustness of our results. First, we simply include a number of lags of the short-term interest rate r_t:

$$X_t = [y_{t-1},\ y_{t-2},\ \ldots,\ r_{t-1},\ r_{t-2},\ \ldots] \tag{5}$$

If the impact of monetary policy is asymmetric over the business cycle, one would expect the coefficients of r_t to be greater and/or more significant during recessions than during booms.

Our second indicator of monetary policy follows a large body of recent literature in which only unanticipated shocks ε_t^r of the short-term interest rate are supposed to influence real activity:

$$X_t = [y_{t-1},\ y_{t-2},\ \ldots,\ \varepsilon_{t-1}^r,\ \varepsilon_{t-2}^r, \ldots] \tag{6}$$

We generated these shocks from the interest rate equation of a four variable vector autoregressive (VAR) model in levels that includes prices, the oil price, industrial production and the short-term interest rate. Innovations are identified by imposing a causal ordering with the interest rate ordered last. Since the latter is considered as a policy variable, the corresponding equation in the VAR can be interpreted as the central bank's reaction function. Obviously, there may be a conceptual problem here since we use a linear, or single-regime, framework to derive policy shocks. Hence, we implicitly assume that the central bank's reaction function remains constant over the business cycle.

Third, we use a qualitative indicator ind_t of monetary stance: the Bundesbank index, developed by Dominguez (1997) and extended by Maier (1999):

$$X_t = [y_{t-1},\ y_{t-2},\ \ldots,\ ind_{t-1},\ ind_{t-2},\ \ldots] \tag{7}$$

This indicator varies between 0 (loose policy) and 4 (tight policy). We use quarterly averages of this series, which has originally been constructed on a monthly basis. The Bundesbank index summarizes intended monetary policy stance, based on several policy instruments and statements in the Bundesbank's *Monthly Reports*. This is an important difference with both interest-based measures, which are supposed to reflect actual policy.

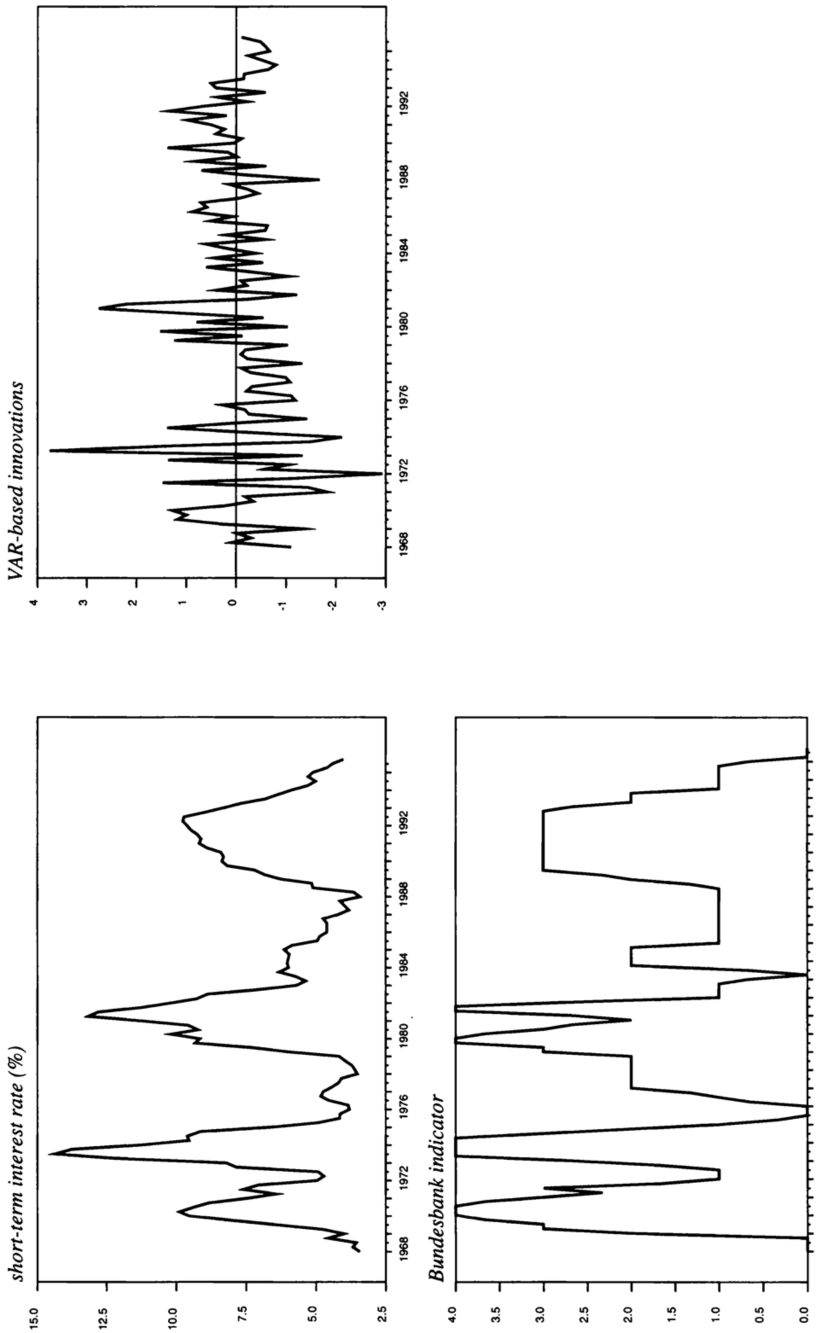


Figure 1: Monetary policy indicators

The three monetary policy indicators are plotted in Figure 1. It appears that r_t and ind_t show a similar pattern, although there are striking differences at times: for instance, the Bundesbank indicator points to substantial monetary contractions in monetary policy in 1976 and 1983 – increasing from 0 to 2 in both cases – which are not captured by the short-term interest rate. The use of both r_t and ind_t can be criticized for measuring the overall stance of monetary policy, including endogenous responses of the Bundesbank to developments that are likely to have real effects by themselves – *e.g.* oil price shocks – or which can be anticipated and should therefore be ineffective. In order to meet this criticism, we also use the VAR-based policy measure which, as we indicated, may be subject to other problems. Given their different advantages and disadvantages, the fact that we consider three indictors of monetary policy is likely to increase the robustness of our analysis.

III. Results

We analyze quarterly data over an effective sample that runs from 1971Q1 to 1995Q4. Industrial production growth y_t is calculated as the difference between the production level (in logs) and its level four quarters earlier. It appeared to be impossible to obtain sensible solutions of the MSM model with a first-differenced series: the high volatility – even after removing the seasonal pattern – in quarter-to-quarter growth makes it difficult, if not impossible, to discern a cyclical pattern. Taking four quarter differences results in a much smoother series, which is suitable for our analysis (see Figure 2).

First, we estimate an MSM that specifies a pure AR(6) process for each regime, in order to obtain starting values to estimate more extended spe-

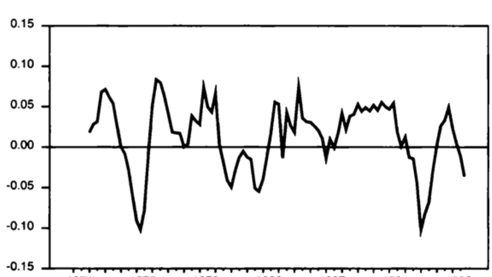


Figure 2: Industrial production growth

cifications. Lags that are insignificant for both regimes are dropped. Next, we add six lags of a monetary policy variable to the equation and, subsequently, remove insignificant lags:

$$y_t = c_{S_t} + \sum_{i=1}^{L^y} \beta_{y,i,S_t} y_{t-i} + \sum_{i=1}^{L^{MP}} \beta_{MP,i,S_t} MP_{t-i} + e_{t,S_t} \tag{8}$$

where MP_t is r_t, ε_t^r and ind_t, respectively, and L^y and L^{MP} are six or less.

A first analysis with a pure AR model – not reported here – showed that only the first five lags of y_t are significant. Therefore we drop the sixth lag in our extended models. Tables 1 to 3 present, for each indicator, the estimation results of both the full MSM specification and a restricted version. In all cases, the average growth rates $\bar{y}_t$ in both states imply that regime 1 can be associated with a recession and regime 2 with a boom. The transition probabilities q_{11} and q_{22} imply that both regimes show persistence. For the models in Tables 1 and 3, expansions last longer than recessions, but this does not hold for models GER3 and

Table 1

Short-term interest rate

	GER1		GER2	
S_t	1	2	1	2
c	–0.0102*	0.0157*	–0.0089*	0.0161*
y_{t-1}	1.0378*	0.4784*	1.0569*	0.4933*
y_{t-2}	–0.3206*	0.1420*	–0.3386*	0.1367
y_{t-3}	–0.1724	0.2692*	–0.1494	0.2477*
y_{t-4}	–0.5880*	–0.4917*	–0.5765*	–0.4929*
y_{t-5}	0.5399*	0.1009	0.5638*	0.1159*
r_{t-1}	–0.0004	0.0013		
r_{t-2}	–0.0006	–0.0013		
r_{t-3}	0.0009	–0.0027		
r_{t-4}	0.0005	0.0027		
r_{t-5}	0.0003	0.0010		
r_{t-6}	–0.0047*	–0.0023	–0.0041*	–0.0010
q_{ii}	0.8623	0.9170	0.8665	0.9134
$\bar{y}_t$	–0.019	0.032	–0.019	0.032
$\ln L$	265.29		263.93	

Estimation results. A '*' indicates significance at a 90 % confidence level.

Table 2

VAR-based innovations

	GER3		GER4	
S_t	1	2	1	2
c	–0.0030	0.0251*	–0.0056*	0.0226*
y_{t-1}	1.1337*	0.3875*	1.2083*	0.4654*
y_{t-2}	–0.2013*	0.2206*	–0.2954*	0.2335*
y_{t-3}	–0.1082*	0.4022*	–0.0447	0.2719*
y_{t-4}	–0.3217*	–0.5793*	–0.4550*	–0.5376*
y_{t-5}	0.2237*	–0.0579*	0.3302*	–0.1067
ε^r_{t-1}	0.0036	–0.0011		
ε^r_{t-2}	–0.0055*	0.0028	–0.0059*	–0.0008
ε^r_{t-3}	0.0012	0.0023		
ε^r_{t-4}	0.0011	0.0004		
ε^r_{t-5}	–0.0006	–0.0007		
ε^r_{t-6}	–0.0065*	0.0019	–0.0076*	0.0019
q_{ii}	0.9255	0.8932	0.9349	0.9277
$\bar{y}_t$	–0.003	0.035	–0.012	0.032
$\ln L$	267.88		265.67	

See Table 1.

Table 3

Bundesbank indicator

	GER5		GER6	
S_t	1	2	1	2
c	–0.0131*	0.0216*	–0.0149*	0.0214*
y_{t-1}	1.0457*	0.4952*	1.0286*	0.4851*
y_{t-2}	–0.1616	0.2734*	–0.1465*	0.2451*
y_{t-3}	–0.1117	0.4084*	–0.1132*	0.3896*
y_{t-4}	–0.1379	–0.6596*	–0.1763*	–0.6264*
y_{t-5}	0.1963*	–0.1156	0.2730*	–0.1023
ind_{t-1}	0.0027	–0.0054		
ind_{t-2}	–0.0108*	0.0042	–0.0095*	–0.0021
ind_{t-3}	–0.0021	–0.0005		
ind_{t-4}	0.0077	–0.0003		
ind_{t-5}	–0.0190*	–0.0024	–0.0102*	0.0019
ind_{t-6}	0.0062	0.0035		
q_{ii}	0.9128	0.9176	0.9159	0.9212
$\bar{y}_t$	–0.007	0.031	–0.007	0.031
$\ln L$	273.09		269.89	

See Table 1.

GER4 in Table 2. For each observation, the probability to belong to a particular regime can be calculated, using the estimated likelihood function, by applying Bayes' rule. The resulting recession probabilities for the models GER2, GER4 and GER6 are reported in Figure 3. Three recession periods can be distinguished which show a plausible pattern: the first two recessions can be associated with the oil crises and the third recession with the international economic slow-down in the early 1990s. The latter has been relatively severe in Germany, also due to reunification costs (see *Lindlar* and *Scheremet* (1998)).

The models GER1 and GER2 show the effect of monetary policy measured by the short-term interest rate r_t: GER1 is the full specification, GER2 is the model after removing the insignificant lags. This model shows a distinct asymmetry between the two regimes: considering the only remaining coefficient of the policy variable in GER2, the real impact of monetary policy in a recession is clearly negative (−0.0041), while the effect during a boom is insignificant. The impact of an unanticipated monetary policy shock ε_t^r, reported by GER3 and the more restricted model GER4, is also strongly asymmetric: the coefficients of the recession state are significantly negative while the coefficients of the expansionary regime are not significant. Comparing GER2 and GER4, it appears that unanticipated monetary policy shocks ε_t^r work relatively fast in recessions while changes in r_t, which reflect both anticipated and unanticipated elements, become effective after a significant lag. Furthermore, the total effect of an unanticipated shock, indicated by model GER4, is more than three times as large as the accumulated effect in model GER2. These differences in impact should be interpreted with caution, though, as the estimated parameters are not elasticities but reflect the effect of absolute changes in the level of both policy variables. The results based on the qualitative index in Table 3, finally, also imply that German monetary policy is most effective in influencing economic activity during a recession.

These conclusions are confirmed by Figure 4, in which the impact of a 1%-point increase in the policy variables r_t, ε_t^r and ind_t during one period is simulated over ten quarters, using the restricted models GER2, GER4 and GER6. These simulations also take the lag structure of y_t into account, and therefore give a more complete picture of the impact of a monetary tightening than just the estimated coefficients of the policy variables. The results are consistent with our earlier observations: unanticipated monetary policy in Germany works almost immediately whereas changes in the overall stance of monetary policy – indicated by

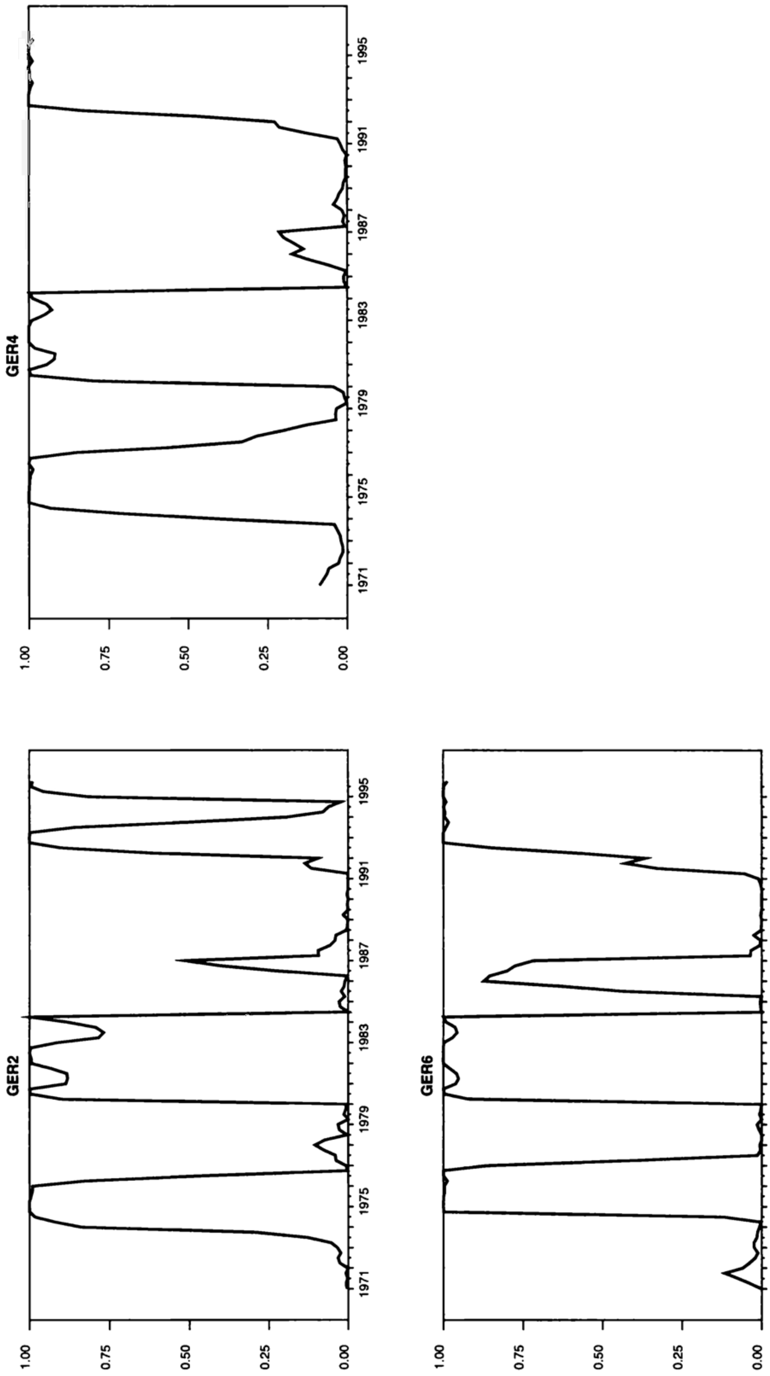


Figure 3: Recession probabilities

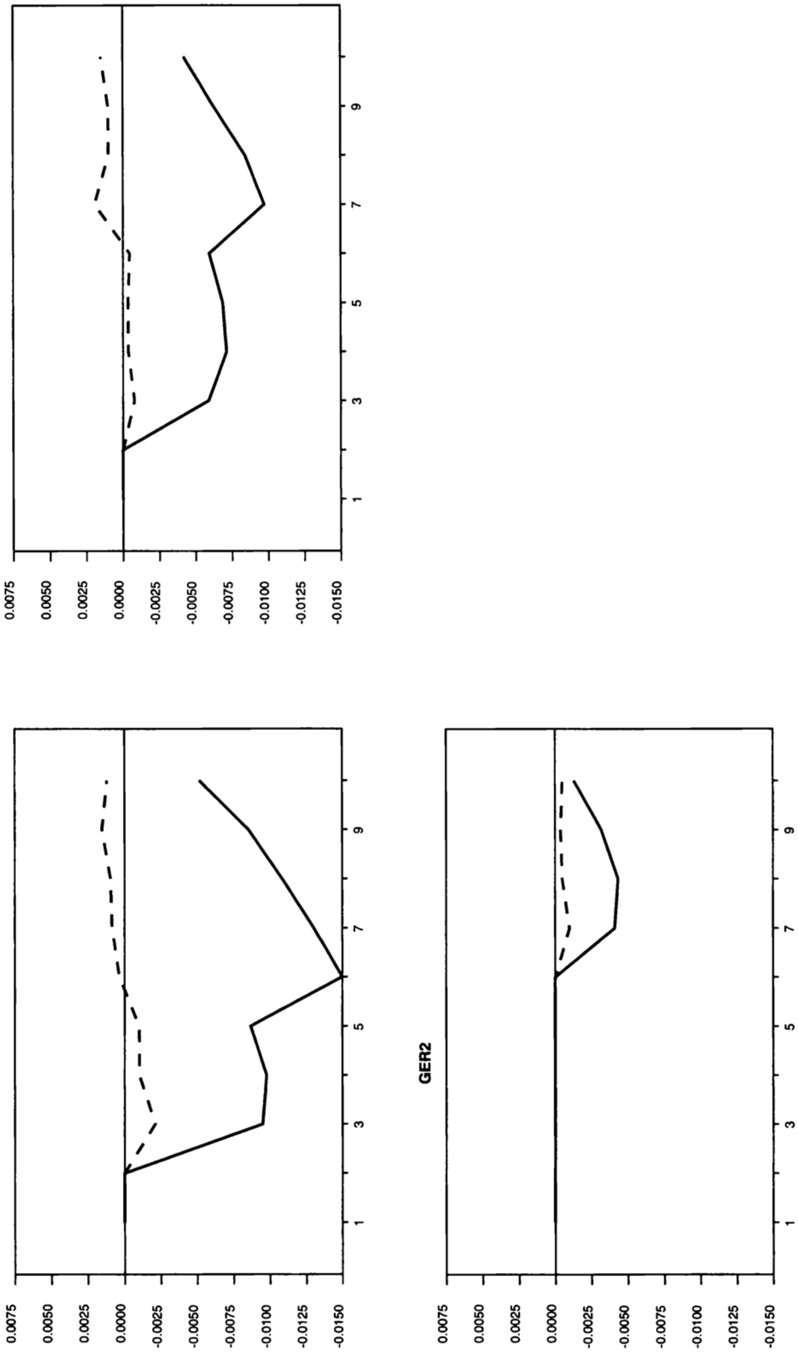
the short-term interest level – influence real activity only after a significant lag. The simulations based on GER4 and GER6 follow a similar pattern, which is no surprise given the two remaining significant coefficients of the policy variable in both models at two and, respectively, five or six lags.

IV. Concluding remarks

In this paper the relation between monetary policy and business cycle asymmetry is investigated. Using a nonlinear framework, asymmetry is interpreted as being reflected by two alternating regimes which represent the expansionary and contractionary phase. Asymmetric effects of monetary policy over the business cycle can be investigated by looking at the impact of monetary policy indicators in each regime. We looked at three policy indicators: (1) the short-term interest rate level which is supposed to summarize the stance of monetary policy, (2) short-term interest innovations that are generated from an identified VAR model which can be interpreted as unanticipated monetary policy shocks, and (3) a qualitative index.

All three indicators imply that asymmetry of monetary policy over the business cycle is a relevant phenomenon. Given the different backgrounds of the policy indicators, this result seems quite robust. In addition, unanticipated monetary policy shocks in Germany seem to work faster and have more impact on real activity than changes in the short-term interest rate in general.

Our analysis has been limited in many respects. We focused on the question whether asymmetric effects of monetary policy can be established, without considering possible explanations of the observed asymmetry. An explanation based on downward price rigidity may be relevant, as price rigidities are presumably important in Europe, at least more important than in the United States (*Van Bergeijk* and *Haffner*, 1993). Panel data studies by *Audretsch* and *Elston* (1994), *Elston* (1996) and *Bond* et al. (1997) conclude that German firms' investments are affected by financial market imperfections. This suggests that the financial accelerator may be relevant as an explanation of asymmetry, although these studies do not explicitly consider the impact of monetary policy. More direct evidence of a financial accelerator effect in Germany is provided by *De Bondt* (2000), who focuses on the impact of monetary policy through this mechanism on private consumption. In a recent VAR



Solid lines show the impact of monetary policy in the recession regime; dotted lines reflect monetary policy during a boom.

Figure 4: Dynamic simulations

study *Guender* and *Moersch* (1997) conclude that a credit channel is not an important monetary transmission mechanism in Germany, but their linear approach may mask the fact that a credit mechanism is only working in particular phases of the business cycle. Hence, it may be interesting to consider more extended specifications of our nonlinear approach, for instance by including proxies that reflect agency costs, in order to investigate more explicitly time-varying effects of credit market imperfections.

V. Data appendix

All the data we used are taken from the IMF's *International Financial Statistics*. We use the overnight interest rate (IFS line 60b) as a policy variable and industrial production (IFS line 66) as a measure of real activity. In addition, we use the consumer price index (IFS line 64) and the oil price (IFS line 00176nid) to construct our VAR-based policy variable. The Bundesbank index was provided by Philipp Maier.

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Summary

Monetary Policy and Business Cycle Asymmetry in Germany

In this paper, we investigate whether the impact of monetary policy on industrial production in Germany is larger in a recession than during a boom. Using a two-state Markov Switching Model to separate recessions and expansions, and three different policy indicators, we find strong evidence of asymmetric effects of monetary policy over the business cycle. Our findings imply that standard linear approaches, such as VAR models, ignore important time-varying aspects of the monetary transmission mechanism. (JEL E 32, E 52)

Zusammenfassung

Geldpolitik und Konjunkturasymmetrie in Deutschland

In diesem Beitrag untersuchen wir, ob die Auswirkungen der Geldpolitik auf die industrielle Produktion in Deutschland im Verlauf eines von Rezession gekennzeichneten Zeitraums stärker sind als während eines Konjunkturaufschwungs. Wendet man zur Trennung von Rezession und Expansion ein Markovsches Zwei-Stufen-Schaltmodell sowie drei verschiedene Politikindikatoren an, stößt man auf starke Beweise dafür, daß asymmetrische Auswirkungen der Geldpolitik auf den Konjunkturzyklus vorhanden sind. Unsere Erkenntnisse beinhalten, daß bei den üblichen linearen Vorgehensweisen, wie zum Beispiel VAR-Modellen, wichtige zeitvariable Aspekte des Geldtransmissionsmechanismus außer acht gelassen werden.

Résumé

Politique monétaire et asymétrie du cycle des affaires en Allemagne

Dans cet article, l'auteur examine si l'impact de la politique monétaire sur la production industrielle en Allemagne est plus important en récession que durant un boom. En utilisant un modèle de Markov à deux états pour séparer les récessions et les expansions et trois indicateurs différents de politique, on constate une forte évidence des effets asymétriques de la politique monétaire sur le cycle des affaires. Les résultats impliquent que les approches linéaires standards, telles que des modèles VAR, ignorent des aspects importants de variation dans le temps des mécanismes monétaires de transmission.