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Vladimir Kuzin
Silke Tober

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DIW Berlin

German Institute
for Economic Research

Königin-Luise-Str. 5
14195 Berlin,
Germany

Phone +49-30-897 89-0
Fax +49-30-897 89-200

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Asymmetric monetary policy effects in Germany

Vladimir Kuzin and Silke Tober[1]

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Abstract

In a small structural model we find asymmetries in the effects of monetary policy in Germany depending on whether the economy is in an upswing or a downswing. These two different regimes are also identified using a Markov-switching model and the Kalman filter. Our results indicate that the effects of monetary policy are significantly higher in a downswing than in an upswing. It follows not only that monetary policy has to raise interest rates markedly if an economy is overheating but also that once a downturn is discernible, interest rates have to be lowered rapidly so as to prevent an overly large reaction of the real economy.

JEL Classification*: C32, C51, E32, E44, E5*

Keywords*: Asymmetry, monetary policy, Markov switching, structural model*

1. Introduction

To gauge the quantitative effects of a monetary policy impulse in Germany and to test for asymmetries in these effects a small structural model was constructed. The model consists of three equations: one equation for the output gap (IS-curve), one for inflation (Phillips curve) and one for the monetary policy reaction (Taylor rule). The output gap is modelled as being dependent on its own lags, the second lag of the real interest rate and the change in investment demand in the rest of the world. Inflation is determined by its own lags, the output gap, the change in German import prices and the change in the international competitiveness of the German economy. The monetary reaction function models the short-term interest rate as a function of a constant (the equilibrium real interest rate), the inflation target of the central bank, the inflation gap, the output gap, the US federal funds rate and its own lags. The symmetric version of this model was tested for autocorrelation in the residuals, stability and misspecification with satisfactory results. The effects of a monetary policy impulse in this model are comparable to those of other models that

[1] Vladimir Kuzin, Statistics and Econometric Methods, Goethe-University Frankfurt, Gräfstr. 78, D-60054 Frankfurt, Germany, kuzin@wiwi.uni-frankfurt.de; Silke Tober DIW Berlin, Koenigin-Luise-Strasse 5, D-14195 Berlin, stober@diw.de.

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quantify these effects.[2] The model was subsequently modified to capture possible asymmetric effects of monetary policy. For this purpose a dummy was used that reflects whether the output gap is increasing or decreasing. According to this model the effects of monetary policy are weak in an upswing and strong in a downswing of the economy. The difference in the two coefficients of the real interest rate is significant according to the Wald test.

In what follows we first describe the data used and the way in which the asymmetry dummy was constructed. We then present the asymmetric model for Germany and finally derive some policy conclusions from the analysis.

2. The theory behind asymmetric effects of monetary policy

In the literature one finds two main explanations for asymmetric effects of monetary policy in different stages of the business cycle: the existence of a credit channel of monetary transmission and a convex Phillips curve.[3] Both theoretical approaches imply a larger effect of monetary policy during downturns than during upswings.

The credit channel of monetary transmission is based on the assumption of asymmetric information and resulting agency problems that give rise to an external finance premium which, in turn, is inversely related to the borrower's net worth (Bernanke/Gertler 1989). In an upswing the cash flow of firms and their net worth are high with the consequence that they are less dependent on bank loans and that the external finance premium is low. The real effects of monetary policy are therefore small. In contrast, an economic downturn coincides with a worsening of firms' balance sheets, a less abundant cash flow and a rising external finance premium. In this case monetary policy can have a stronger effect on the real economy.

A convex Phillips curve can also give rise to asymmetric real effects of monetary policy impulses. The convexity of the Phillips curve is motivated by downward nominal rigidities as well as capacity constraints. A downward rigidity of prices is for example modelled by Mankiw/Ball (1994) for a monopolistically competitive economy with positive trend inflation and menu costs. Firms will be less likely to react to a negative price shock than to

[2] In a simulation of an increase in the interest rate by one percentage point for two years, the GDP is 0.1 % and 0.4 % below baseline in the first and second year respectively. The maximum deviation of 0.6 % is reached in the third year after which the gap starts to narrow. For an overview of other studies on the real effects of monetary policy in Germany see Van Els et al. (2001: 58).

[3] The „option value of waiting" (Dixit/Pindyck 1994) resulting from increased uncertainty in recessions and Keynes' liquidity trap (Keynes 1936) are a third explanation for asymmetry. In this case the economy is less interest sensitive in recessions.

a positive price shock of the same size because in the former case trend inflation implies price adjustment. A downward rigidity of nominal wages can result from efficiency wages set by firm to minimise shirking (Shapiro/Stiglitz 1984). Given a convex Phillips curve, monetary policy has a larger effect on production and a smaller effect on inflation in a downturn than in an upswing.

Asymmetric monetary policy effects are found inter alia by Kakes (2000), Peersman/Smets (2001), Garcia/Schaller (2002), Dolores (2002) and Lo/Piger (2003). Kakes (2000) applies a Markov-switching model and finds a statistically significant asymmetry in the real effects of monetary policy over the business cycle, in particular for Germany. Within an SVAR-framework and a Markov-switching model Peersman/Smets (2001) find an asymmetric effect of monetary policy for Germany similar to the one identified here.[4] They furthermore discovered that monetary policy seems to be able to induce a regime change from boom to recession, not however from recession to boom. Garcia/Schaller (2002) also use a Markov-switching model and find for the US that the real effects of interest rates changes are 2 to 3 times higher in recessions than in boom periods. Unlike the findings of Peersman/Smets (2001) for the Euro Area, interest rate changes have a substantial effect on the probability of regime switches in the US according to the model employed by Garcia/Schaller (2002). Focussing on interest-rate shocks María-Dolores (2002) presents empirical evidence from a Markov-switching model of larger effects of monetary policy in recessions for five European countries including Germany. Lo/Piger (2003) find for the United States that policy actions have larger effects when taken in recessions than in booms.

Our results support the findings presented above. The approach is similar as well in that we use a Markov-switching model to identify asymmetries and the two corresponding regimes. Markov-switching is, however, only one of the models used by us. The small structural model supplements this approach by allowing us to quantify the effect of real interest rate changes on the economy in each of the stages of the business cycle. The timing of the stages of the business cycle for Germany differs between the studies because of the dependent variable used and the specification of the equations: Whereas we use a quarterly GDP growth, Peersman/Smets (2001) and Kakes (2000) base their estimate on monthly growth rates of industrial production. María-Dolores (2002) employs quarterly GDP growth as we do but we include as an additional variable changes in the volatility of GDP and María-Dolores (2002) allows for endogenous switching.

[4] Peersman/Smets (2001) estimate VARs for the period from 1978 to 1998 and use as the real economic variable industrial production. They find for the Euro Area and especially for Germany, that monetary policy has a considerably larger effect in recessions than in boom periods.

3. Data

For the small structural model for Germany we used the following time series on a quarterly basis from the early seventies until the first quarter of 2003. The output gap (x_t) is taken from the IMF's World Economic Outlook database (June 2003). Because the IMF's output gap calculations are only available on an annual basis, this time series and the time series for the German GDP were used to construct a series for potential output which was then converted to quarterly data using Eurostat's program for temporal disaggregation Ecotrim (Barcellan 1994). The output gap based on this quarterly potential output and the quarterly German GDP is almost identical to the one that the Rotemberg filter yields with the parameters proposed by Rotemberg.[5] A long time series for the German GDP was constructed by chaining the GDP for the current Germany with the West German GDP in the first quarter of 1991, where the two series overlap. Both time series are published by the German Statistical Office and both are seasonally adjusted as well as adjusted for working days. The real interest rate is the three-month interbank rate (i_t) minus the annualised quarter-over-quarter inflation rate (π_t). The inflation rate is calculated on the basis of the seasonally adjusted consumer price index series published by the German Bundesbank. Again, a long time series is constructed by chaining the corresponding price indexes for Germany and West Germany. We used the West-German data until the first quarter of 1995 so as not to capture the transition-related price increases in East Germany. The inflation target of the Bundesbank (π^*) was derived from the Bundesbank's formulation of its target for monetary growth as published in its monthly bulletins. Investment in the rest of the World is the sum of gross capital formation in the United States, the United Kingdom, France, Italy and Spain as published by the OECD and converted into euro using the bilateral exchange (or conversion) rates in the first quarter of 1999. It enters the model in logarithms. The change in German import prices (π^{imp}) is calculated quarter-over-quarter on the basis of the seasonally adjusted time series published by the German Bundesbank. The international competitiveness of the German economy (rx_t) is calculated by the German Bundesbank on the basis of consumer prices and enters the equation in logarithms. Oil, which is only used as an instrument, is the logarithm of the price of oil (brent, per barrel) in D-mark and ff is the Federal Funds Rate as published by the Federal Reserve System. The dummy d_t reflects an upswing – its construction is described below.

[5] The filter developed by Rotemberg (1998) is a variant of the Baxter-King filter that has the additional restriction of minimizing the covariance between the trend and the cycle components for a given length of time.

Whereas the output gap, the real interest rate, the inflation rate and the change in import prices are stationary variables according to ADF-tests, investment in the rest of the world, the international competitiveness of the German economy and the federal funds rate are I(1)-variables.[6] The latter therefore enter the model in differences. The following instruments were used for the system (lags in brackets): log GDP in first differences (6), the international competitiveness of the German economy in first differences (10), oil price (brent, in D-mark) in first differences (6), change in import prices (6), the inflation target (1), the interbank rate (6), the Federal Funds rate in first differences (6), the output gap (9), inflation (8), real interest rate (6) as well as the real interest rate (6) and the output gap (6) in an upswing and downswing respectively.

4. The asymmetry dummy

In order to tests for asymmetries in the effects of monetary policy depending on the stage of the business cycle a dummy was used that reflects whether the output gap is increasing or decreasing. In a first step this dummy was constructed using the differences of the smoothed output gap. A Markov-switching model and the Kalman filter were then used to check the robustness of this identification of the two phases of the business cycle.

Chart 1 illustrates that first differences of the output gap cannot simply be used to construct the dummy because there are too many high-frequency fluctuations. Therefore we used a Hodrick-Prescott filter (smoothing parameter: $\lambda = 100$)[7] to smooth the time series and only then differenced the data. The thus constructed time series was used to generate the dummy, whereby slight modifications were made, when the turning points did not coincide with the peaks and troughs. The dummy is 1 when the differences of the smoothed output gap are above zero, i.e. when the smoothed output gap rises, and 0 when the differences of

[6] **Table**

ADF – Tests

Sample 1974:1–2003:2 (1975:1–2003:2 for import price inflation because of outliers)

Variable	Deterministic	Lags	ADF-statistic	Test decision
Output gap	none	-4	-2.66***	I(0)
Interbank rate	constant	-1, -4	-4.36***	I(0)
inflation	constant	-1, -2	-2.66*	I(0)
import price infl.	constant	-3	-5.90***	I(0)
Federal funds rate	constant	-1, -2, -3, -5, -7	-1.83	I(1)
Log (rx)	constant	-1	-2.26	I(1)

Significance at 1, 5 and 10% level is denoted by ***, ** and * respectively.

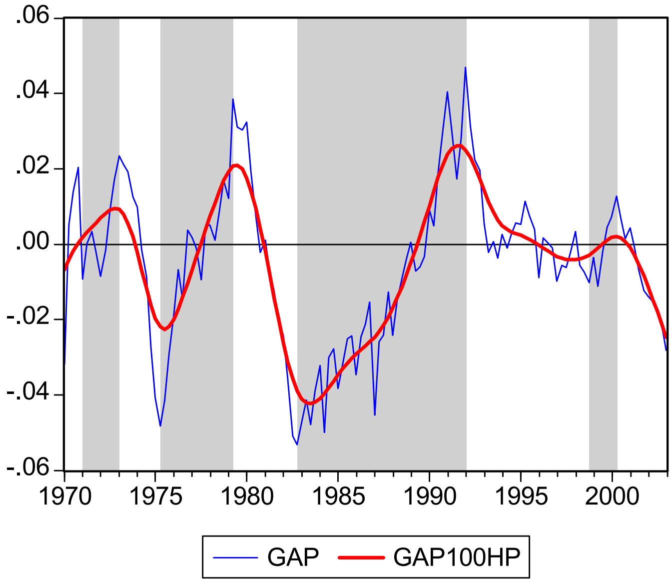
[7] A relatively small λ was chosen for the Hodrick-Prescott filter because the objective was to filter out only short-term movements of the output gap.

the smoothed output gap are below zero, i.e. when the smoothed output gap falls. The shaded areas are stages of an increasing output gap.

Chart 1

Stages of the business cycle in Germany based on smoothed differences of the output gap (asymmetry dummy)[1]

– 1970:1 to 2003:1 –



1 Difference between GDP and potential output in percent of potential output. Calculated on the basis of annual data provided by the International Monetary Fund; IMF (2003).

The dating of the two regimes is supported by a Markov-switching model.[8] The following small model was estimated in the Markov-switching framework. The dependent variable is GDP in log differences, Δy_t, the explanatory variable is the second lag of the real interest rate, r_{t-2}.

$$\Delta y_t = \alpha + \beta_i(S_t) \cdot r_{t-2} + u_t \qquad u_t \sim N(0, \sigma^2(S_t)),$$

where S_t is an unobservable first-order discrete Markov chain with two states, $\beta_i(S_t)$, and $\sigma^2(S_t)$ are discrete real-valued functions of S_t. The assumption is that the Markov chain S_t is exogenous and its transition dynamics can be characterised by the matrix of transition probabilities $p_{ij} = \Pr\{S_t{=}i \mid S_{t-1}{=}j\}$. The diagonal of the transition matrix consists of the transition probabilities of remaining in the respective regime; the columns add up to one.

[8] Cf. Hamilton (1994), Hamilton (1989) and Goldfeld/Quandt (1973).

In a Markov-switching model it is possible to calculate for each point in time the probability, that the unobservable Markov chain is in regime j. The time series of these probabilities are called smoothed probabilities and can be interpreted in economic terms. In what follows the smoothed probabilities are compared to the stages of the business cycle determined above.

In this model asymmetry was found only when, in addition to the real interest rate as exogenous variable, changes in the volatility of GDP were also included in the model. The estimation output is summarised in Table 1.

Table 1
Output of the Markov-switching estimate

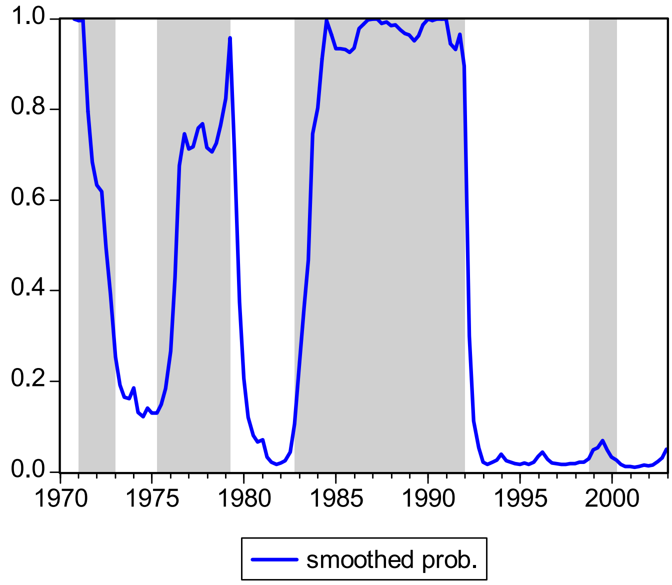
Coefficient	Estimated value	t-statistic
$\hat{\alpha}$	0.0087	7.3472
$\hat{\beta}(S_t = 1)$	-0.19339	-5.5476
$\hat{\beta}(S_t = 2)$	-0.029031	-0.56045
$\hat{\sigma}^2(S_t = 1)$	3.6846e-005	-
$\hat{\sigma}^2(S_t = 2)$	0.00012812	-
$\hat{p}_{11} = \Pr\{S_t = 1 \mid S_{t-1} = 1\}$	0.96	-
$\hat{p}_{22} = \Pr\{S_t = 2 \mid S_{t-1} = 2\}$	0.93	-
Log-likelihood	434.3586	-
AIC	-6.5747	-

Regime 2 of the Markov-switching model (small effects of monetary policy, high volatility of output) largely corresponds to the upswings generated with the dummy variable as shown in Chart 2. As in Chart 1 the shaded areas represent stages of an increasing output gap according to the asymmetry dummy.

Chart 2

Stages of the business cycle (Markov switching)[1]

– 1970:1 to 2003:1 –



Based on the information in Table 1 the estimation results can be summarised in the following equation:

$$\Delta y_t = \underset{(0.00)}{0.0087} - \begin{cases} \underset{(0.03)}{0.1934} \cdot r_{t-2} & \text{und} \quad \hat{\sigma}^2 = 0.000037 \quad \text{falls} \quad s_t = 1 \\ \underset{(0.05)}{0.0290} \cdot r_{t-2} & \text{und} \quad \hat{\sigma}^2 = 0.000128 \quad \text{falls} \quad s_t = 2 \end{cases}$$

In Regime 1 monetary policy has a significant effect and the conditional volatility of GDP is small. In regime 2, in contrast, monetary policy does not have a significant effect and the conditional volatility of GDP is considerably higher. The transition matrix is as follows:

$$\hat{P} = \begin{bmatrix} 0.96 & 0.07 \\ 0.04 & 0.93 \end{bmatrix}$$

The Kalman filter was used as a third approach to identify the stages of the economic cycle. It is assumed that the coefficient of the real interest rate varies over time and that this coefficient follows a stationary AR(1) process. On the basis of these assumptions and the observed time series of the real interest rate and of log GDP in first differences the Kalman filter estimates the expected values and the variances of the unobserved process of the real interest rate coefficient.

The state-space model can be written as follows:

$$\Delta y_t = a + \rho_1 \Delta y_{t-1} + \rho_4 \Delta y_{t-4} + s_t \cdot r_{t-2} + u_t$$
$$s_t = \alpha + \phi \cdot s_{t-1} + e_t$$

The estimation results are summarised in Table 2 below.

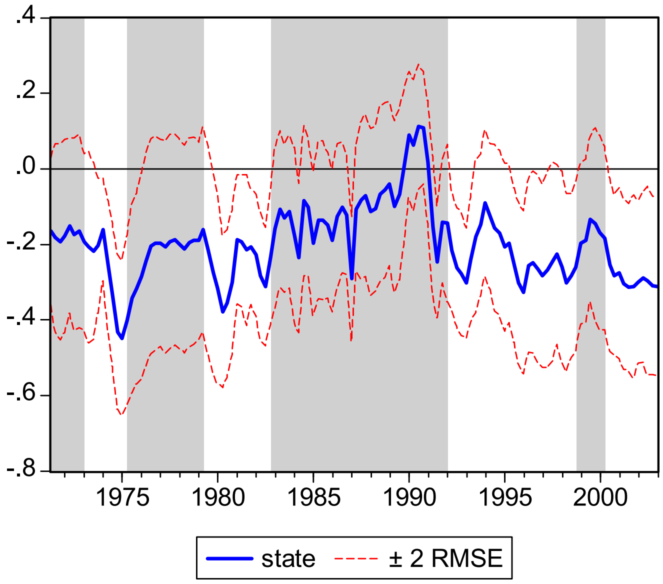
Table 2
Output of the Kalman-filter estimate

Method: Maximum likelihood (Marquardt)				
Sample: 1971:2 2003:2				
Included observations: 129				
Convergence achieved after 22 iterations				
	Coefficient	Std. Error	z-Statistic	Prob.
$\hat{a}$	0.011043	0.001478	7.473876	0.0000
$\hat{\rho}_1$	-0.302164	0.089545	-3.374445	0.0007
$\hat{\rho}_4$	0.245266	0.082465	2.974196	0.0029
$\ln \sigma_u$	-9.978557	0.186996	-53.36228	0.0000
$\ln \sigma_{\acute{e}}$	-4.440272	0.624608	-7.108897	0.0000
$\hat{\phi}$	0.682976	0.161953	4.217120	0.0000
$\hat{\alpha}$	-0.064398	0.029393	-2.190964	0.0285
	Final State	Root MSE	z-Statistic	Prob.
s_t	-0.285636	0.135882	-2.102078	0.0355
Log likelihood	438.1524	Akaike info criterion		-6.684534
Parameters	7	Schwarz criterion		-6.529350
Diffuse priors	0	Hannan-Quinn criter.		-6.621480

Chart 3

Stages of the business cycle (Kalman filter)[1]

– 1970:1 to 2003:1 –



As in the Markov-switching model, the interest-rate sensitivity of the economy is significantly higher in a downturn than in an upswing. In an upswing the mean of the interest rate coefficient according to the Kalman filter is 0.15, in a downturn it is 0.26; without the autoregressive dynamics the respective coefficients are 0.14 and 0.24.

5. A small structural model for Germany

The small structural model tests for an asymmetric reaction of output to the short-term real interest rate depending on whether the economy is in a stage of an increasing or decreasing output gap. The model consists of three equations (t-values in brackets):[9]

[9] The test statistics are in the annex.

$$(1)\quad \hat{x}_t = \underset{(3.53)}{0.01} + \underset{(6.97)}{0.7}(x_{t-1}d_t) + \underset{(1.51)}{0.17}(x_{t-2}d_t) + \underset{(2.73)}{0.32}(x_{t-4}d_t) - \underset{(-2.00)}{0.21}(x_{t-5}d_t) + \underset{(14.92)}{0.96}(x_{t-1}(1-d_t)) - \underset{(-2.01)}{0.09}(i_{t-2} - \pi_{t-2})d_t - \underset{(-5.60)}{0.26}(i_{t-2} - \pi_{t-2})(1-d_t)$$

$$(2)\quad \hat{\pi}_t = \underset{(5.05)}{0.01} + \underset{(3.82)}{0.22}\pi_{t-1} + \underset{(6.04)}{0.33}\pi_{t-3} + \underset{(1.98)}{0.08}(x_{t-4}) + \underset{(9.45)}{0.13}\pi_t^{imp} + + \underset{(4.88)}{0.04}(\pi_{t-5}^{imp}) + \underset{(3.71)}{0.26}rx_t + \underset{(5.34)}{0.05}I_t^{9103}$$

$$(3)\quad \hat{i}_t = (\pi_t^* + \underset{(4.61)}{0.03} + \underset{(3.09)}{1.29}(\pi_t - \pi_t^*) + \underset{(1.71)}{0.65}x_{t+1} + \underset{(2.56)}{2.93}\Delta ff_t - \underset{(-2.44)}{2.17}\Delta ff_{t-3}) (1 - 1.42 + 0.49) + \underset{(20.75)}{1.42}i_{t-1} - \underset{(-7.36)}{0.49}i_{t-2} + \underset{(3.61)}{0.02}I_{t-1}^{8001}$$

The equations were tested for autocorrelation, stability and normality and passed all tests.

The system was estimated using Three-Stage-Least-Squares to take account of possible correlation between the residuals of the equations of the system. The reaction function of the central bank is plausible and consistent with a Taylor-style policy rule. In particular, the reaction to the inflation gap exceeds 1, the reaction to output is about half as large. Inflation is significantly influenced by the output gap, but the effect is small with a one-percentage point increase in the output gap reducing inflation in the long-run by only 0.16 percentage points. The effects of a change in import prices and in the international competitiveness of the German economy are more than twice as large. The output gap equation shows that the real interest rate affects the real economy more when the output gap is decreasing than when it is increasing. In a thus defined upswing an increase in real interest rates lowers the output gap by 0.09 percentage points in the short run, in a downturn the effect is about 3 times as large (-0.26). The difference in the two coefficients of the real interest rate is significant according to the Wald test. (The null hypothesis that the coefficients are equal was rejected with a probability of 0.0001.)

The dynamics of the system can be seen in a simulation. We simulate an interest rate increase by 1 percentage point in the first quarter. This change in interest rates is reinforced in the following quarters due to the lagged interest rate variables in the monetary reaction function. The development of the short-term interest rate is different in the two stages of the business cycle because the reaction of the output gap and of inflation to the interest rate hike differ (Table 3).

The difference in the real effects of monetary policy depending on the stage of the business cycle is particularly visible in the first two years of the simulation, in which the development of interest rates is quite similar. In periods of an increasing (positive) output gap (upswing) the deviations from baseline are -0.1 % and -0.4 % respectively and thus much smaller than in periods of a decreasing output gap, in which GDP is 0.2 % below the baseline in the first year and 1.4 % below the baseline in the second year.

Table 3
Simulation:
Reaction of real GDP to an increase in the interest rate in Germany within the small structural model

	Economic downturn		Economic upswing	
	Nominal interest rate (short-term)	GDP (real)	Nominal interest rate (short-term)	GDP (real)
	– deviation from baseline in % and percentage points respectively –			
1. year	1.31	-0.22	1.34	-0.07
2. year	0.76	-1.36	1.00	-0.39
3. year	-0.19	-1.76	0.32	-0.61
4. year	-0.74	-1.37	-0.11	-0.68
5. year	-0.86	-0.66	-0.34	-0.64
6. year	-0.66	0.01	-0.44	-0.55

Source: Simulation.

6. Conclusion

Using a small structural model, a Markov-switching model and the Kalman filter we found in each case that the German economy was considerably more interest-rate sensitive in a downturn than in an upswing. Our results support the findings by Kakes 2000, Peersman/Smets 2001 and María-Dolores 2002. We differ from these studies in that we use several methods to establish asymmetry, one of which allows us to quantify monetary policy effects because it is not estimated in reduced form. The second difference concerns the specification of the estimated equation which leads to differences in the classification of the stages of the business cycle. Whereas we use a quarterly GDP growth, Peersman/Smets (2001) and Kakes (2000) base their estimate on monthly growth rates of industrial production. María-Dolores (2002) employs quarterly GDP growth as we do but we include as an additional variable changes in the volatility of GDP and María-Dolores (2002) allows for endogenous switching.

What follows from this asymmetric reaction of the economy to monetary policy impulses? Given the relatively weak reaction of the real economy to interest rate changes during an upswing monetary policy has to react more strongly in the face of an overheating of the economy than in a downturn. At the same time, however, the central bank has to take into consideration that interest rate increases generated to dampen economic activity will have a much larger effect once the economy has begun to slow down. If, as was for example the case in the Euro Area in late 2000, interest rates are increased when the economy is hardly growing anymore, then the interest rate impact will be three times as high than it would have been if the economy were still expanding vigorously.

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Annex

Small structural model for Germany (t-values in brackets):

Estimation Method: Three-Stage Least Squares
Sample: 1975:2 2003:1 Total system (balanced) observations 336

$$\hat{x}_t = \underset{(3.53)}{0.01} + \underset{(6.97)}{0.7}(x_{t-1} d_t) + \underset{(1.51)}{0.17}(x_{t-2} d_t) + \underset{(2.73)}{0.32}(x_{t-4} d_t) - \underset{(-2.00)}{0.21}(x_{t-5} d_t) + \underset{(14.92)}{0.96}(x_{t-1}(1-d_t))$$
$$- \underset{(-2.01)}{0.09}(i_{t-2} - \pi_{t-2}) d_t - \underset{(-5.60)}{0.26}(i_{t-2} - \pi_{t-2})(1-d_t)$$

observations: 114				Mean dependent var	-0.01
R-squared	0.87	Adjusted R-squared	0.86	S.D. dependent var	0.02
S.E. of regression	0.01	Durbin-Watson stat	2.07	Sum squared resid	0.01

$$\hat{\pi}_t = \underset{(5.05)}{0.01} + \underset{(3.82)}{0.22}\pi_{t-1} + \underset{(6.04)}{0.33}\pi_{t-3} + \underset{(1.98)}{0.08}(x_{t-4}) + \underset{(9.45)}{0.13\pi_t^{imp}} + + \underset{(4.88)}{0.04}(\pi_{t-5}^{imp}) + \underset{(3.71)}{0.26} rx_t + \underset{(5.34)}{0.05} I_t^{9103}$$

observations: 114				Mean dependent var	0.03
R-squared	0.79	Adjusted R-squared	0.78	S.D. dependent var	0.02
S.E. of regression	0.01	Durbin-Watson stat	2.08	Sum squared resid	0.01

$$\hat{i}_t = (\pi_t^* + \underset{(4.61)}{0.03} + \underset{(3.09)}{1.29}(\pi_t - \pi_t^*) + \underset{(1.71)}{0.65} x_{t+1} + \underset{(2.56)}{2.93}\Delta ff_t - \underset{(-2.44)}{2.17}\Delta ff_{t-3})$$
$$(1 - 1.42 + 0.49) + \underset{(20.75)}{1.42} i_{t-1} - \underset{(-7.36)}{0.49} i_{t-2} + \underset{(3.61)}{0.02} I_{t-1}^{8001}$$

observations: 114				Mean dependent var	0.06
R-squared	0.97	Adjusted R-squared	0.97	S.D. dependent var	0.02
S.E. of regression	0.00	Durbin-Watson stat	2.11	Sum squared resid	0.00