MAGKS

Joint Discussion Paper
Series in Economics

by the Universities of
Aachen · Gießen · Göttingen
Kassel · Marburg · Siegen

ISSN 1867-3678

No. 08-2010

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This paper can be downloaded from
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Regime-dependent effects of monetary policy shocks. Evidence from threshold vector autoregressions

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Abstract

This paper studies regime dependence in the effects of monetary policy shocks for the U.S. using a threshold vector autoregressive model. In a high inflation regime the standard results from the literature obtain. In a low inflation regime output shows no significant response to monetary policy while the inflation response is negative. The paper endogenously determines two distinct regimes, while the literature thus far only considers alternative subsamples.

Keywords: monetary policy shocks, threshold vector autoregression

JEL Classification: E52, E58, C32

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1 Introduction

Since the mid 1990s a very successful research program has studied the effects of monetary policy on macroeconomic variables. These effects have been identified by estimating the dynamic responses of output, inflation and other variables to "monetary policy shocks" in vector autoregressive (VAR) models of the economy.
This paper investigates the stability of these results by studying threshold effects in the standard "monetary policy" VAR model. Our results show strong evidence for regime dependent reactions of macroeconomic variables to monetary policy shocks with the standard results being related to a regime of high inflation.

The starting point of our analysis is related to recent literature concerning the robustness of the conventional VAR evidence about monetary policy shocks. For example, estimating the canonical VAR model on post-1985 observations leads to results that differ from the standard evidence in important respects (Mojon, 2008). In particular, the responses of output and inflation to a monetary policy shock are not significantly different from zero. Mojon (2008) argues that these differences are the result of shifts in the mean of inflation.
Instead of being exogenous these changes might actually be triggered by the state of the economy where the focus in this paper is on the level of inflation. For example, the relationship between output and inflation and the persistence of inflation depends on expected inflation and on the credibility of monetary policy which might be eroded by high inflation. Changes in the monetary policy reaction function can also depend on the level of inflation as the central bank might react differently to shocks depending on the size and direction of the deviations of inflation from its target (e.g. Orphanides and Wilcox (2003)).

A straightforward way to model nonlinearities like these empirically is the estimation of a threshold model that allows for different sets of model parameters depending on the state of the economy. Univariate threshold autoregressive models have been introduced by Tong (1978). These models have been extended to a multivariate context by Tsay (1998) and Balke (2000).

2 Econometric Methodology

The threshold vector autoregressive (TVAR) model with two regimes can be written as:

$$Y_t = \mu^1 + A^1 Y_t + B^1(L) Y_{t-1} + (\mu^2 + A^2 Y_t + B^2(L) Y_{t-1}) I(c_{t-d} > \gamma) + u_t. \qquad (1)$$

Y_t is a vector of endogenous variables. I is an indicator variable that equals 1 when the threshold variable c_{t-d} exceeds γ and 0 otherwise. If $I = 0$ the dynamics of the VAR are given by the vector of constants μ^1, the matrix of contemporaneous interaction coefficients A^1 and the matrix of lag polynomials $B^1(L)$. If $I = 1$ the relevant coefficients are $\mu^1 + \mu^2$, $A^1 + A^2$ and $B^1(L) + B^2(L)$. u_t is a vector of structural innovations. The (diagonal) variance-covariance matrix of these innovations can also be regime dependent (Σ_u^i, $i = 1, 2$).

To test for threshold effects the model is estimated by OLS on a grid of possible threshold values chosen to provide for each regime at least 15% of the overall number of observations plus the number of coefficients in each equation. For each threshold value a Wald statistic is computed and three test statistics for the null hypothesis of no threshold effects are constructed: (sup-Wald) the maximum of the Wald statistic over all possible threshold values, (avg-Wald) the average of the individual Wald statistics, and (exp-Wald) the sum of exponential Wald statistics (Andrews and Ploberger (1994)). Testing for threshold effects in (1) is complicated by the fact that the threshold value γ is not identified under the null hypothesis of no threshold effects. P-values for the test statistics can be obtained by using the simulation method of Hansen (1996).

The estimate of the threshold value is the one minimizing the log determinant of the variance-covariance matrix of the VAR residuals.

3 Results

3.1 Threshold tests and estimates

Y_t includes the standard variables from the VAR literature on monetary policy shocks (e.g. Christiano et al., 1999). We use quarterly observations from 1965Q3 to 2007Q2 on real GDP, the GDP deflator and the monetary aggregate M1. The indicator for monetary policy is the Federal Funds Rate. As in standard VAR studies we also include an indicator of commodity prices (e.g. Christiano et al., 1999).

Including non-stationary data in the VAR might lead to spurious non-linearities (Calza and Sousa, 2005) and might also violate the regularity conditions required to obtain simulated p-values using the Hansen (1996) technique. Hence, we set up the VAR in log differences except for the Federal Funds Rate and include annualized rates of quarter-to-quarter output growth, inflation, commodity price inflation and money growth.

For reference Figure 1 replicates the standard results for the effects of an exogenous increase in the Federal Funds Rate of one standard deviation and using the VAR estimates for the period 1965Q3 to 1995Q2 as in Christiano et al. (1999). The monetary policy shock is identified as in Christiano et al. (1999) by assuming a recursive structure of the contemporaneous interaction between the variables. The ordering of the variables is output growth ($GDPGR$), inflation ($INFL$), commodity price inflation, Federal Funds Rate (FF), and M1 growth.

Figure 1 shows that a monetary policy shock causes a significant decline in output growth with a lag of about two quarters. Inflation declines after two quarters but the fall in inflation becomes marginally significant only after a considerable lag. The

Table 1: Tests for threshold VAR
Variables: GDP growth, inflation, com. inflation, Fed Funds Rate, M1 growth

A: No threshold effect in contemporaneous relationships

threshold variable	Estimated Threshold value	sup-Wald	avg-Wald	exp-Wald
INFLATION	$\gamma = 4.86$	7152.61	1832.50	700.22
Lag=1		(0.00)	(0.00)	(0.00)

B: Threshold effect in contemporaneous relationships

threshold variable	Estimated Threshold value	sup-Wald	avg-Wald	exp-Wald
INFLATION	$\gamma = 4.86$	1249.53	306.16	620.16
Lag=1		(0.00)	(0.00)	(0.00)

NOTES: Sample period is 1965Q3-2007Q2. P-Values in parentheses.

Based on Hansen (1996) with 1000 replications.

positive response of inflation in the first quarter after the shock indicates the presence of a price puzzle. The Federal Funds Rate shock leads to a significant increase in the Federal Funds rate itself which persists for some quarters.

« Insert Figure 1 »

Estimation of the threshold VAR (1) requires selection of a threshold variable c_t and of its lag order d. In our model we chose the lagged inflation rate. Table 1 presents tests for the null hypothesis of no threshold effects in the VAR ($A^2 = B^2(L) = 0, \mu^2 = 0$).

In Panel A the contemporaneous interaction coefficients in A and the variance-covariance matrix of the reduced form residuals are treated as identical in both regimes ($A^2 = 0$, $\Sigma_u^1 = \Sigma_u^2$) Panel B allows for $A^2 \neq 0$ and $\Sigma_u^1 \neq \Sigma_u^2$. The results show strong evidence for the presence of threshold effects.

3.2 Regime-dependent impulse responses and variance decompositions

The next figures show regime-dependent impulse response functions based on the specification in Panel B and a threshold value of 4.86 percent. The Figures display the median impulse response along with 90% confidence bands. The median Federal Funds Rate shock in the high inflation regime is almost three times as large as in the low inflation regime, the inflation shock about 50 percent larger and the output shock is about 25 percent larger.

Figure 2 shows the effects of a monetary policy shock for each regime. A significant decline in output growth is caused only in the high inflation regime. Inflation responds significantly negative only in the low inflation regime and after a lag of one year. The price puzzle is only present when inflation is high. The Federal Funds Rate increase is much more persistent in the low inflation regime. Note that the standard results on the effects of monetary policy shock on output and inflation from Figure 1 pertain to the high inflation regime whereas the response of the Federal Funds Rate to its own shock is similar to the low inflation regime.

« Insert Figure 2 »

Figures 3 and 4 present the responses of the Federal Funds Rate to exogenous shocks to output and inflation scaled to identical size in both regimes. The Federal Funds rate increase after an inflation shock is stronger in the high inflation regime (Figure 3) and becomes insignificant in both regimes after about one year. The immediate reaction to an output shock again is smaller in the low inflation regime but remains significantly positive for about three years while it is always insignificant in the high inflation regime.

« Insert Figure 3 »

« Insert Figure 4 »

Table 2: Variance decompositions

A: Percentage contribution to GDPGR			
	1 quarter	4 quarters	16 quarters
FF	0.05	19.90	17.70
	(0.05)	(1.98)	(5.25)

B: Percentage contribution to INFL			
	1 quarter	4 quarters	16 quarters
FF	1.97	1.55	5.54
	(0.38)	(1.30)	(12.13)

C: Percentage contribution to FF			
	1 quarter	4 quarters	16 quarters
RGDPGR	4.87	9.34	9.79
	(8.03)	(36.49)	(51.44)
INFL	2.79	27.36	19.78
	(8.70)	(14.92)	(10.92)
FF	87.50	57.75	21.40
	(75.07)	(38.20)	(24.09)

NOTES: Sample period is 1965Q3-2007Q2. Numbers in brackets apply to regime $INFL_{t-1} \geq 2.58$

Table 2 presents the results of regime-dependent variance decompositions. In the low inflation regime Federal Funds Rate shocks have a reduced effect on the forecast variance of output growth but a higher impact on the forecast variance of inflation. Output growth shocks become less important for unexpected variations in the Federal Funds Rate in the short-run but more important in the long run while inflation shocks have a lower explanatory power.

4 Conclusions

This paper presents evidence for regime dependent effects of monetary policy shocks in the U.S. The standard results from the literature are obtained for a regime of higher inflation which dominates the sample periods used in the standard literature. A second regime with lower inflation shows output growth to be not significantly affected by monetary policy shocks but inflation to fall quickly and significantly. The responses of monetary policy to shocks to output growth and the explanatory power of output growth and inflation shocks for the Federal Funds rate differ across regimes as well.

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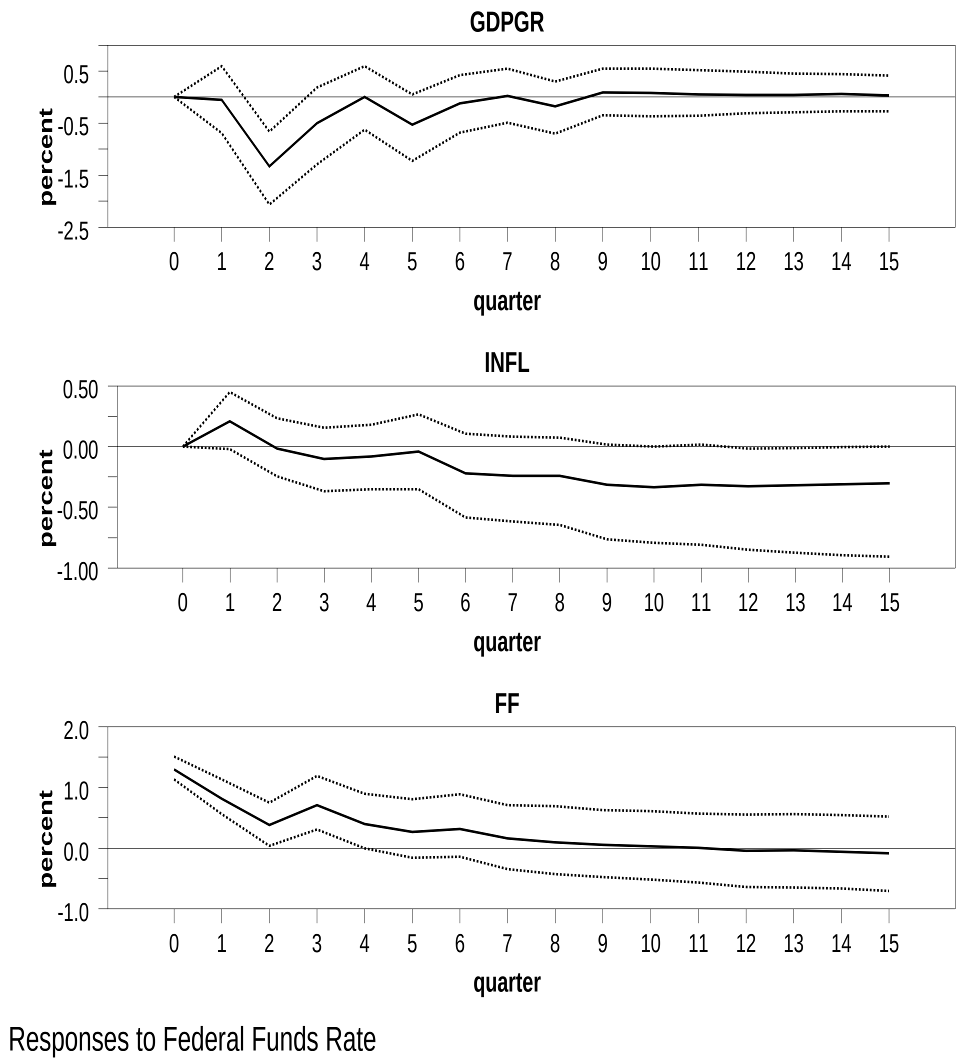

Figure 1: Impulse responses to monetary policy shock (1965Q3 - 1995Q2).

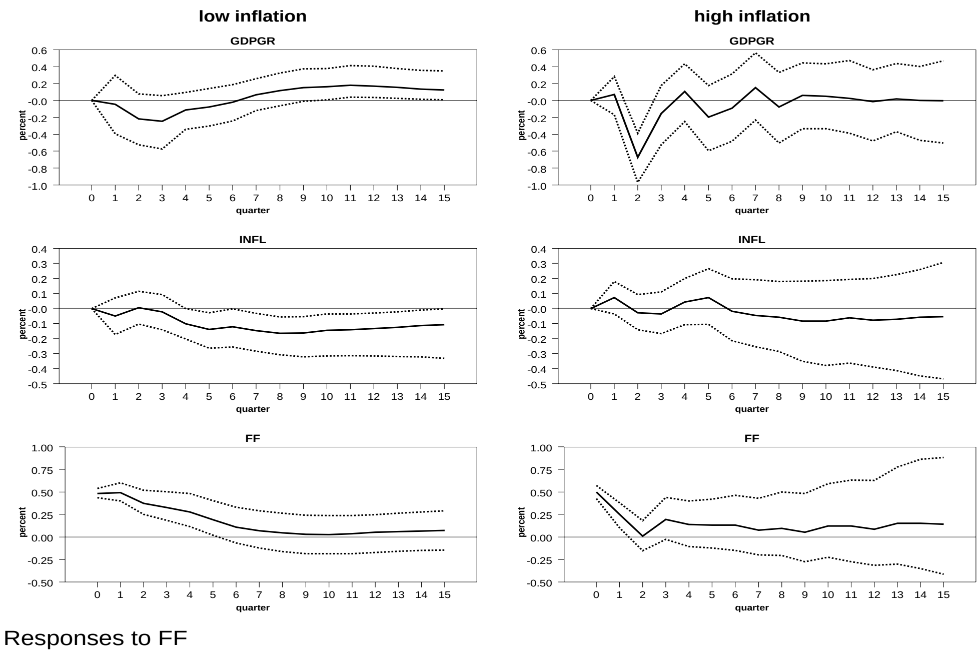

Figure 2: Impulse responses to monetary policy shock.

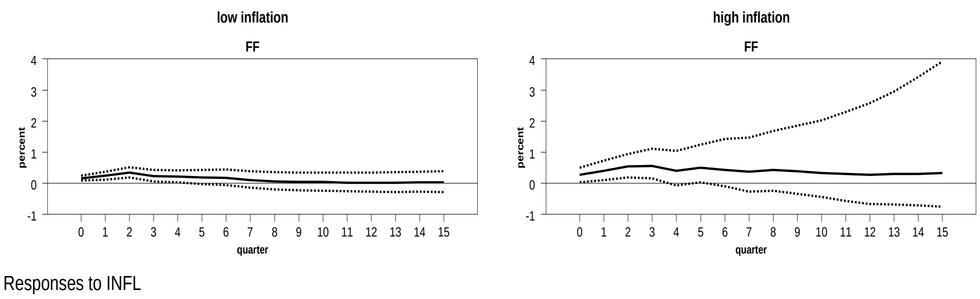

Figure 3: Impulse responses to inflation shock.

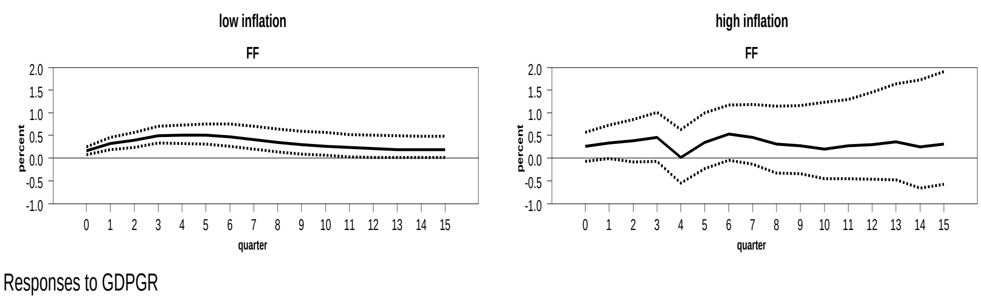

Figure 4: Impulse responses to output growth shock.