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Did the Fed and ECB react asymmetrically with respect to asset market developments?

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Did the Fed and ECB react asymmetrically with respect to asset market developments?[1]

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Abstract

This paper studies the monetary policy of the Federal Reserve (Fed) and the Bundesbank / European Central Bank (ECB) with respect to stock or/and foreign exchange markets from 1979 to 2009. I find that Fed policy changed over time, dependent on the chairman of the Fed. During the Greenspan era stock markets mattered for the Fed. In this period, the Fed lowered interest rates when stock prices fell, but did not raise interest rates in the boom. This asymmetry potentially put a downward pressure on interest rates. For the ECB, the exchange rate to the dollar played a role in monetary policy decisions until 2006. While I do not find evidence of asymmetric monetary policy with respect to the stock market, the ECB may be argued to indirectly have followed asymmetric US monetary policy via the exchange rate channel.

Keywords: Monetary policy, Taylor rule, Asset prices.
JEL: E52, E61.

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1 Introduction

Most economists agree that countercyclical monetary policies are useful to stabilize the general price level and thereby smooth business cycles. During a downturn, monetary policy has to lower interest rates to prevent deflation and deep crisis. In a boom period, interest rates have to be raised to prevent inflation and an overheating economy. In practice, however, major central banks seem to have reacted stronger in times of crisis than in boom periods since the late 1980s (Schnabl and Hoffmann, 2008).

For instance, the Bank of Japan (BoJ) has not increased interest rates during the upswing in 1995-96. In contrast, with the event of the Asian crisis in 1997-98, the BoJ cut interest rates decisively to zero. In the US and Europe, a similar policy was seen after the burst of the dot-com bubble in 2000. While the downturn justified sharp interest rate cuts to stabilize prices and output, interest rates were held relatively low in the post-crisis period, even though the economies boomed again (Schnabl and Hoffmann, 2008; Taylor, 2009).

This provided low-cost liquidity to flourishing asset markets which eventually contributed to new bubbles in the US housing market, South and Eastern Europe, and East Asia. And yet again, in the wake of the financial crisis of 2007-09 major central banks slashed interest rates. Because the initial interest rate level was still relatively low, interest rates fell close to zero (Schnabl and Hoffmann, 2008; Taylor, 2009; and Belke et al., 2010). To provide an explanation for this interest rate setting behavior, this paper analyzes the role of asset markets in Federal Reserve (Fed) and European Central Bank (ECB) policies over time. Particularly, I want to investigate whether and why US and euro area monetary policies responded asymmetrically with respect to asset market developments. Has policy changed over time?

Previous research has estimated augmented monetary policy (Taylor) rules to answer the question of whether asset prices have an impact on US or euro area monetary policy decisions. While Rigobon and Sack (2003) and Dupor and Conley (2004) find evidence for monetary policy reactions of the Fed towards stock markets, Fuhrer and Tootell (2008) find the opposite. For the ECB, Botzen and Marey (2010) and Belke and Polleit (2006) challenge Bohl et al. (2004; 2007) in showing that the ECB adjusted interest rates following changes in the dollar/euro exchange rate and stock markets.

While these papers test for a symmetrical reaction of central banks towards asset price movements, little research focuses on asymmetric monetary policy responses with respect to asset markets. But *fear of crisis* when stock markets burst or exchange rates appreciate may have implications on policy. In order to close this gap, I apply the approach taken by Danne and Schnabl (2008) and Hoffmann (2009). Schnabl and Danne (2008) use threshold dummies and moving window regressions to single out effects of appreciating versus depreciating exchange rates on Japanese monetary policy. The authors find that the BoJ lowered interest rates when the yen appreciated from 1993 to 1999. In contrast, the BoJ did not raise interest rates accordingly, when the yen depreciated. Hoffmann (2009) provides first evidence of asymmetric behavior of the Fed.

This paper is organized as follows. In section 2, I explain how and why the Fed's and ECB's monetary policies may have changed over time. I present different arguments about how asset markets *should* be taken into account by monetary policy makers. In section 3, I review the literature that tests whether asset markets *are* included in monetary policy rules. I provide first graphical evidence of my thesis that monetary policy responds asymmetrically towards asset markets in certain periods. Further, I introduce a model to test for this asymmetry. In section 4, tests are carried out to determine whether the Fed and ECB reacted asymmetrically towards positive and negative asset price developments in certain periods. I assume that a change of a big player, such as the Fed chairman, may cause a shift in policy. Section 5 concludes.

2 Changes in Monetary Policy Frameworks

2.1 From Money to Inflation and Output Targeting

Monetary policy frameworks have changed over time. Traditionally central banks in advanced economies tried to achieve price stability by broad money targeting, which is based upon *"the quantity theory of money"* (Friedman, 1956). According to this theory, money growth is the ultimate source of inflation in the long run. Changes in broad money are set equal to changes in output plus inflation (under the assumption of a constant velocity of money). Therefore, Friedman (1956) proposes that broad money growth should not exceed output growth plus an agreed rate of inflation.

Building upon this concept, the Deutsche Bundesbank saw M3 growth within a corridor of 4 - 6 percent as inflation neutral. Similarly, the ECB introduced a two-pillar strategy including a monetary pillar as framework for its interest rate decisions with a reference value of 4.5 percent for money growth. However, since the 1990s broad money has grown at annual rates of 10 percent in the advanced economies.

Given low inflation in the 1990s, although broad money grew rapidly, many authors question the impact of money growth on inflation. For instance, De Grauwe and Polan (2005) show that, in the short term, differences in money growth among countries cannot explain differences in their inflation rates. Further, money demand, being defined as the reciprocal of the velocity of money, is not constant over time – especially in the US.[2]

[2] For the euro area, Brüggemann (2000) and Coenen and Vega (2001) find that money demand is stable in the long run.

As money demand is unstable, Estrella and Mishkin (1997), Gerlach and Svensson (2003) and Stock and Watson (1999) argue that money growth is not a good indicator to predict future inflation. Instead, they propose current inflation and output as indicators to forecast future inflation. Alesina et al. (2001) and Begg et al. (2002) find that following a monetary target can lead to restrictive policies even if inflation rates are stable. Therefore, targeting money growth has a negative impact on growth. As consumer price inflation seems to be a more reliable monetary policy target than broad money growth, these authors propose inflation targeting frameworks.

The New-Keynesian models incorporate interest rate rules to model how central banks adjust the nominal interest rate in response to changes in inflation and output (Woodford, 2003). In this framework, monetary policy follows a Taylor rule (Taylor, 1993). The interest rate is the main operating target to control consumer price inflation. Furthermore, output can be stimulated by lower interest rates as long as consumer price inflation is stable (without reference to money growth). Money growth is only considered via the secondary pillar of the ECB. The Fed no longer publishes any data concerning M3 growth.

2.2 Asset Markets and Monetary Policy

After the burst of the dot-com bubble, monetary policy makers cut interest rates sharply to stabilize the price level and output. While the resulting money growth did not have direct effects on good markets, it affected stock, commodity and foreign exchange markets around the world (Borio, 2008). Because money and asset price growth often precede inflationary periods (Adalid and Detken, 2007), this has spurred an academic discussion about the need to include asset markets in monetary policy reaction functions.

On the one hand, Filardo (2001) and Polleit (2005) argue that monetary policy shall respond towards asset markets if they contain information on future inflation or output. This shall help prevent the emergence of asset market bubbles. Also, Johnson (2001) proposes to include further measurable (forward-looking) indicators in the monetary policy response function, for instance foreign exchange, bond and commodity market developments. To prevent future inflation and instability, this strand of literature emphasizes the need for central bank reactions in order to smooth asset market developments (e.g. Borio, 2008; Cecchetti et al., 2000).

In contrast, Bernanke and Gertler (2001) argue that there is no need to take asset markets into account as they are already considered indirectly via the output and inflation channel. Blinder and Reis (2005) further explain that the Fed should not intervene when asset market developments are friendly for the economic performance because it is uncertain whether asset markets reflect fundamentals or not. Furthermore, pricking e.g. a stock market bubble may cause instability. Accordingly, monetary policy should only react towards the stock market when a bubble bursts to prevent a crisis. Otherwise, it should remain passive (Blinder and Reis, 2005, p. 67).

Similarly, Mishkin (2007, p. 40) argues that preventing asset market bubbles is not the task of a central bank. However, monetary authorities should respond quickly after a bubble has burst to stabilize the economy and prevent a possible crisis. As American central bankers widely agree on this issue, this position is known as *Jackson Hole Consensus*. By proposing interest rate cuts when bubbles burst, but not wanting interest rates to rise in boom periods, the *Jackson Hole Consensus* implicitly proposes asymmetric reactions towards asset market developments. Similarly, the ECB states that “financial imbalances and asset price misalignments may need to be taken into account in current monetary policy decisions” (ECB, 2004, p. 57).

3 Asymmetric Monetary Policy with Respect to Asset Markets

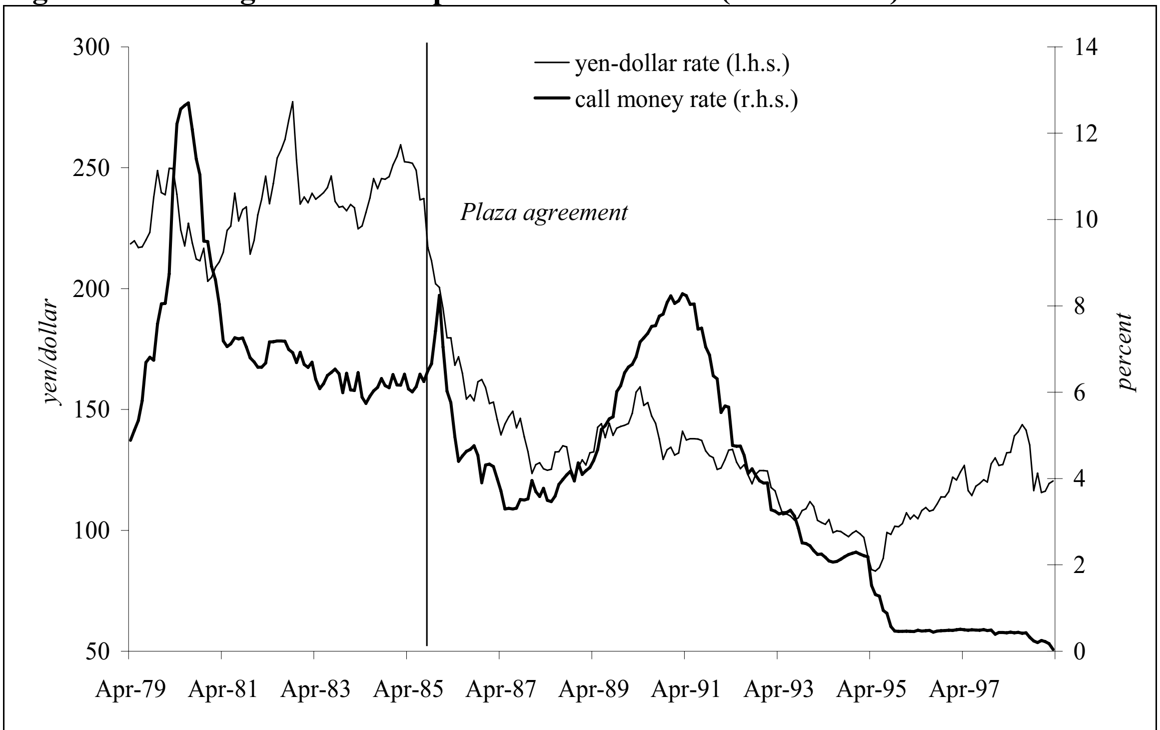
3.1 Previous Research and Graphical Evidence

There is a growing literature that addresses the question of whether central banks react (symmetrically) towards asset markets. For instance, Rigobon and Sack (2003) and Dupor and Conley (2004) find evidence for monetary policy reactions of the Fed towards stock markets from 1985 to 1999 and 1991 to 2002, respectively. On the contrary, Fuhrer and Tootell (2008) reject this hypothesis. For the ECB, Botzen and Marey (2010) and Belke and Polleit (2006) challenge Bohl et al. (2004; 2007) in showing that the ECB adjusted interest rates following changes in the euro/dollar exchange rate and stock markets. For Japanese monetary policy, the yen/dollar exchange rate played a role for interest rate decisions during the 1990s (Clarida et al., 1998).

This essay addresses asymmetric responses of the Fed and Bundesbank / ECB with respect to asset markets. For the Bank of Japan, Danne and Schnabl (2008) find asymmetric monetary policy reactions with respect to exchange rate changes. Figure 1 provides an intuition for an impact of the foreign exchange market on interest rate decisions, in particular after the Plaza agreement (vertical line) when the US forced Japan to appreciate its currency to reduce its current account surplus (up to 1995). Figure 1 indicates that exchange rate and interest rate changes went along from 1985 to 1995. When the yen appreciated, interest rates were cut. Whereas, when the yen depreciated, the BoJ did not raise interest rates. According to the authors, this contributed to Japan's fall into the liquidity trap.

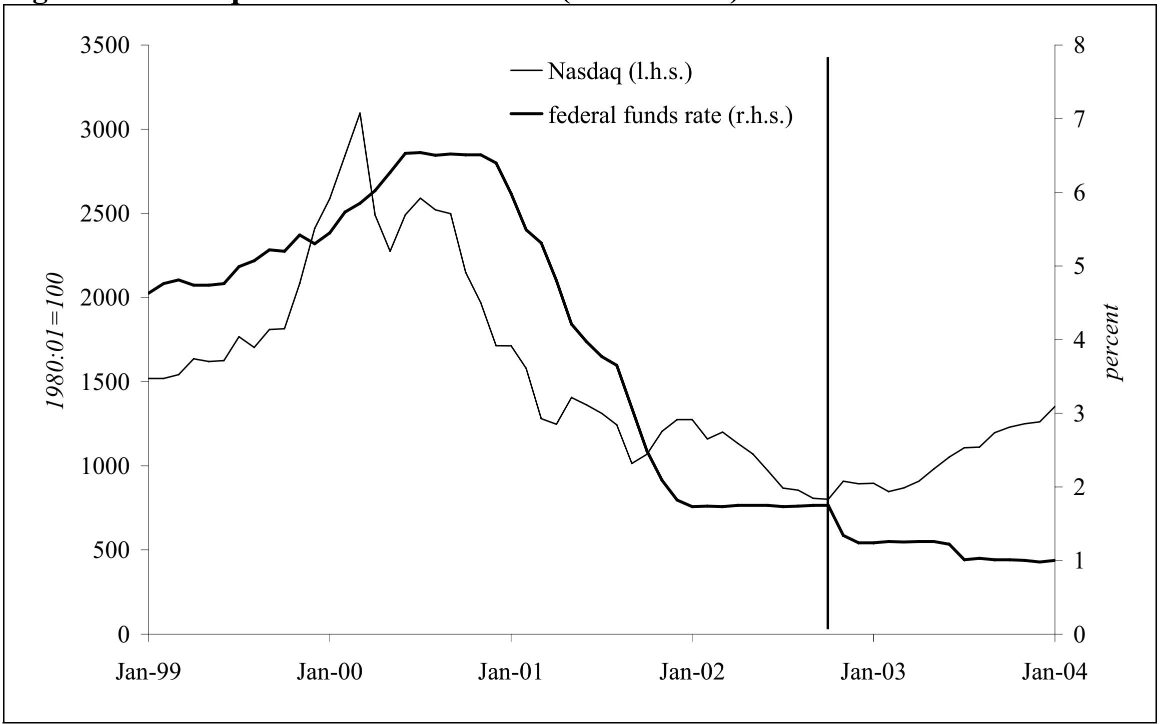
There is also evidence for asymmetric monetary policy of the US Fed and ECB. Schnabl and Hoffmann (2008) and Hoffmann (2009) argue that the US Fed cut interest rates heavily following the burst of the dot-com bubble in 2000, when *fear of crisis* prevailed. Whereas when markets calmed down in 2002 the Fed did not increase interest rates in the same manner. I plot the data of the Nasdaq and the US federal funds rate in Figure 2. When the Nasdaq fell (to the left of vertical line), the interest rate was slashed. However, when the Nasdaq rose, this was not accompanied by rising interest rates. Instead, from late-2002 up to 2004 the Fed further cut interest rates (to the right of the vertical line).

Figure 1: Exchange rate and Japanese interest rates (1979 – 1998)



Source: IMF, IFS 2011. See Danne and Schnabl (2008).

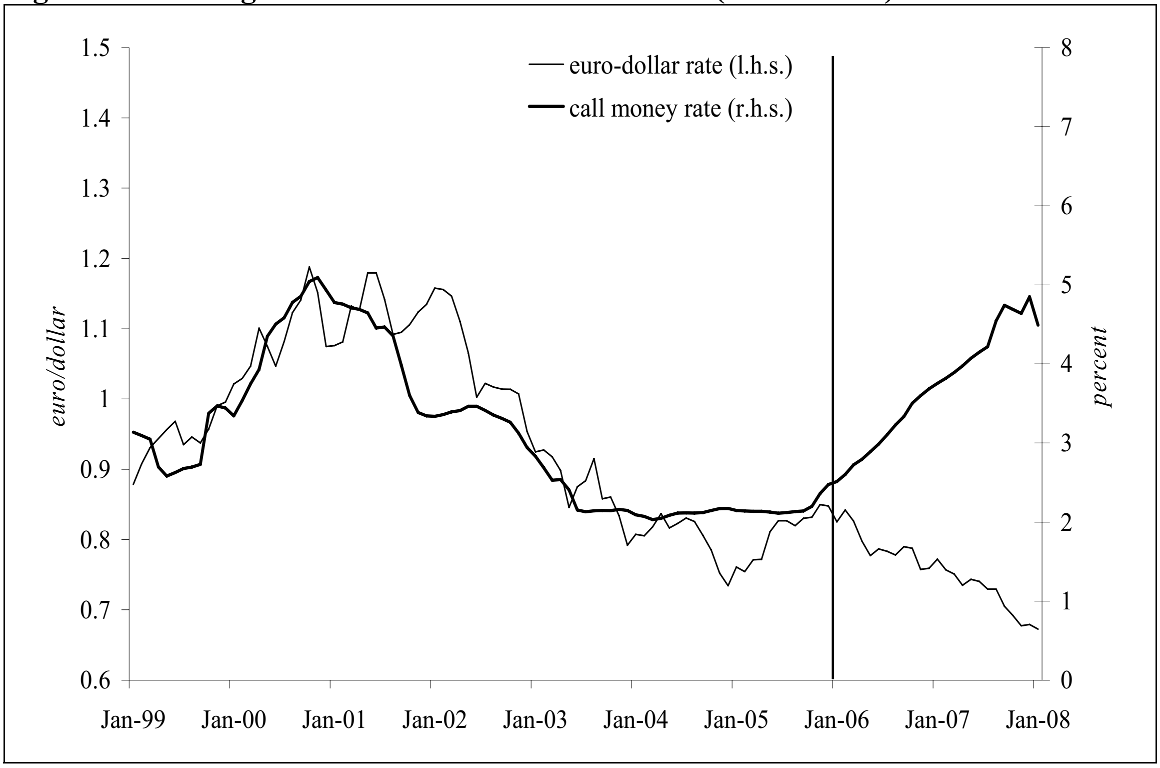
Figure 2: Nasdaq and federal funds rate (1999 – 2004)



Source: IMF, IFS 2011.

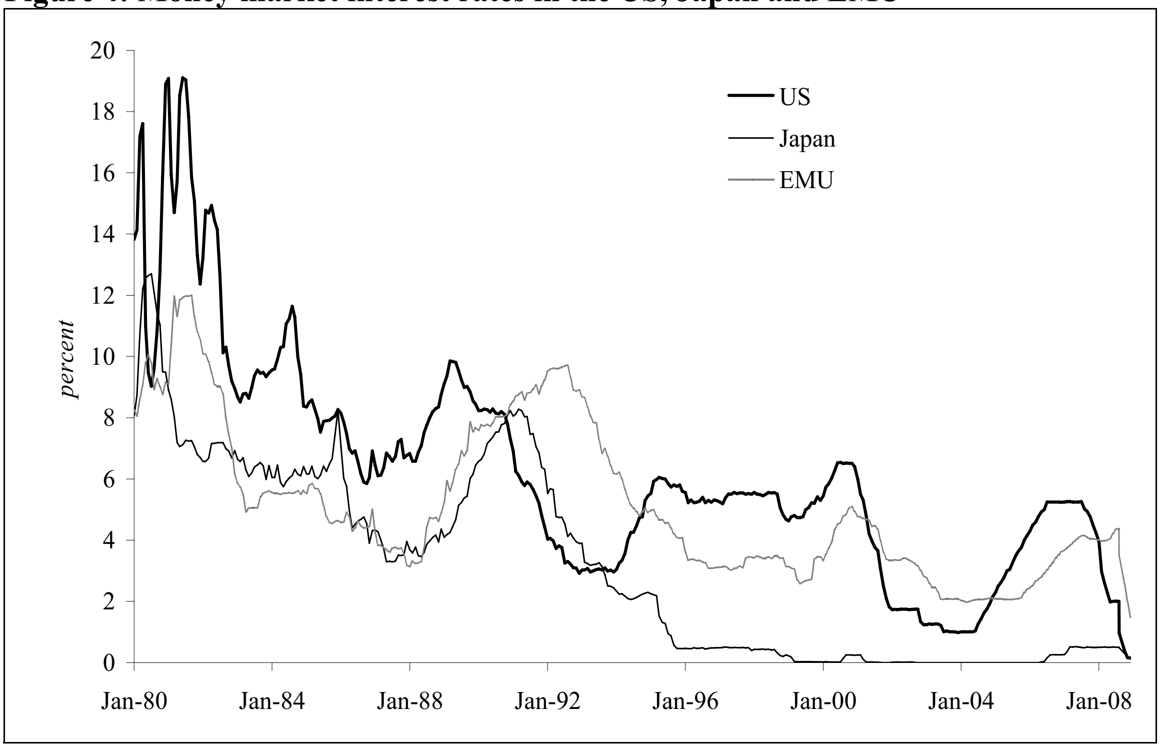
With the US Fed's expansionary policy devaluing the dollar, it is plausible that the ECB followed the Fed's policy via the exchange rate channel from 1999 to 2006 to keep the European economies competitive during this period (Belke and Polleit, 2006). Figure 3 gives some intuition for this argument. The ECB seems to have cut interest rates during the appreciation of the euro from 2001 to 2005. Thereafter (to the right of the vertical line), Figure 3 indicates that the ECB raised interest rates and exchange rate developments do not go hand in hand with the interest rate set by the central bank. This may signal *fear of appreciation* as found for Japan by Danne and Schnabl (2008).

Figure 3: Exchange rate and euro area interest rate (1999 – 2008)



Source: IMF, IFS 2011.

Figure 4: Money market interest rates in the US, Japan and EMU



Source: IMF, IFS 2011.

Because output growth and inflation levels remained relatively stable in the US and euro area since the 1990s, Schnabl and Hoffmann (2008) further argue that asymmetric monetary policy responses towards asset markets contributed to the downward-trend in interest rates – as it is obvious in Figure 4 – that fuelled a wave of worldwide asset market bubbles.[3] Figure 4 indicates that interest rates have a downward-trend in the three advanced economies.

3.2 The Model

To model asymmetric monetary policy decisions with respect to asset markets I use the forward-looking monetary policy reaction function as proposed by Clarida et al. (1998).

$$i_t^* = \bar{i} + \beta(E[\pi_{t+12}|\Omega_t] - \pi^*) + \gamma(E[y_t|\Omega_t] - y_t^*) \qquad (1)$$

Equation (1) shows the decision parameters for the central bank to set its nominal interest rate i_t^* at time t. The decision depends on the gap between optimum rates of inflation π^* and expected inflation π_{t+12} (twelve periods ahead) as well as optimum output y_t^* and the actual output growth y_t. The optimum output is assumed to be the trend of output growth around which the actual growth rate oscillates. Because future inflation and output are not observable in time t, expected values have to be used that depend on information availability. Thereby E indicates expected values. Ω_t stands for the information available at time t. The

[3] Hoffmann and Schnabl (2011) provide a theoretical explanation of asymmetric monetary policy behavior from the viewpoint of monetary overinvestment theories. In a way, this paper econometrically tests a part of the argument.

coefficients β and γ weight the importance of inflation and output gap for setting the nominal interest rate. John Taylor (1993), who introduced the Taylor rule, quantified β to be 1.5 and γ to be 0.5 in the US.

Finally the decision depends on the natural rate of interest $\bar{i}$, which is the interest rate where inflation target and output target are at the equilibrium level. Then, inflation and the output gaps are zero. In contrast to Taylor (1993), the policy rule proposed by Clarida et al. (1998) is a forward-looking rule.[4] It uses future variables for monetary policy decisions. The rational behind the use of future variables is that there is a certain time needed for inflation and output to follow interest rate decisions. Therefore, central banks have to anticipate what happens in future and follow a forward-looking rule, rather than using past developments (Bernanke, 2003).[5] The monetary policy decisions are made under uncertainty.

Further, Clarida et al. (1998, pp. 7-8) introduce interest rate smoothing into the reaction function, as interest rate setting depends on the level of the interest rate in the past. The economic reason behind it is that central banks do not set rates randomly as sudden interest rate adjustments shock markets and signal instability. Thus,

$$i_t = (1-\rho)i_t^* + \rho i_{t-1} + v_t \tag{2}$$

[4] Bohl et al. (2004) argue that forward-looking rules are more accurate in explaining monetary policy.

[5] "Because monetary policy influences inflation with a lag, keeping inflation under control may require the central bank to anticipate future movements in inflation and move preemptively. Hence constrained discretion is an inherently forward-looking policy approach." Bernanke at the Annual Washington Policy Conference of the National Association of Business Economists, Washington, D.C. on March 25, 2003.

with ρ being a parameter between 0 and 1. The closer ρ is to 1 the higher the degree of interest rate smoothing. The error term v_t is assumed to be normally distributed. To eliminate the expectation parameters, Clarida et al. (1998) further define $\alpha = \bar{i} - \beta\pi^*$, and replace i_t^* by the augmented Taylor rule from equation (1). The policy rule including interest rate smoothing and using realized variables finally takes the form

$$i_t = (1-\rho)\alpha + (1-\rho)\beta\pi_{t+12} + (1-\rho)\gamma(y_t - y_t^*) + \rho i_{t-1} + \varepsilon_t \qquad (3)$$

with

$$\varepsilon_t = -(1-\rho)\left(\beta\left(\pi_{t+12} - E\left[\pi_{t+12}|\Omega_t\right]\right) + \gamma\left(y_t - y_t^* - E\left[y - y_t^*|\Omega_t\right]\right)\right) + v_t,$$

capturing the unobserved forecast variables and the error term v_t in time *t* (Clarida et al., 1998).

Following Bernanke and Gertler (1999, pp. 25-26), Clarida et al. (1998), Dupor and Conley (2004) and Botzen and Marey (2010) asset markets have to be explicitly taken into account in the reaction function if I assume asset markets affect interest rate setting directly, and not just via the future inflation and output channel. For this purpose, I extend the policy rule by the deviation of asset market indicators (exchange rate developments, stock price changes) p_t from their trend p_t^* which is seen as their optimum. The rule changes to

$$i_t = (1-\rho)\alpha + (1-\rho)\beta\pi_{t+12} + (1-\rho)\gamma(y_t - y_t^*) + (1-\rho)\delta_1(p_t - p_t^*) + \rho i_{t-1} + \varepsilon_t. \qquad (4)$$

An expectation or uncertainty parameter is not needed for asset market gaps, as they are known at any time t. δ_1 captures the effect of asset markets on monetary policy.

Equation (4) does not include asymmetric reactions towards asset market developments. Estimating this equation only allows for a test of symmetric responses with respect to asset market deviations from trend. When analyzing equally distributed deviations, interest rates should oscillate around equilibrium. But I aim to test whether the Fed or ECB respond differently towards positive and negative asset market deviations.

There are two ways in which this is possible in this framework. First, I can single out periods of rising and falling stock prices or depreciating and appreciating exchange rates via rolling window regressions and analyze when central banks reacted towards stock prices or exchange rates. Second, I can include a dummy in the regression that distinguishes between ups and downs. Therefore, following Schnabl and Danne (2008), a threshold dummy is added to equation (4). The dummy D_t is 0, when asset market indicators are above the trend ($p_t > p_t^*$). The dummy D_t is 1, when these deviations from trend are negative ($p_t < p_t^*$). The equation now takes the form

$$i_t = (1-\rho)\alpha + (1-\rho)\beta\pi_{t+12} + (1-\rho)\gamma(y_t - y_t^*) + (1-\rho)(p_t - p_t^*)(\delta_2 + \mu D_t) + \rho i_{t-1} + \varepsilon_t \qquad (5)$$

In equation (5) δ_2 represents the effect of positive asset market deviations from trend on monetary policy. μ is the additional effect from negative asset market deviations. Thus, if monetary policy does not react more sensitive towards negative asset market deviations from trend $\mu = 0$, and thus $\delta_1 = \delta_2$.

4 Empirical Estimations

4.1 Data and Method

To analyze monetary policy and estimate equations (3), (4) and (5), I take monthly data from 1974 to 2009 from the IMF's International Financial Statistics that represent the parameters of the equations. Because real GDP is only available on a quarterly basis, industrial production is used as proxy for output.

For the US, I use the federal funds rate, year-over-year (y-o-y) changes in consumer price inflation (cpi), the all shares index (as stock market variable) and industrial production. The data for the euro area starts in 1999. I use the Eurostoxx 50, y-o-y cpi, industrial production and the euro/dollar exchange rate. To test for the period before 1999, I additionally use German data to analyze Bundesbank policy up to 1998. This is the Dax 30, the German y-o-y cpi, industrial production and the dm-dollar rate.

Available data up to 1974 is not used because the monetary framework differed significantly until the final break down of the Bretton Woods System in February 1973, when currency markets closed (and only reopened with floating exchange rates in March 1973). It took until 1976 until all currencies were (more or less) floating. Following Clarida et al. (2008) the Taylor rule can be applied to explain monetary policy of the Fed and Bundesbank from 1979 onwards. Before 1979 the interest rate was not used to control inflation. Nominal interest rates were at the same level as consumer price inflation. Thus, data from 1974 to 1979 is only used to construct the trends needed in the estimations.

The output gap and asset market gaps are calculated by subtracting the year-over-year log-differences of industrial production, stock prices and exchange rates from their trends, which is approximated by the Hodrick-Prescott filter (Bjørnland, 2005).[6] Further, I calculate the exchange rate gap following Schnabl and Danne (2008) as a deviation of the exchange rate from a 60-month backward moving average. At the 10 percent significance level, the Dickey-Fuller test does not identify unit roots in cpi, output gap or asset price (exchange rate and stock price) gaps.

Following Clarida et al. (1998) I use generalized method of moments (GMM) to estimate the parameters to control for endogeneity of the interest rate and its explanatory variables (inflation, output, asset prices) (Arellano and Bover, 1995). Newey West standard errors provide robust error terms. Using realized 12-month forward inflation rates in the regression to estimate equation (4) and (5) assumes that expectations of policy makers are accurate in forecasting this variable.

As widely used when estimating Taylor rules, lags of the regressors of up to twelve periods (one year) and a constant are used as instruments (Dupor and Conley, 2004; Clarida el al., 1998). The impact of asset prices on future output and inflation is taken into account for by including asset prices as instruments (Fuhrer and Tootell, 2008; Bohl et al., 2004, p. 23). Because more orthogonality conditions (instruments) than needed are used to estimate the parameters of the equations, Sargan (1958) and Hansen (1982) suggest a test for validity of instruments. All sample moments shall be close to zero. To do so, J-statistics are multiplied with the number of observations. If the respective value is smaller than the critical value of the χ^2 - distribution, the null hypothesis of validity of instruments is not rejected.

[6] Like proposed by Taylor (1993), I construct the gaps from growth rates in my estimations. I also construct the gaps from levels to test robustness. Further, I use the Dow Jones from IMF, IFS to calculate alternative gaps for robustness analysis.

4.2 Federal Reserve

Set-up

I begin with the analysis of the Fed's monetary policy. Following Clarida et al. (1998) US monetary policy has been trying to reign in stagflation since shortly after Paul Volcker became the chairman of the Fed in August 1979. Therefore, I use data from August 1979 to December 2009 in the regressions (but earlier data is used to calculate trends and as lagged instruments).

Because monetary policy has changed over time, I consider three periods. First, the full sample is analyzed. Then, two sub-samples are distinguished. My a priori assumption is that the conduct of monetary policy changes with a change in a big player. Thus, the two sub-periods correspond to the incumbencies of the two Federal Reserve chairmen Paul Volcker and Alan Greenspan (including the beginning of the Bernanke incumbency). Therefore, the second period ranges from August 1979 to August 1987. The third period starts in September 1987 and goes up to December 2009 (Table 1).

Drawing the line according to the incumbency periods is sensible, because Paul Volcker and Alan Greenspan faced very different economic environments. While Volcker brought inflation under control in the 1980s which pulled down nominal interest rates significantly (Figure 4), Greenspan faced the dot-com bubble and tried to stabilize output at the turn of the millennium. During this time, inflation was already at comparatively low levels. This may have resulted in policy shifts, also independent of different believes about policy that chairmen may have. Ben Bernanke is the chairman of the Fed since February 2006. This data is included in the second sub-sample.[7]

[7] The 12-month forward-looking rule would only include 35 observations (February 2006 – December 2008) if I test for the Bernanke period itself. This seems to be too few for reliable results.

Estimation results

First, I estimate a baseline regression (which corresponds to equation (3)) as a benchmark. The results are presented in Table 1. The first column in Table 1 indicates the time period and equation that is estimated. The following columns present the coefficients with their standard errors in parentheses. Stars mark significant coefficients as described in the Table.

Table 1: Federal Reserve

	Constant	*Inflation*	*Output*	*Asset*	*A-Term*	*Interest*
Sample	α	β	γ	$\delta_{1,2}$	μ	ρ
Baseline						
(1) 1979:08 - 2008:12	-0.016	2.114***	0.713**	-	-	0.946***
Full sample	(0.015)	(0.370)	(0.298)			(0.011)
Stocks[8]						
(2) 1979:08 - 2008:12	-0.016	2.099***	0.784***	0.069	-	0.950***
Full sample	(0.015)	(0.386)	(0.321)	(0.070)		(0.012)
(3) 1979:08 - 1987:08	0.037*	1.340***	0.649**	0.065	-	0.891***
Volcker	(0.027)	(0.551)	(0.283	(0.087)		(0.032)
(4) 1987:08 - 2008:12	-0.059	3.331***	1.161*	-0.113*	-	0.971***
Greenspan-Bernanke	(0.040)	(1.289)	(0.707)	(0.064)		(0.012)
(5) 1979:08 - 2008:12	-0.025	2.026***	0.704**	0.207	-0.275	0.943***
Full sample	(0.019)	(0.363)	(0.363)	(0.193)	(0.350)	(0.013)
(6) 1979:08 - 1987:08	-0.005**	1.472***	0.509**	0.338	-0.630	0.864***
Volcker	(0.039)	(0.542)	(0.255)	(0.209)	(0.412)	(0.044)
(7) 1987:08 - 2008:12	-0.032	3.715***	1.041**	-0.616**	0.947**[9]	0.961***
Greenspan-Bernanke	(0.025)	(1.041)	(0.426)	(0.295)	(0.473)	(0.013)

Standard errors in parentheses, ***,**,* denote significance at 1, 5 and 10 percent levels. Test for over-identifying restrictions: J-statistics multiplied by the number of observations is always smaller than χ^2(27 or 28). As 33 instruments are used and 5 or 6 coefficients estimated, I have 27 or 28 degrees of freedom.

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[8] Various types of asset price gaps in levels and as y-o-y changes (Dow Jones, 60-month backward rolling gaps) have been used to check robustness. Also, the number of lags included and instruments can be varied. The main results are not affected by the robustness tests. Further, excluding the post-February 2006 data does not have a major effect on the results. Thus, they are not solely driven by the responses of the 2007-08 financial crisis (and the Bernanke incumbency). Exchange rates are not considered (and would also not be significant) as the US is the center of the world monetary system which does not stabilize exchange rates (McKinnon, 2010).

[9] To decide whether the cumulated coefficient is significant, its t-statistic has to be calculated as follows.

$$tstat(\delta_2,\mu)=\frac{\delta_2+\mu}{\sqrt{\text{var}(\delta_2)+\text{var}(\mu)+2*\text{cov}(\delta_2,\mu)}}=\frac{-0.62+0.95}{\sqrt{0.29^2+0.47^2+2*(-0.14)}}=\frac{0.33}{0.16}=\underline{\underline{2.06}}$$

The first line in Table 1 reports the results for the baseline estimation (equation 3). I explain the meaning of the parameters in detail for this regression. For further specifications, I focus on the most important insights and emphasize the differences with respect to the baseline estimation.

α is a constant and ρ is the coefficient on interest rate smoothing. This coefficient is close to 1 because interest rates are set dependent on the previous period as explained in section 3.2. The coefficient on inflation β is 2.11 with a standard error of 0.37. Thus, a rise in inflation by 1 percent led to an increase in real interest rates (nominal interest rates – inflation) of 1.11 percent or 111 basis points (BP) over the whole estimation period. Nominal interest rates are raised more than the rise in expected inflation to offset inflationary pressure. This result is statistically significant.

The coefficient on the output gap γ is significant, too. Given expected inflation is constant, a 1 percent rise in the output gap brings about a 0.71 percent rise in (real and nominal) interest rates (holding inflation constant). Both coefficients are very close to the findings by Clarida et al. (2008) as well as the suggested coefficients by the seminal Taylor rule (Taylor, 1993). Thus, the Taylor rule seems to be a valuable tool to model monetary policy of the Fed.

Next, I estimate equation (4) to find evidence of whether stock markets affect US monetary policy. The coefficients on inflation and output gaps remain widely unchanged, using the full sample. The coefficient on the stock market gap is insignificant (entry 2). The sub-samples reveal that coefficients are larger in the Greenspan-Bernanke period, than in the Volcker period. Monetary policy seems to have become more active in fighting in- and deflation as well as stabilizing output. The most interesting variable in this analysis is the impact of the stock market gap δ_1. The regression suggests that during Greenspan's incumbency, stock market gaps had a negative significant impact on interest rates (entry 4).

This confirms the intuition as plotted in Figures 2 and 4. After 2002, when stock markets accelerated but inflation and output growth have not yet picked up (section 2), monetary policy continued to fuel the economy. Thus, the Fed does not *lean against the wind*. Stock markets pushed interest rates downwards.

To test for asymmetric behavior with respect to the stock market, I add the asymmetric term μ to estimate equation (5). Entries 5 – 8 of Table 1 show the results for the estimation including the asymmetric term. The coefficients on inflation and output gap remain at widely unchanged levels. The coefficient on the stock market gap is now labeled δ_2. Like before, the stock market coefficient is not significant in the overall sample and the Volcker period. However, the results for the Greenspan-Bernanke period indicate that stock markets affect US interest rates negatively.

The asymmetric term μ is the additional effect that stems from negative stock market gaps, while δ_2 is the effect positive stock market gaps have on the interest rate. Thus, to calculate the total effect of a negative stock market gap on interest rate setting, δ_2 and μ have to be added. In the Greenspan period, which can be found in line 7 of Table 1 the joint effect is positive. Also, the joint t-statistic for below trend stock market developments is positive and significant at the five percent level. Therefore, the estimation of equation (5) indicates that stock market busts had a significant negative effect on the Fed's policy. When stock prices fell, the Fed lowered interest rates.

Further, Alan Greenspan did not raise interest rates when stock markets boomed. Otherwise, the general effect δ_2 would be positive, too. The negative coefficient is driven by the post 2002 period – as is in line with Figure 2. Thus, the Fed reacted asymmetrically with respect to the stock market since the late eighties.[10] This put a downward pressure on the interest rate.

To summarize, Table 1 indicates that the impact of stock prices on monetary policy decisions was weak during the Volcker era, but increased when Greenspan came to power. Because significance of the stock market gaps depends on the time period taken into account, this may be a reason why some authors find a response with respect to asset markets and others do not.

Rolling window

Rolling window regressions can help identify changes in asymmetric monetary policy with respect to the stock market. I estimate equation (5) using a ten year moving window (120 months), starting with the period August 1979 to August 1989 and moving forward to the period from December 1998 to December 2008.

Figure 5 illustrates the joint t-statistics for $\delta_2 + \mu$, thus for the reaction with respect to falling stock prices. The separation line signals that from this period onwards there is no overlap of data between the Volcker period and the time when his successors Greenspan and Bernanke were in charge of monetary policy. Until 1991 negative stock market developments seem to have had no impact on monetary policy. The t-statistics do not touch levels of significance. This is in line with the static estimations and implies that between 1979 and 1990 asset price busts did not affect interest rates.

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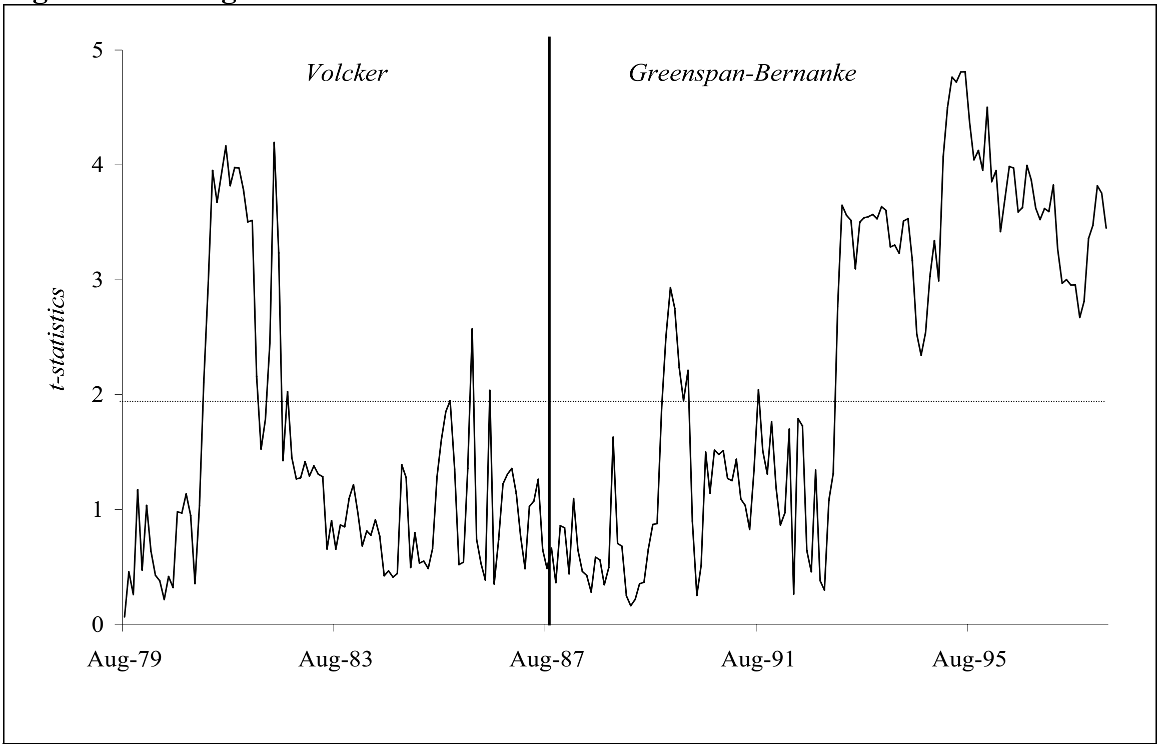
[10] To decide whether the cumulated coefficient is significant, its t-statistic has to be calculated.

$$tstat(\delta_2,\mu) = \frac{\delta_2 + \mu}{\sqrt{\text{var}(\delta_2) + \text{var}(\mu) + 2*\text{cov}(\delta_2,\mu)}} = \frac{-0.62 + 0.95}{\sqrt{0.29^2 + 0.47^2 + 2*(-0.14)}} = \frac{0.33}{0.16} = \underline{\underline{2.06}}$$

Figure 5: Rolling window t-statistics: Stock market busts



Note: 1.96 is the threshold for significance of five percent. The graph starts with the August 1979-August 1989 period and moves forward month by month to the December 1998-December 2008 period

When 1990-91 data enters the regression, the t-statistics reaches levels of significance for a short period (1980 – 1990 up to 1982 – 1992). This is when the Japanese crisis as well as the US stock market crash of 1987 is included in the estimation period. Then again, busts turns out to be significant from 2003 onwards. For the estimation period starting in January 1993 (going up to January 2003), t-statistics stay above the five-percent significance levels. The t-statistic suggests that the Fed lowered interest rates with respect to a negative stock market gap.

To summarize, the findings indicate that the Fed has cut interest rates in response to stock market busts when Greenspan was in office. Whereas, when stock markets recovered after 2003, the Fed has not increased interest rates, given constant inflation and output gaps (therefore the negative sign). Following Aladid and Detken (2007) and Greiber and Setzer (2007) the Fed may have held interest rates low while asset markets (instead of consumer prices) absorbed additional liquidity. With inflation not picking up, the Fed tried to fuel growth and consumption via loose monetary policy. In line with the *Jackson Hole Consensus*, monetary policy has not tried to prick bubbles but only reacted when a crisis was possible. Given that the Fed responded towards falling stock prices, this asymmetric behavior put a downward pressure on interest rates.

4.3 ECB (and Bundesbank)

Set-up

The analysis for the ECB (and Bundesbank) takes into account data from March 1979 to December 2009. In March 1979, the Bundesbank started to reign in inflation. Therefore, the Taylor rule may be applicable to analyze monetary policy (Clarida et al., 1998). To estimate equations (4) and (5), I consider two asset market variables. These are exchange rates and stock prices. Like for the Fed, I distinguish between three different periods. First, I use the full sample. Then, I estimate the equations separately for the Deutsche Bundesbank and ECB to find evidence of policy changes due to the new institutional environment. I include M3 growth as additional instrumental variable in the regressions. This is consistent with the monetary strategy of the ECB, in which money growth is (officially) monitored to control inflation.

Estimation results

Like for the Fed, I begin with estimating a baseline regression without any asset market variable. The results can be found in entry 1 of Table 2. The coefficients on inflation β and output gap γ are positive and significant at the commonly used levels. Interestingly, they are at the same levels as for the Fed. Thus, German / European monetary policy was on average similar to that of the Fed, and applying a Taylor rule is sensible.

A rise in inflation by 1 percent led to an increase in real interest rates of 1.29 percent or 129 BP in the baseline specification. This result is statistically significant. The coefficient on the output gap γ is 1.09. The result reconfirms Botzen and Marey (2010), Belke and Polleit (2006) and Bohl et al. (2008) in finding that German / euro area policy rules include an output gap and inflation.[11]

Next, I estimate equations (4) with the exchange rate gap as asset market variable for the three different periods. The coefficients on inflation and output are robust with respect to the baseline specification. In the sub-periods, they are closer to the findings in earlier literature and near to the levels suggested by Taylor's rule (1993) for the Fed.

In the further explanation, I shall focus mainly on the impact of the exchange rate gap. Entries 2 – 4 indicate that exchange rate gap δ_1 played a role in monetary policy of the ECB but not of the Bundesbank. Therefore, there is no significant effect of exchange rate gaps on interest rate setting, when using the full sample. But the estimation for the period from 1999 to 2008 signals a positive significant impact of the exchange rate gap on ECB monetary policy.

[11] They are also significant when I estimate equation (3) separately for the Bundesbank and ECB.

Table 2: ECB (and Bundesbank)

	Constant	*Inflation*	*Output*	*Assets*	*A-Term*	*Interest*
Sample	α	β	γ	$\delta_{1,2}$	μ	ρ
Baseline						
(1) 1979:03 - 2008:12 Full sample	-0.008 (0.009)	2.291*** (0.317)	1.088*** (0.349)	-	-	0.955*** (0.009)
Exchange Rates						
(2) 1979:03 - 2008:12 Full sample	-0.003 (0.011)	2.285*** (0.327)	0.885** (0.427)	0.039 (0.024)	-	0.956*** (0.009)
(3) 1979:03 - 1998:12 Bundesbank	0.015** (0.008)	1.729*** (0.314)	0.529* (0.320)	0.036 (0.046)	-	0.942*** (0.018)
(4) 1999:01 - 2008:12 ECB	0.004 (0.012)	1.260*** (0.509)	0.633*** (0.186)	0.047*** (0.006)	-	0.848*** (0.049)
(5) 1979:03 - 2008:12 Full sample	-0.018*** (0.026)	2.328*** (0.557)	0.984 (0.828)	0.119 (0.143)	-0.181 (0.308)	0.963*** (0.014)
(6) 1979:03 - 1998:12 Bundesbank	0.014*** (0.026)	1.748*** (0.181)	0.530 (0.341)	0.045 (0.055)	-0.017 (0.101)	0.943*** (0.011)
(7) 1999:01 - 2008:12 ECB	0.003 (0.012)	1.262** (0.520)	0.626*** (0.182)	0.052** (0.023)	-0.008 (0.046)	0.849*** (0.049)
Stocks						
(8) 1979:03 - 2008:12 Full sample	-0.005 (0.013)	2.317*** (0.545)	0.979 (0.658)	0.079 (0.112)	-	0.961*** (0.010)
(9) 1979:03 - 1998:12 Bundesbank	0.014 (0.009)	1.786*** (0.360)	0.461 (0.554)	0.056 (0.085)	-	0.941*** (0.015)
(10) 1999:01 - 2008:12 ECB	-0.050 (0.056)	3.618 (2.461)	3.465* (2.143)	-1.092 (0.708)	-	0.967*** (0.020)
(11) 1979:03 - 2008:12 Full sample	0.119** (0.062)	1.411 (0.887)	1.489 (1.592)	-1.940 (1.443)	3.802 (2.742)	0.975*** (0.018)
(12) 1979:03 - 1998:12 Bundesbank	0.038 (0.013)	1.571*** (0.327)	0.520 (0.550)	-0.295 (0.186)	0.688*[12] (0.377)	0.967*** (0.019)
(13) 1999:01 - 2008:12 ECB	-0.017 (0.049)	2.691 (2.292)	4.423 (3.074)	-1.589 (1.131)	0.403 (0.331)	0.975*** (0.017)

Standard errors in parentheses, ***,**,* denote significance at 1, 5 and 10 percent levels. Test for over-identifying restrictions: J-statistics multiplied by the number of observations was always smaller than χ^2(33 or 34). As M3 growth was added to the instrument list, I have 39 instruments and 5 or 6 coefficients. Thus, there are 33 to 34 degrees of freedom.

Thus, the ECB lowered interest rates when exchange rates appreciated above trend. On the other hand, when they depreciated, interest rates were raised. My findings confirm those of Botzen and Marey (2010) and Belke and Polleit (2006), using more data and monthly frequencies. Given previous research, this result seems to be robust. However, since the coefficients in each study vary, I cautiously do not interpret the size of the coefficients.

[12] The cumulated effect is not significant. The joint t-statistic is too small. Thus, there is no effect.

$$tstat(\delta_2,\mu)=\frac{\delta_2+\mu}{\sqrt{\mathrm{var}(\delta_2)+\mathrm{var}(\mu)+2*\mathrm{cov}(\delta_2,\mu)}}=\frac{-0.29+0.69}{\sqrt{0.19^2+0.38^2+2*(-0.05)}}=\frac{0.40}{0.28}=\underline{\underline{1.42}}$$

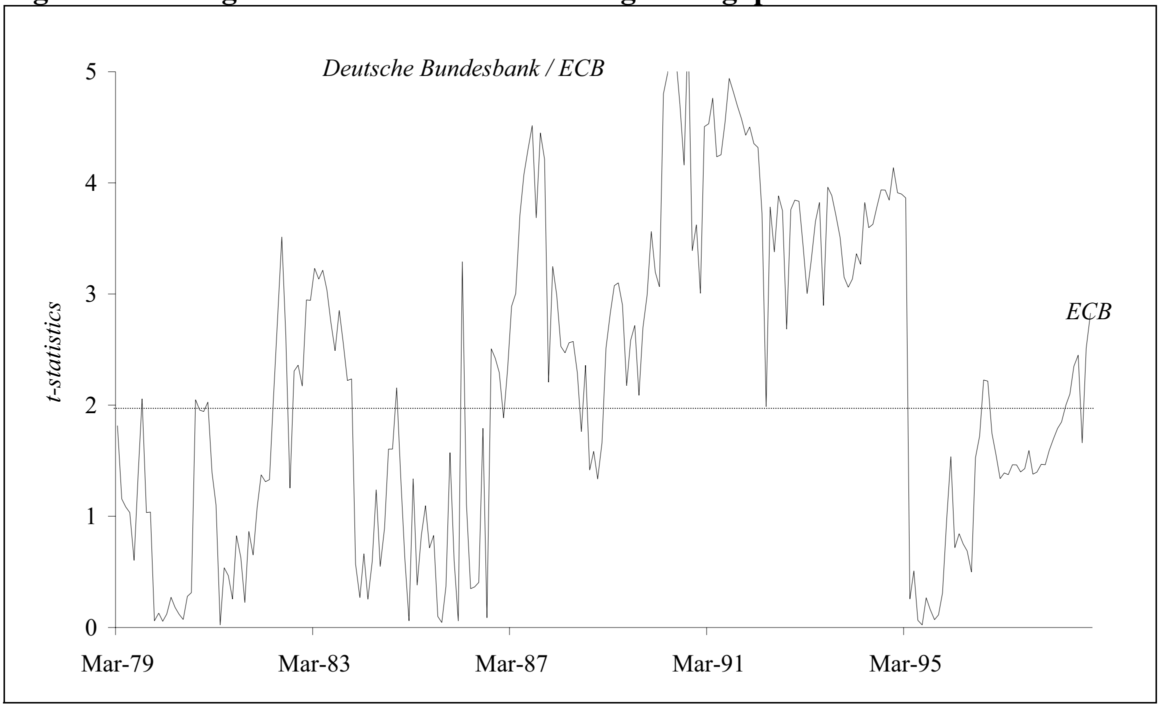
Estimating equation (5) I do not find evidence for asymmetric responses towards exchange rate changes for the ECB / Bundesbank. Hence, entries 5 – 7 provide no further insights but only confirm the results from estimating equation (4). Using the stock market gaps as opposed to the exchange rate gaps (entries 8 – 13) does not provide any further insights either. I find no significant coefficients. Instead, adding the stock market gap seems to affect the coefficients on inflation and output and make the regressions less stable.[13]

Rolling window

Since the estimation of equation (5) does not yield valuable results for the Bundesbank or ECB, I use equation (4) to analyze policy shifts over time. Particularly, I am interested in when the exchange rate gap enters the monetary policy reaction function as a significant variable. A rolling window regression of equation (4) analog to that of the Fed is used to collect data to draw a graph of the rolling window t-statistics for the exchange rate gap.

[13] But adding them as instrument seems to provide more stable results - as suggested by Bohl et al. (2004).

Figure 6: Rolling window t-statistics: Exchange rate gap



Note: 1.96 is the threshold for significance of five percent. The first data point is the t-statistic for the estimation of the March 1979 – March 1989 window.

Figure 6 illustrates that until 1986 – a period when the Bundesbank was in charge of monetary policy – the exchange rate gap seemed to be less important, although there are short periods when the exchange rate term turns out significant. In the period from January 1989 – January 1999, the exchange rate gap is significant. During this time, most of the data is from the Bundesbank period. Although it is intuitive, the ten-year window size (120 observations) used to get robust results does not allow for a final statement about whether the exchange rate played a role in monetary policy considerations of the Bundesbank during the reunification boom in Germany (especially during the time when the European Monetary System (EMS) failed in 1992). But the analysis suggests that the exchange rate gap played some role in Bundesbank monetary policy after 1986 in general. It seems as if 1995, when the reunification boom was over, monetary policy did not focus on the exchange rate anymore. Unfortunately, there is no period that solely includes the ECB. While levels of significance of the exchange rate gap rise to the end of the sample again, there is no data to robustly estimate rolling window t-statistics for different periods during the time the ECB was in charge of monetary policy.

To summarize the findings for the ECB and Bundesbank, the estimation of equation (4) suggests that the ECB pursued monetary policy with respect to the exchange rate gap. Therefore, the ECB can be argued to have indirectly followed the asymmetric intervention pattern of the Fed after the burst of the dot-com bubble. However, the graphical intuition in Figure 3 signals a change in ECB monetary policy in 2005. Thus, the ECB may have changed its course and did not follow the US exchange rate from 2006 to 2008. The moving window regression does not help with finding additional evidence for the ECB. The Bundesbank generally seems to have not reacted with respect to the exchange rate gap (as shown in Table 2). But the moving window analysis suggests that after 1986, the exchange rate gap played a role – probably during the reunification boom and break up of the EMS.

5 Policy Implications

In this essay, I have tested for monetary policy responses with respect to asset markets in the US and the euro area or Germany, respectively. Although the estimations provide evidence of multiple monetary policy goals in the two major economies as suggested in section 2, asymmetric monetary policy could only be found for the Fed.

The estimation results suggest that the Fed lowered interest rates, when as it was in *fear of crisis* when stock markets burst, but did not raise them when they boomed since the Greenspan era. In specific, the Fed reacted asymmetrically with respect to the stock market after the dot-com bubble when interest rates were not raised in accordance with the recovery. Even though the ECB has not reacted asymmetrically towards stock markets, I found an impact of the euro/dollar exchange rate on interest rate setting from at least 1999 to 2006. As during this period the euro appreciated against the dollar, taking into account exchange rate changes signals that the ECB followed the asymmetric US interest rate decisions to some extent. Therefore, asymmetric US monetary policy may have been transmitted to the monetary policy of the ECB.

Whereas monetary policies, especially of the Fed, supported growth, asymmetric policy responses hold some severe risks. Predictable interest rate cuts may cause moral hazard, when cuts are anticipated and higher risks are taken by banks that refinance with lower cost liquidity. As interest rates in the major economies have continuously declined, given asymmetric Fed monetary policy, they may have promoted credit expansions and overinvestment. After 2001, expansionary monetary policies to fuel growth possibly contributed to *"vagabonding bubbles"* around the globe (Schnabl and Hoffmann, 2008) and the financial crisis of 2007-9. From this perspective, it seems plausible to concur with Axel Weber (2008) who claims that interest rates have to be symmetrically raised and lowered during boom-and-bust to reduce the probability of bubbles and stop the downward-trend in world interest rates.

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