

Does the ECB respond to the stock market?

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Abstract

The role of asset prices in monetary policy has been widely debated. This paper examines the role that stock prices play in the monetary policy of the ECB. For this purpose, standard and augmented forward-looking Taylor rules are estimated for the ECB using monthly data between 1999 and 2005. Of special interest is the impact of adding stock prices to the standard Taylor rule of the ECB. The GMM estimations of a standard Taylor rule and augmented Taylor rules for the Euro area indicate that the ECB considered stock price developments in setting interest rates. Monetary policy of the ECB stabilized asset prices by raising interest rates when the stock market index was above average and lowering rates when the index was below average. Stock prices are not only relevant as instruments but also as arguments in the ECB policy rule. The empirical plausibility of the Taylor rule improves when it allows for a reaction to the stock market. These results challenge previous studies.

Keywords: Taylor rules, Asset prices, ECB monetary policy

JEL-classification: E4, E5

1. Introduction

The debate concerning the optimal monetary response to asset price bubbles has regained interest of policy makers and academics after the Japanese asset price bubble in the late 1980s and the recent “new technology” stock market boom. The U.S. stock market crash in 1929 and the Japanese crash in 1989 showed that economic losses can be huge when stock prices collapse as a result of speculative behaviour. These losses might have been limited if monetary authorities had restrained the boom in asset prices that preceded the crash by raising interest rates. Moreover, interest rate reductions might be appropriate when asset prices collapse, in order to limit the resulting output losses. This discussion about active monetary policy towards stock prices heated up again during the stock market boom in the late 1990s. It was argued that the stock market contained a bubble due to irrational speculation with “new economy” Internet stocks. Alan Greenspan also expressed these concerns in 1996 when he argued that the stock market displayed irrational exuberance. The necessity of monetary tightening to prick the perceived bubble has been widely debated; *The Economist* advocated a pro-active monetary stance towards stock prices in several articles. Officially, the main emphasis of monetary policy of many central banks is on inflation control. This is usually interpreted as specifying a target for consumer price inflation. However, it has been argued that asset prices have played a role in monetary policy conduct as well. The tendency of asset prices to stimulate the economy during asset price booms and to restrain economic activity during a bust of asset prices can be a rationale for central bank intervention.

The European Central Bank (ECB) admits that asset price developments are considered in its policy deliberations (ECB, 2004). However, it is still unclear whether this means that the ECB responds to asset price movements directly, or only insofar asset prices affect inflation. This paper empirically examines the role that stock prices have played in monetary policy of the ECB. The majority of research about ECB’s monetary policy neglects the influence of stock prices on interest rates. This paper aims to fill this gap and improve knowledge about the ambiguous role of stock prices in monetary policy in the Euro area. This issue has also been investigated by Bohl et al. (2004), however their results are likely to give an inadequate description of ECB’s interest rate setting.

Bohl et al. (2004) estimate Taylor rules for the main Euro area countries: France, Italy and Germany. The role of asset prices in monetary policy is examined by estimating augmented

Taylor rules that incorporate asset prices. They also consider that asset prices may serve as forward-looking variables that contain information about future inflation and thus play a role as instruments in estimates of forward-looking Taylor rules. It is concluded that inclusion of asset prices as instruments improves the theoretical plausibility of forward-looking Taylor rules. In addition, asset prices enter the Taylor rule significantly in some cases. Especially for Italy, it appears to be the case that asset prices serve as explanatory variables in the monetary policy rule. The authors extend this analysis to the ECB and construct an ECB Taylor rule indirectly, by basing it on the pre-1999 Taylor rules of France, Germany and Italy. Actual interest rates are compared to the interest rates generated by this constructed Taylor rule. The fitted interest rates obtained from the constructed policy rule with a reaction to stock prices do not reflect actual rates. The authors conclude from this counterfactual experiment that the ECB did not respond to stock prices in setting interest rates. These results are challenged in this paper. Instead of constructing a monetary policy rule for the ECB from monetary policy rules of Germany, Italy and France, a monetary policy rule is estimated directly for the ECB. Policy rules are estimated with the Generalized Method of Moments (GMM) using monthly data between January 1999 and July 2005.¹ This procedure can more accurately assess whether the ECB has responded to stock prices in addition to other goal variables of monetary policy. Estimation results from this augmented Taylor rule give new insights about the influence of stock prices on monetary policy in Europe.

The remainder of this paper is structured as follows. Section 2 outlines the rationale behind a central bank's reaction to stock prices. Furthermore, some insight into the debate concerning the optimal monetary response to asset prices is given. Section 3 lays down the theoretical framework of the monetary policy rules that are estimated in this paper. Section 4 discusses the estimation results and its implications. Finally, section 5 concludes.

¹ This results in 79 observations, which should be sufficient to estimate a Taylor rule for the ECB directly.

2. Monetary Policy and Stock Prices

This section gives an insight into the debate whether it is optimal for monetary authorities to stabilize stock prices. The main rationale behind an active monetary policy towards stock prices as well as practical difficulties with such a policy will be outlined. Most central banks have adopted an approach of inflation targeting, while they take the output gap² into consideration as well. This approach can be represented by a (standard) Taylor rule, which describes how the central bank changes interest rates in response to inflation and output gaps. As a consequence a central bank that follows that approach raises interest rates when stock prices increase, if this increase is associated with increased inflation expectations. The central bank reduces interest rates in response to a stock market crash, when GDP growth decreases and inflation expectations decline. This central bank behaviour stabilizes stock prices as well. However, it should be stressed that in this approach the central bank raises interest rates only insofar rising asset prices signal future inflation or affect output positively. This policy of flexible inflation targeting has been advocated by Bernanke & Gertler (1999, 2001). These authors simulate a bubble process in the economy and estimate whether variability of output and inflation falls when the central bank incorporates stock prices in its monetary policy rule. Macroeconomic performance appears to be best when the central bank pursues an approach of flexible inflation targeting only. However, it is still debated whether this approach results in the best macroeconomic performance in general.

The alternative policy suggested is that the central bank should actively try to stabilize asset prices around fundamental values or that central banks should try to prick certain asset price bubbles. This approach can be represented by an augmented Taylor rule, which describes how the central bank adjusts interest rates in response to inflation, output gaps, and stock prices. Cecchetti et al. (2000) use a slightly adapted version of the Bernanke and Gertler model and conclude that macroeconomic performance improves when stock prices are included in the reaction function of the central bank. Tetlow (2004) also performs simulations with an adapted version of the Bernanke and Gertler model, using the most realistic elements of the other two studies. These simulations indicate that although reacting to the stock market is helpful, the gain in terms of reduced losses is very small. Tetlow (2004) shows that reacting to stock price misalignments is likely to be better in certain cases. The case for reacting to asset

² The output gap is defined as the difference between actual and potential output.

price misalignments becomes stronger for small bubble continuation probabilities. Furthermore, it is also optimal for a central bank to respond to bubble shocks with large variances.

The main rationale behind a central bank intervention in response to stock price developments is that stock prices can amplify the business cycle. Output and inflation rise during stock market booms, while they can fall significantly when a stock market collapses. Stock prices affect output via consumption and investment expenditures. An increase in stock prices leads to higher consumption because of increases in wealth, borrowing capacity and expected income from labour and capital. The latter effect is often referred to as the confidence channel (Poterba, 2000). An increase in stock prices leads to higher investment because of increases in Tobin's q , balance sheet improvements of firms, and higher growth expectations. The first effect³ can be quite significant because the elasticity of Tobin's q with respect to investment is estimated to be around 2 (Bernanke & Gertler, 1999). The second effect is known as the credit or balance sheet channel (Bernanke & Gertler, 1995). Improved balance sheets reduce the risks associated with lending to these firms, which lowers the costs of attracting external funds for firms, in turn this leads to higher investment by firms. The case is reversed when the stock market crashes and even amplified by the financial accelerator⁴ and the debt deflation mechanism⁵. During the asset price boom in the late 1990s it was apparent that firms could raise external funds with unusual ease, boosting investment expenditures. The situation was reversed after the collapse of asset prices (Tetlow, 2004). The third effect, the expectations channel, is predicted by the flexible accelerator model, which claims that investment rises in response to increased asset prices if the growth in stock prices is perceived to be the result of improved expectations of future economic growth.

Another rationale for a monetary reaction to stock prices is that the collapse of a stock market can result in a financial crisis, as well as a sharp contraction in economic activity. Minsky's (1977, 1982a, 1982b) theory about financial instability explains how economic expansion can result in the replacement of a robust financial structure with a fragile financial structure. The

³ Tobin's q is defined as the ratio of the market value of installed capital over the replacement costs of installed capital. A rise in stock prices raises the market value of capital and increases Tobin's q . Investment increases if the rise in asset prices increases Tobin's q above unity (Tobin, 1969).

⁴ Cash flows and spending are further decreased as a result of declining sales and employment (Bernanke et al., 1996).

⁵ Forced asset sales due to deterioration of banks' balance sheets together with decreased income and spending lead to further declines in asset prices (Fisher, 1933).

asset market booms during an economic expansion, boosting investments further and increasing leverage in the economy, since firms find it easier to acquire external finance. Asset price bubbles can emerge due to euphoria. Financing regimes move towards speculative and Ponzi regimes when speculation in the economy increases, which creates a situation of economic fragility. The theory of financial instability of Mishkin (1991, 1997) stresses that the collapse of an asset price bubble increases adverse selection and moral hazard problems in financial markets, because the net worth of firms deteriorates. This results in financial instability and a contraction of bank lending. Furthermore, balance sheets of banks worsen when asset values collapse, reducing the ability of banks to engage in financial intermediation. A significant increase in non-performing loans can lead to a banking crisis in case the banking sector is fragile. A financial crisis emerges when a debt deflation process sets off, which is caused by the economic downturn or by a banking crisis (Fisher, 1933). This process worsens asymmetric information problems even further, deepening the recession. Classical examples of stock market crashes that triggered a severe financial crisis are the U.S. 1929 stock market crash and the Japanese 1989 stock market crash.

A possible problem with the implementation of a monetary policy that is responsive to asset markets is that the optimal responses of monetary policy to fundamental and non-fundamental asset price shocks are inherently different. Detken & Smets (2004) argue that central banks should raise interest rates in case stock prices increase as a result of non-fundamental factors, while interest rates should be reduced in the presence of a positive fundamental shock. A non-fundamental shock is present when asset prices rise above their fundamental values due to speculative behaviour. The importance of mass psychology in financial markets has been stressed by for example Shiller et al. (1984) and Shiller (1989). A common explanation for these bubbles in the stock market is that they are caused by the presence of noise traders in the market (Kyle, 1985, Black, 1986, De Long et al., 1990, 1991). The actions of noise traders limit arbitrage by rational investors and can cause stock prices to deviate from their fundamental values for long periods. This challenges the arguments of market efficiency of Fama (1965). In practice, it is very hard for a central bank to distinguish whether a change in asset prices results from fundamental factors, non-fundamental factors or both. This complicates the task for monetary policy (Bernanke & Gertler, 1999, Bean, 2004). However, as has been pointed out by Cecchetti et al. (2002) this task should not be much more difficult than estimating the output gap, which is an indicator that is commonly used in framing monetary policy.

Another problem is that the credibility of a central bank may be jeopardized if the central bank aims to stabilize asset prices. The link between monetary policy and stock prices is not very strong. Therefore, situations in which stock prices move in opposite directions than desired by the central bank are likely to arise in practice (Mishkin & White, 2002). In addition, stabilization of asset prices with the objective to reduce inflationary pressures or output deviations at longer horizons may be hard to communicate to the public. A monetary policy that responds to stock prices is therefore less transparent than when the central bank follows a pure inflation targeting approach.

Summarizing, stabilizing stock prices could be optimal in certain cases. Macroeconomic performance is likely to be improved when the central bank adjusts interest rates in case asset price misalignments are considerable and output, inflation and financial stability are likely to be significantly affected when the bubble continues. However, several practical difficulties with an active monetary policy towards stock prices exist, posing considerable challenges for monetary authorities.

3. Specification and Estimation of Taylor Rules

This paragraph sets the theoretical framework for the monetary policy rules that are estimated later on. These interest rate rules are simple rules that describe monetary policy by linking short-term interest rate targets to the output gap and deviations of inflation from the target inflation rate. A stock market variable is added to the interest rate rule in order to investigate whether stock prices influence interest rate decisions. The framework laid down here builds on Taylor (1993) and Clarida et al. (1998, 2000).

Monetary policy actions affect the economy with significant time lags. The ECB (2000) states that an unexpected, temporary rise in the short-term interest rate of about 0.25% tends to be followed by a temporary fall in output after six months. Prices are more sluggish and start to fall significantly after one and a half year. The confidence bands around these estimates are large. Therefore, monetary policy actions transmit through the economy with long and variable lags (Bofinger, 2001). Monetary responses are likely to be incorrect if they are based on current or past inflation rates, while time lags are present. Considering the first pillar of the strategy of the ECB, in which future price developments are forecasted, a forward-looking monetary policy rule seems appropriate. In these rules monetary authorities focus on future price developments rather than current or past inflation rates, as in contemporaneous or backward-looking monetary policy rules, such as the original Taylor rule (Taylor, 1993).

Following Clarida et al. (1998, 2000), the standard (forward-looking) Taylor rule can be described as follows:

$$r_t^* = r^* + \beta(E_t \pi_{t+k} - \pi^*) + \gamma E_t y_t \quad (1)$$

In this equation r_t^* is the target nominal interest rate in period t , r^* is the long run equilibrium nominal interest rate, π_{t+k} is the inflation rate in period $t+k$, E_t is the expectations operator, conditional on information available to the central bank in period t , π^* is the target inflation rate and y_t is the output gap in period t , which is defined as actual real output minus potential real output. This rule describes the conduct of central banks to raise interest rates when inflation is above its target and when the output gap is positive. Interest rates are lowered when inflation is below its target and when the output gap is negative. Short-run rigidities in

wages and prices allow the central bank to affect real activity with the nominal interest rate, implying that monetary neutrality does not hold in the short-run.

In this paper we add a stock price variable to analyse whether stock prices have determined interest rate decisions of the ECB. Insofar stock prices help to signal future price developments they are already reflected in the forecast of inflation rates. Stock price changes also impact on real economic activity and therefore affect the output gap variable. The rationale behind including a stock price variable in the regression is to examine whether the central bank has responded to stock price developments over and above the effects they have on future inflation and output. The augmented Taylor rule is given by:

$$r_t^* = r^* + \beta(E_t \pi_{t+k} - \pi^*) + \gamma E_t y_t + \Phi E_t S_t \quad (2)$$

where S_t refers to the stock market variable.

The central bank may want to smooth interest rate changes to reach the target interest rate. Sudden interest rate changes can have disrupting effects on bond and equity markets. Other reasons for interest rate smoothing are the loss of credibility when monetary policy reverses suddenly and the need for consensus building to support a policy change (Clarida et al., 1998). A simple interest smoothing rule describes current interest rates as a weighted average of the interest rate of the last period and the target interest rate. Such a rule takes the form:

$$r_t = \rho r_{t-1} + (1 - \rho) r_t^* \quad (3)$$

where the parameter ρ indicates the degree of interest rate smoothing. This parameter takes on values between 0 and 1. A high value of ρ indicates a high degree of smoothing, implying that the interest rate adjusts gradually towards its target. Incorporating interest rate smoothing in the augmented Taylor rule results in the following monetary policy rule:

$$r_t = (1 - \rho)(r^* + \pi^*) + (1 - \rho)\beta(E_t \pi_{t+k} - \pi^*) + (1 - \rho)\gamma E_t y_t + (1 - \rho)\Phi E_t S_t + \rho r_{t-1} + \varepsilon_t \quad (4)$$

where $\varepsilon_t = -(1 - \rho)\{\beta(\pi_{t+k} - E_t \pi_{t+k}) + \gamma(y_t - E_t y_t) + \Phi(S_t - E_t S_t)\}$.

As is common in the literature⁶, we estimate the monetary policy rule using the Generalized Method of Moments (GMM).⁷ The explanatory variables are unknown to the policy maker at the time decisions are made, this is especially the case for the future inflation rate. The instruments used should signal future price and output developments, while they are uncorrelated with the error term ε_t . The error term corresponds to the forecast errors that are orthogonal to any variable in the information set at time t . Notice that due to the overlapping observations structure, the error term will follow an MA($q-1$) process. Therefore, GMM will be implemented by a Bartlett kernel with bandwidth q .⁸ The vector of instruments z_t includes variables known to the central bank at the time it sets interest rates and that help forecasting inflation and output. The set of orthogonality conditions that provides the basis for estimating the parameter vector $(\alpha, \beta, \gamma, \Phi)$ using GMM is given by:⁹

$$E\left[\left\{r_t - (1 - \rho)(r^* + \pi^*) + \beta(\pi_{t+k} - \pi^*) + \gamma y_t + \Phi S_t + \rho r_{t-1}\right\} z_t\right] = 0 \quad (5)$$

⁶ See Clarida et al. (1998, 2000), Fuhrer & Tootell (2004) and Bohl et al. (2004).

⁷ The econometric analysis assumes that the variables are $I(0)$ in this short sample. This assumption is commonly made in the literature; see Clarida et al. (1998, 2000) and Bohl et al. (2004). The augmented Dickey-Fuller test cannot reject the null that the output gap and the deviation of the stock market index from its average value are $I(1)$, while the hypothesis is rejected at the 5% significance level for the inflation rate and the interest rate. However, the Dickey-Fuller test has low power against the alternative of stationarity in short samples.

⁸ A Bartlett kernel with bandwidth q takes into account $q-1$ autocorrelations (Hayashi, 2000).

⁹ Hansen & Singleton (1982).

4. Empirical Evidence and Implications

In this section estimation results of the interest rate rules are presented. The data used cover the period January 1999 until July 2005; all data are in monthly intervals. The start of the sample corresponds to the date the ECB started to operate.

The following variables are used for the GMM estimations:

- INTEREST: this is the daily money market rate of the Euro zone in percentage, recorded at the beginning of the following month, source: *Eurostat*;
- HICP: this is the inflation rate of the Harmonised Index of Consumer Prices of the Euro zone, the index is calculated as the yearly percentage change from one month to the same month in the previous year, source: *Eurostat*;
- OUTPUTDEV: this is the deviation of the industrial production growth rate from the average growth rate between 1985 and 2005 of 2%¹⁰, the growth rate is calculated as the yearly percentage change of the industrial production index from one month to the same month in the previous year, source: *Eurostat*;
- STOCKDEV: this is the percentage deviation of the Euro zone stock index from its average value of the sample of 73.88, the stock index used is the Dow Jones EURO STOXX Broad Index comprising of 320-plus companies in the Euro area and covering 80% of market capitalisation, the variable is an average of daily quotations, source: *OECD*.

The regression equation takes the following form:

$$INTEREST_t = c_0 + c_1 INTEREST_{t-1} + c_2 HICP_{t+q} + c_3 OUTPUTDEV_t + c_4 STOCKDEV_t + \varepsilon_t$$

(6)

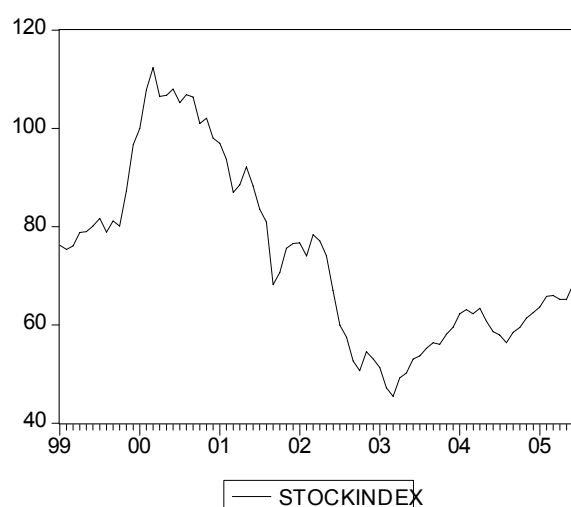
where $c_0 = (1 - \rho)(r + \pi^* - \beta\pi^*)$, $c_1 = \rho$, $c_2 = (1 - \rho)\beta$, $c_3 = (1 - \rho)\gamma$, $c_4 = (1 - \rho)\Phi$.

Firstly, the behaviour of stock prices is examined. The development of the stock price index during the estimation period is shown in Figure I. From the figure it is apparent that a sharp

¹⁰ This variable serves as a proxy for the output gap. The 2% average growth rate is calculated from the industrial production index between 1985 and 2005. Source: *Datastream*.

rise in the stock market index occurred between the end of 1999 and mid 2000. The peak of the stock market was reached in June in the year 2000. Stock prices had increased with 43% in that month compared to January 1999. Large increases occurred in November and December of 1999, when the index increased with 8.9% and 10.8% respectively. Stock prices started to fall in the second half of 2000 and they kept falling until the beginning of 2003. The lowest point of the stock price index was reached on March 2003. In that month, stock prices had fallen with 58% compared to the peak in 2000. Afterwards, the stock market recovered again although the value of the index in July 2005 is still far below its peak level of 2000. The biggest drop in stock prices occurred in September 2001 when the terrorist attack on the World Trade Centre took place; stock prices decreased with 15.8% in that month. Volatility in stock prices was considerable during the period under investigation. Moreover, a boom as well as a bust in stock prices occurred. Therefore, it is of interest to analyse how the ECB responded to these stock price developments.

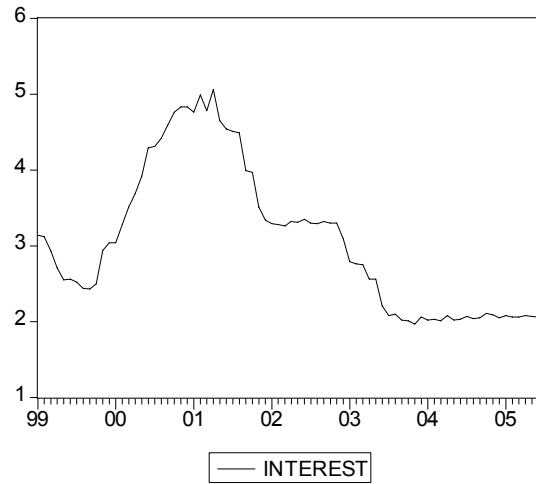
Figure I
The Dow Jones EURO STOXX Broad Index



Source: OECD

From Figure II it is apparent that the central bank raised interest rates in the end of 1999 until the beginning of 2001, while interest rates decreased from the second half of 2001 on. This implies that monetary policy was tightened during the stock market boom while it was eased afterwards. This interest rate policy works to stabilize stock prices. An examination of the standard goal variables of monetary policy, the inflation rate and the output gap, is necessary before we can infer whether the stock market was the driving force behind monetary policy.

Figure II
Daily Money Market Interest Rate



Source: Eurostat

The deviation of the industrial production growth rate from its average between 1985 and 2005 is used as a proxy for the output gap.¹¹ Production growth rates introduce a forward-looking element with respect to the business cycle. They tend to lead deviations from trend growth in expansionary phases, in contrast to deviations of industrial production from potential.¹² Therefore, using the deviation of industrial production growth rates from trend as a proxy for the output gap might be more appropriate in estimating forward-looking Taylor rules. This variable is shown in Figure III. Industrial production growth was above its trend between the second half of 1999 and the beginning of 2001, with a peak of 5.6% above trend in May 2001. The growth rate fell towards 5.8% below trend in December 2001. An explanation of the high growth in output and its subsequent fall might be the boom and bust in stock prices. Industrial production recovered again in the course of 2002.

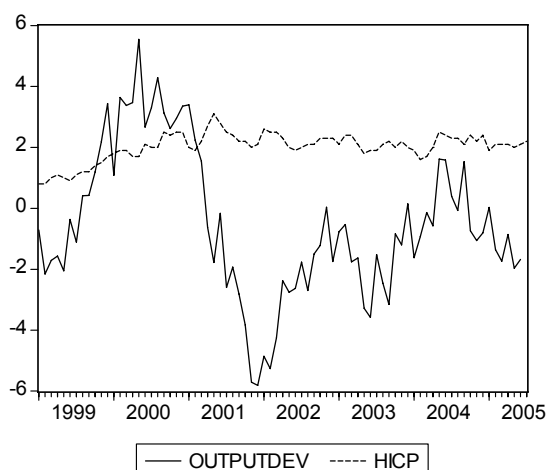
The inflation rate of the Euro zone is also shown in Figure III. The inflation rate calculated from the Harmonised Index of Consumer Prices is below the 2% target in 1999. Afterwards it fluctuates around this target, having its peak value of 3.1% in May 2005. This analysis indicates that the tightening in monetary policy can be explained by the desire of the ECB to

¹¹ Main results are not affected when the deviation of the growth in industrial production from trend growth obtained with a Hodrick-Prescott filter is used as a proxy for the output gap.

¹² For a discussion about the forward-looking nature of growth rates of industrial production we refer to Sauer & Sturm (2003). Using the growth rate of industrial production instead of the deviation of the index from trend generally results in lower output gap coefficients.

restrain the stock market boom, to close the output gap, or to reduce inflationary expectations. The monetary loosening is likely to be the result of the decline in economic activity or the collapse of stock prices. Regression analysis is necessary to disentangle the separate effects of stock prices, output, and inflation on interest rate setting.

Figure III
Inflation Rate and Output Gap



Source: Eurostat

The GMM results are presented in Table I. In forward-looking Taylor rules it is assumed that the central bank bases its interest rate decisions on expected inflation rather than current inflation. In our regressions we include the inflation rate of six-months ahead, since it takes at least six months before the effects of a change in monetary policy can be noticed in practice. A longer time period like a year ahead may be more suitable, however because of the small sample period a six-months ahead period is preferred.¹³ Furthermore, it is assumed that the central bank's expectations of inflation are on average correct. More specifically, we assume that the rational expectations hypothesis holds. This allows the inclusion of the realization of the six-months ahead inflation rate. The error term ε_t in equation (4) is random under the assumption of rational expectations. The current output variable is included as well. This gives the opportunity to observe whether the central bank reacts to the output gap independently of concerns for future inflation (Clarida et al., 1998). In the standard forward-looking Taylor rule (first row of Table I), only output deviations and deviations of the future inflation rate from its target determine the target interest rate. To take interest rate smoothing

¹³ Clarida et al. (1998, 2000) as well as Bohl et al. (2004) use the one-year ahead inflation rate, as is more common in the literature.

by the central bank into account, we also include the lagged interest rate in this regression. The instruments used include 6 lags of the interest rate, the inflation rate, the output variable¹⁴, the stock price index, the growth rate of the monetary aggregate M3, and the interest rate spread¹⁵. These variables should convey information about future output and price developments.

Table I
Estimated coefficients of forward-looking Taylor rules

	C0	INTEREST(-1)	HICP(+6)	OUTPUTDEV	STOCKDEV	J
Standard Taylor rule	-0.30 (0.03)	0.99 (0.003)	0.16 (0.01)	0.04 (0.001)	- -	0.15
Augmented by STOCKDEV	-0.16 (0.06)	0.89 (0.008)	0.21 (0.03)	0.022 (0.004)	0.004 (0.0004)	0.14

Notes. Estimated coefficients are reported without brackets and their corresponding standard errors are shown in between brackets. Estimates are obtained by GMM with Bartlett kernel (bandwidth 6) and pre-whitening. J is the p-value for the test of over-identifying restrictions. The exact list of GMM instruments includes 6 lags of the interest rate, the inflation rate, the output gap, the stock price index, the growth rate of M3 and the interest rate spread. The sizes and significance of the coefficients of the augmented rule are robust to the number of lags of instruments used.

The estimation results in Table I show that the lagged interest rate, the six-months ahead inflation rate as well as the deviation of the industrial production growth rate from its trend are all highly significant in the standard Taylor rule. However, the implied policy parameters in Table II that follow from these estimates are theoretically implausible. Therefore, the standard Taylor rule results in a very poor description of monetary policy.

Table II
Implied policy parameters of forward-looking Taylor rules

	ρ	β	γ	Φ
Standard Taylor rule	0.99***	16.35***	3.74***	
Augmented by STOCKDEV	0.89***	1.89***	0.20***	0.033***

*** indicates significance at the 1% significance level

Next we augment the Taylor rule by including the stock price variable. The stock price variable enters in its contemporaneous form, because monetary policy actions are immediately

¹⁴ The output variable included as instrument is the deviation of the growth rate of the industrial production index from the average growth rate of 2.2% between 1985 and 1998. The 2.2% is chosen as trend in order to reflect the information available to the central bank when interest rates decisions are made.

¹⁵ The interest rate spread is the spread between the 10-year government bond yield and the 3-month money market rate.

incorporated in stock prices. This method of including the stock price variable can be criticized by arguing that stock prices are forward-looking indicators of inflation and therefore, may act as proxies for expected inflation and expected output. However, asset prices are no reliable forecasters for future inflation and output (Bohl et al., 2004).¹⁶ In addition, the information that stock prices do convey about future inflation and output is already accounted for by including the stock price index in the instrument set (Fuhrer & Tootell, 2004). From the second row of Table I we see that the deviation of the stock price index from its average value is highly significant, indicating that it belongs as an argument in the interest rate rule. Inclusion of the stock market variable reduces the interest rate smoothing parameter to 0.89.¹⁷ The other variables in the augmented forward-looking Taylor rule are also highly significant and of the theoretically expected sign. The implied policy parameters of the augmented Taylor rule all have theoretically plausible values, as can be seen in the second row of Table II.

The J-test for over-identifying restrictions (Hansen, 1982) confirms that the Taylor rule is well specified. Under the null hypothesis, the ECB follows Taylor rule (4) with the expectations on the right hand side based on all the relevant information available at that time (Clarida et al., 1998). Under the alternative hypothesis some relevant explanatory variables are omitted from the Taylor rule. Hence the set of orthogonality conditions, as described in equation (5), is violated. The J statistics reported in Table I indicate that the null cannot be rejected.

In order to compare our results, we show the policy parameters of the Taylor rules that Clarida et al. (1998) estimate for Germany, Italy and France in Table III. We can see that the interest rate smoothing parameter is comparable to the ones of Germany, Italy and France. The inflation parameter in Table II is 1.89, which implies that the ECB raises the target interest rate with 1.89% when the inflation rate increases with 1% above its target. This parameter is closest to the one that Clarida et al. (1998) estimate for Germany, compared to Italy and France. The reaction of the ECB to future inflationary expectations is strong enough to work in a stabilizing manner, since $\beta > 1$. In case expected inflation is higher than the inflation target, the ECB has to raise interest rates. If $\beta < 1$ then the increase in the nominal interest rate is smaller than the anticipated increase in inflation, implying that the real interest rate falls. A

¹⁶ See the study of Filardo (2000) and Stock & Watson (2003).

¹⁷ This coefficient might be biased upward due to possible misspecification of the model, which can be the result of serial correlation of the exogenous shocks as Rudebusch (2002) argues. He showed that models with strong inertia and models with serially correlated shocks are hard to distinguish.

decreasing real interest rate stimulates aggregate demand, which increases inflation further via the Phillips curve mechanism. In contrast, if $\beta > 1$ then the ECB raises the nominal interest rate enough to increase the real interest rate. This results in a fall of aggregated demand, which decreases inflation (Taylor, 1999).

Table III
Policy parameters for Germany, France and Italy

Baseline reaction functions	ρ	β	γ
Germany	0,91***	1,31***	0,25***
France	0,95***	1,13***	0,88***
Italy	0,95***	0,90***	0,22***

*** indicates significance at the 1% significance level

Source: Clarida et al. (1998)

The implied parameter γ on the output gap is 0.20 in Table II. This means that the ECB raises the target interest rate with 0.2% when the industrial growth rate is 1% above its average value. This value is quite close to the German and Italian output gap parameters. The stock market variable is of special interest in our analysis. The implied policy parameter in Table II Φ is 0.033, which implies that the ECB raises the target interest rate with 0.33% when the stock price index is 10% above its average value. The ECB raised interest rates when the index was above its average value, while monetary policy was eased when the stock price index was below average. This reaction to stock prices is also economically strong, since the stock market was significantly over-valued during the stock market boom. The deviation of the index from its average value was above 20% between the end of 1999 and the beginning of 2001, while it was below -20% between August 2002 and November 2003.

An interesting test of the robustness of our results can be based on a study by Fourçans & Vranceanu (2004), who analysed monetary policy of the ECB under the Duisenberg presidency using Taylor rules. They concluded that forward-looking Taylor rules outperform contemporaneous Taylor rules in describing monetary policy in the Euro zone. These authors estimate standard policy rules as well as augmented rules that allow for a reaction to the exchange rate. Their estimated coefficients on inflation are 2.8 and 1.21 in their standard and augmented forward-looking rules. The coefficients on the deviation of industrial production growth from average are 0.19 and 0.21 in the standard and augmented specifications of Fourçans and Vranceanu, which is comparable to the coefficients estimated in this paper. Their main finding is that the percentage deviation of the exchange rate from its average value

is significant in explaining interest rate setting, in addition to output and inflation. Therefore, it is of interest to examine the effect of adding this variable¹⁸ to the Taylor rule that includes a reaction to the stock market. The results of this estimation are shown in Table IV and the implied policy parameters are shown in Table V. The stock market variable remains statistically significant, but the exchange rate variable is statistically insignificant with a p-value of 0.61. This indicates that our results are robust to allowing for a reaction to the exchange rate in the policy rule.

Table IV

Estimated coefficients of the forward-looking Taylor rule including EXRATEDEV

	C_0	INTEREST(-1)	HICP(+6)	OUTPUTDEV	STOCKDEV	EXRATEDEV
Augmented by EXRATEDEV	-0.11 (0.05)	0.90 (0.01)	0.18 (0.03)	0.03 (0.004)	0.003 (0.0005)	-0.0005 (0.001)

The instruments and estimation procedure are the same as explained in Table I.

Table V

Implied policy parameters of the forward-looking Taylor rule including EXRATEDEV

	ρ	β	γ	Φ	ζ
Augmented by EXRATEDEV	0.90***	1.80***	0.27***	0.03***	-0.005

*** indicates significance at the 1% significance level, ζ refers to the policy parameter of the exchange rate variable.

It may be argued that the significance of the stock market variable is caused by its non-stationarity. Therefore, the same regression is performed with the first difference of the stock market index, which corresponds to the monthly growth in stock prices.¹⁹ This solves possible problems of non-stationarity (Fuhrer & Tootell, 2004). Estimation results shown in Table VI indicate that the growth in stock prices remains statistically significant. The exchange rate variable is significant in this regression as well, which indicates that its significance depends on the specification of the stock market variable. Estimation with this alternative policy rule indicates the robustness of our previous results with respect to the effect of stock prices on interest rate setting by the ECB.

¹⁸ The variable included is EXRATEDEV: this is the percentage deviation of the nominal exchange rate measured in dollars per euro from the average value of the sample of 1.06, the exchange used is the monthly average. Source: *Eurostat*.

²⁰ The variable included is STOCKCHG: this is the first difference of the EURO STOXX Broad stock market index.

Table VI
The stock price index in first differences

	C ₀	INTEREST(-1)	HICP(+6)	OUTPUTDEV	STOCKCHG	EXRATEDEV
Augmented by STOCKCHG	-0.3 (0.04)	0.97 (0.009)	0.2 (0.02)	0.03 (0.001)	0.77 (0.09)	-0.002 (0.0006)

The instruments and estimation procedure are the same as explained in Table I.

5. Conclusion

The GMM estimations of a standard Taylor rule and augmented Taylor rules for the Euro area indicate that the ECB took stock price developments into account in setting interest rates between 1999 and 2005. The deviation of the stock price index from its average value enters the equation significantly. The ECB raised interest rates when the index was above its average value and reduced interest rates when the stock price index was below average. The STOCKDEV variable can be interpreted as an indicator for a stock market bubble. The observed reaction of the ECB to this variable is likely to decrease the magnitude of possible stock price misalignments. Moreover, the policy coefficients become theoretically plausible when the stock market variable is included in the policy rule. These results are robust to allowing for a reaction to the exchange rate in the Taylor rule. Furthermore, a monetary reaction to stock prices is also observed when the growth rate of stock prices is included in the Taylor rule instead of the deviation of the index from its average, which indicates that the results are not caused by spurious correlation. It should be stressed that this paper does not argue that a continuous monetary response to stock price developments is likely to improve macroeconomic performance.

The sizes of the coefficients on inflation and output are close to estimates of these coefficients in other studies. The policy coefficients in the augmented specification are closer to the policy coefficients that Clarida et al. (1998) have estimated for Germany than the coefficients they estimated for France or Italy. This is to be expected since the German model of central banking was adopted in designing the ECB, as has been laid down in the Maastricht Treaty. The GMM results show that inflation and output are significant as well in explaining interest rate setting. Monetary policy of the ECB was aggressive towards inflation. The coefficient on the inflation rate is well above unity, implying that monetary policy worked to stabilize inflation.

The findings in this paper challenge the conclusions of Bohl et al. (2004), who argue that the ECB does not adjust interest rates in response to stock price developments. The analysis used in this paper, where an ECB interest rate rule is estimated directly, is likely to provide a more accurate analysis of monetary policy of the ECB. Construction of an ECB Taylor rule based on estimated Taylor rules of France, Germany and Italy is likely to result in a sub-optimal description of ECB monetary policy. Clarida et al. (2000) show how regime shifts can alter

the reaction function of central banks considerably. The transmission of monetary responsibilities from national levels towards the ECB can be interpreted as a major regime shift. This regime shift causes past policy functions to be unreliable indicators for monetary policy in the Euro area after 1999. Extrapolating past trends of monetary policy in the Euro area to the post-1999 period is likely to give biased results, as this paper shows.

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