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MASTER'S THESIS

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DO CENTRAL BANKS REACT TO STOCK PRICES?

AN ESTIMATION OF CENTRAL BANKS' REACTION FUNCTION BY THE GENERALIZED METHOD OF MOMENTS

Ljubljana, julij 2011

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Statement

Student Srečko Zimic am declaring that I am author of this Master's thesis which was done under the supervision of dr. Igor Masten and dr. Massimo Giuliodori and in accordance with 1. paragraph of 21. article of the Law on Copyrights and Related Rights I permit that this Master's thesis is published on the faculty's website.

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INTRODUCTION

In 1993 John B. Taylor proposed a simple rule that was meant to describe rate setting by central banks. The remarkable feature of the rule is its simplicity but nevertheless relatively large accuracy when it comes to the description of the behavior of monetary authorities. It was the latter attraction of the rule that spurred extensive research about the conduct of monetary policy using the Taylor-rule.

However, the new developments and findings in monetary theory suggested that the Taylor-rule cannot be properly derived from the microeconomic maximization problem of central bank and is therefore theoretically unfounded. Moreover, econometric estimation techniques employed in early research papers, which tried to apply the Taylor-rule to real world data, turned out to be inconsistent.

The new findings in monetary theory and consistent econometric estimation technique were combined in the paper written by Richard Clarida, Jordi Gali and Mark Gertler in 1998. The backward-looking Taylor-rule is replaced with the forward-looking reaction function more consistent with real-life conduct of monetary policy by central banks. The estimation is performed with a consistent and efficient econometric technique, the Generalized Method of Moments (in further text GMM). Rather than inconsistent and inefficient techniques in estimating reaction functions such as Ordinary least squares and Vector autoregressive models.

In this thesis I build on the work by Clarida et al. and extend it to explore some other interesting questions regarding the behavior of central banks. Firstly, after more than ten years overseeing the world's largest economy, the European Central Bank (in further text ECB) presents a compelling case for investigation. Does the ECB pursue a deliberate inflation targeting strategy and thus aggressively respond to changes in expected inflation? Are developments in the real economy still important factors when the ECB considers the appropriate level of interest rates? Did the German Bundesbank really pursue monetary targeting and is the ECB the descendant of such a policy regime? How does ECB rate setting compare to that of the Federal Reserve? These are the questions that I will explore and try to answer.

The most important part of the thesis concerns the relevance of stock price developments for the conduct of monetary policy. This theme became relevant during a period of macroeconomic stability after the 80's till the start of the new millennium, marked by low inflation and relatively low output variability and increasingly so after the greatest economic crisis since the 1930's stuck the world in 2007. The related research to-date primarily tries to offer a theoretical justification for and against the direct reaction to asset price misalignments by central banks. However, my purpose is not to explore theoretical pros and cons regarding the response of central banks to asset prices, but instead to offer an empirical assessment of the following question: Did central banks use the interest rate policy to affect stock price misalignments in the real world?

The thesis is structured as follows: it starts with a short introduction and continues with the second chapter devoted to the econometric design introduced by Clarida et al.. Chapter 3 offers a basic overview of the GMM technique, relying on the theory presented by Laszlo (1999). Chapter 4 presents important econometric specification tests when empirically applying GMM.

Chapter 5 includes the description of the data used for estimation and the databases where the latter data can be obtained. Chapter 6 is devoted to the presentation of results obtained from the estimation of the reaction functions. Firstly, the estimates of the German and US central banks' reaction function are presented in order to compare the results with those obtained in the Clarida et al.'s papers. The rate setting behavior by ECB and Fed is explored in the chapter 7. Subsequent chapter is devoted to the results of central banks' response to stock price misalignments. Finally, I summarize the results and offer the conclusion.

1 ECONOMETRIC DESIGN – A FORWARD-LOOKING MODEL BY CLARIDA ET AL.

In the following chapter I closely follow Clarida et al.'s influential paper (1998). Given the theoretical background[1] I assume the following policy reaction function: Within each period the central bank has its target interest rate for the short–term nominal interest rate, r_t^*, which depends on the state of the economy. Following CGG, in the baseline scenario I assume that target interest rate depends on both expected inflation and output:

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

Where $\bar{r}$ is long-term nominal equilibrium interest rate, π_{t+n} is the rate of inflation between periods t and $t+n$, y_t is real output, and π^* and y_t^* are respective bliss points for inflation and output. We can view π^* as a target for inflation and, like Clarida et al., I assume y_t^* is given

[1] Look for example at Svensson (1996).

by the potential output that would arise if all prices and wages were perfectly flexible. In addition, E is the expectation operator and Ω_t represents the information set available to the central bank at time *t*. It is important to note that output at time t is expected, because of the fact that GDP is not known at the time of setting the interest rate in that period. Furthermore, specification as proposed by Clarida et al. allows for the possibility that when setting the interest rate the central bank does not have direct information about the current values of either output or the price level (Clarida et al., 1998).

1.1 Taylor principle

To see the (possible) stabilization role of the implied reaction function we need to consider the implied target for the ex-ante real interest rate, $rr_t = r_t - E[\pi_{t+n}|\Omega_t]$:

$$rr_t^* = \overline{rr} + (\beta - 1)(E[\pi_{t+n}|\Omega_t] - \pi^*) + \gamma(E[y_t|\Omega_t] - y_t^*) \quad (2)$$

where $\overline{rr} = \bar{r} - \pi^*$ is the real long-term equilibrium interest rate. I follow CGG and assume that $\overline{rr}$ is determined by purely economic factors and is therefore unaffected by monetary policy (Clarida et al., 1998).

From the equation (2) it is immediately clear that the cyclical behavior of the economy will depend on the size of the slope coefficients. If $\beta < 1$ the reaction function would imply accommodative monetary policy, as real interest rates would not rise sufficiently to offset the change in inflation. On the other hand, if $\beta > 1$ monetary policy would act counter-cyclically as the change in inflation would be more than offset by the change in the real interest rate. In the related literature this feature became known as The Taylor principle – the proposition that central banks can stabilize the economy by adjusting its nominal interest rate instrument more than one-for-one with inflation. On the other hand, even when the central bank raises its nominal interest rate in response to a jump in inflation, but less than one-for-one, this can amplify cyclical behavior and produce large fluctuations in the economy. Taylor (1999), among other authors, has argued that failure to satisfy the Taylor principle by the Federal Reserve might have been the main reason for macroeconomic instability in the late 1960's and the 1970's.

More or less the same reasoning applies to the sign of the γ coefficient – if $\gamma > 0$, monetary policy is stabilizing as the central bank raises the nominal interest rate in response to a positive output gap and vice versa, if $\gamma \leq 0$, monetary policy is destabilizing.

1.2 Interest rate smoothing

The policy reaction function given by equation (1) is not able to describe actual behavior by central banks. CGG list three reasons why the above reaction function is too restrictive (Clarida et al., 2000):

- The specification assumes an immediate adjustment of the actual interest rate set by central bank to its target level, and thus ignores the central bank's tendency to smooth changes in interest rates.
- All changes in interest rates over time are treated as reflecting a central bank's systematic response to economic conditions. Specifically, it does not allow for any randomness in policy actions, other than that associated with incorrect forecasts about the economy.
- Third, the equation assumes that the central bank has perfect control over interest rates; i.e., it succeeds in keeping them at the desired level (e.g., through necessary open market operations).

Therefore, I follow CGG and other authors[2] in the field with the assumption that central banks have a tendency to smooth interest rates. Therefore, I assume that the actual interest rate adjusts only partially to the target interest rate, as follows:

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

where the parameter $\rho \epsilon [0,1]$ captures the degree of interest rate smoothing. Equation (3) assumes a first-order partial adjustment mechanism[3], which can be simply modified to include a higher-order partial adjustment mechanism by including more lagged values of interest rate.

1.3 Estimable equation

To obtain an estimable equation, define $\alpha \equiv \bar{r} - \beta\pi^*$ and $x_t \equiv y_t - y_t^*$. I can then rewrite equation (1) as:

$$r_t^* = \alpha + \beta E[\pi_{t+n}|\Omega_t] + \gamma E[x_t|\Omega_t] \tag{4}$$

combining equation (4) with the partial adjustment in (3), I obtain:

[2] See, for example Goodfriend (1991).
[3] Notice that by imposing such an adjustment rule, $\beta > 1$ does not necessary imply stabilization role of monetary policy, as real interest rate may not immediately change more than one-for-one when inflation picks up.

$$r_t = (1-\rho)(\alpha + \beta E[\pi_{t+n}|\Omega_t] + \gamma\, E[x_t|\Omega_t]) + \rho r_{t-1} + v_t \quad (5)$$

Finally, by rewriting the terms in the realized values and therefore eliminating the unobserved forecast variables:

$$r_t = (1-\rho)\alpha + (1-\rho)\beta\pi_{t+n} + (1-p)\,\gamma\, x_t + \rho r_{t-1} + \varepsilon_t \quad (6)$$

where the error term $\varepsilon_t = -(1-\rho)\{\beta(\pi_{t+n} - E[\pi_{t+n}|\Omega_t]) + \gamma(x_t - E[x_t|\Omega_t])\} + v_t$ is a linear combination of the forecast errors of inflation and output and the exogenous disturbance term[4]. Finally, by defining $\beta_1 \equiv (1-\rho)\alpha$, $\beta_2 \equiv (1-\rho)\beta$, $\beta_3 \equiv (1-\rho)\gamma$ and $\beta_4 \equiv \rho$, I get the (linear)[5] estimable equation:

$$r_t = \beta_1 + \beta_2\pi_{t+n} + \beta_3\, x_t + \beta_4 r_{t-1} + \varepsilon_t \quad (7)$$

Finally, let $\mathbf{u}_t$ be a vector of variables within the central bank's information set at the time it chooses the interest rate (i.e. $\mathbf{u}_t \in \Omega_t$) that are orthogonal to ε_t. Possible elements of $\mathbf{u}_t$ include any lagged variables that help to forecast inflation and output, as well as any contemporaneous variables that are uncorrelated with the current interest rate shock v_t. Then, since $E[\varepsilon_t|\,\mathbf{u}_t] = 0$, equation (7) implies the following set of orthogonal conditions that I exploit for estimation:

$$E[r_t - \beta_1 - \beta_2\pi_{t+n} - \beta_3\, x_t - \beta_4 r_{t-1}|\,\mathrm{u}_t] = 0 \quad (8)$$

To estimate the parameter vector $[\beta_1, \beta_2, \beta_3, \beta_4]$ I will use the econometric technique Generalized method of moments which is explained in details in the next section. I estimate the baseline model using data on inflation and the output gap. Additionally, baseline instrument used always includes lags of the target interest rate itself, inflation, the output gap and commodity price inflation. Other instruments used are reported below each table.

Lastly, when considering the time horizon of the inflation forecast that enters the reaction function I follow Clarida et al. and choose a one-year forecast horizon. This would seem to be a plausible approximation how central bankers operate in the real world. Namely, a shorter period seems highly implausible as, if nothing more, seasonal variability can affect month-to-

[4] Such an approach developed by Clarida et al. and used in this paper relies on the assumption that, within my short samples, short term interest rate and inflation are I(0). However, the Augmented Dickey-Fuller test of the null that inflation and interest rate in most cases does not reject non-stationary - test can be delivered upon request. Nevertheless, considering persistence and the low power of the Augmented Dickey-Fuller test, are follow Clarida et al. and assume that both series are stationary – see Clarida et al. (2000), page 154 for further details.

[5] I also estimated non-linear version of the model, but results do not qualitatively change. Results from non-linear estimation are available upon request.

month variation and the latter variability seems not to be of concern for monetary policy. Furthermore, longer time periods, i.e., five years, do not seem to play an important role when considering rate setting, even if sometimes such a time horizon is pointed out by central bankers as the cornerstone of their monetary policy considerations, especially when the economy is hit by a transitory supply shock. However, as forecast uncertainty is increasing in time, such longer forecast horizons do not seem to have an important role in "normal" times.

1.4 Target interest rate

The econometric approach developed by Clarida et al. also allows to recover the estimate of target inflation rate by central bank, π^*. Particularly, given $\alpha \equiv \bar{r} - \beta\pi^*$ and $\bar{r} \equiv \overline{rr} + \pi^*$, we can extract the target interest rate by the following relationship:

$$\pi^* = \frac{\overline{rr} - \alpha}{\beta - 1} \tag{9}$$

If we have sufficiently long time series we can use the sample average real interest rate to obtain the estimate of $\overline{rr}$. We can then use this measure to obtain the estimate of π^*(Clarida et al., 1998).

1.5 Alternative specifications of reaction functions

Above I have assumed that central banks react solely to the expected inflation and output gap. However, the main contribution of this thesis is to consider alternative factors that might have influenced rate setting by central banks.

Hence, let q_t denote the variable that besides inflation and the output gap affects interest setting (independently of its use as a predictor of future inflation). The equation (1) then changes to:

$$r_t^* = \bar{r} + \beta(E[\pi_{t+n}|\Omega_t] - \pi^*) + \gamma(E[y_t|\Omega_t] - y_t^*) + \xi E[q_{t+n}|\Omega_t] \tag{10}$$

In this case, equation (6) can be rewritten as follows:

$$r_t = (1-\rho)\alpha + (1-\rho)\beta\pi_{t+n} + (1-p)\gamma\, x_t + (1-p)\xi q_{t+n} + \rho r_{t-1} + \varepsilon_t \tag{11}$$

where q_t represent other variables of interest, which may affect the rate setting by the central bank. It is important to notice that such a design accounts for the possibility that other factors captured in q_t and included as instruments may only have predictive power for inflation and the output gap, but they do not directly affect the policy reaction function. By one explanation, we can interpret the statistically significant coefficient on an additional variable, ξ, as evidence that monetary policy is reacting directly to this additionally included variable. I consider two such variables: money growth and stock market imbalances.

Alternatively, the statistical significance of the coefficient on additional variables in the reaction function can also be seen as a sign that monetary policy is pursuing other objectives in addition to expected inflation and the output gap. To the extent that a central bank has other objectives not captured in the specified reaction function, and there is information about these objectives in considered additional variables, then we can see additional variables enter the central bank's reaction function with a statistically significant coefficient, even if the central bank is not directly reacting to considered additional variables. Therefore, a statistically significant coefficient on a particular additional variable cannot be conclusively interpreted as a systematic response by the central bank.

2 GENERALIZED METHOD OF MOMENTS

The Generalized Method of Moments (in further text GMM) was introduced by Hansen in his celebrated 1982's paper. In the last twenty years it has become a widely used tool among empirical researchers, especially in the field of rational expectations, as we only need partial specification of the model and minimal assumptions to estimate the model by GMM[6]. Moreover, GMM is also useful as a heuristic tool, as many standard estimators, including OLS and IV, can be seen as special cases of a GMM estimator.

2.1 Moment conditions

The Method of Moments is an estimation technique that suggests unknown parameters should be estimated by matching population (or theoretical) moments (which are function of the unknown parameters) with the appropriate sample moments. The first step is to define properly the moment conditions (Laszlo, 1999).

Suppose that we have an observed sample $\{x_t: t = 1, \dots, T\}$ from which we want to estimate the unknown $p \times 1$ parameter vector θ with a true value θ_0. Let $f(x_t, \theta)$ be a continuous $q \times 1$ vector function of θ, and let $E(f(x_t, \theta))$ exist and be finite for all t and θ. Then the moment conditions are (Laszlo, 1999):

[6] For example, we do not need assumption of the i.i.d. errors.

$$E\big(f(x_t, \theta_0)\big) = 0 \tag{12}$$

2.2 Moment condition from rational expectations

To relate the theoretical moment condition to the rational expectations framework, consider a simple monetary policy rule, where the central bank sets interest rates solely depending on expected inflation:

$$r_t = \beta E[\pi_{t+n}|\Omega_t] + \epsilon_t \tag{13}$$

noting that $\pi_{t+n} = E[\pi_{t+n}|\Omega_t] + v_t$, where v_t is an expectation (forecast) error, we can rewrite the model as:

$$r_t = \beta E[\pi_{t+n}|\Omega_t] + \epsilon_t = \beta\pi_{t+n} + (\epsilon_t - \beta v_t) = \beta\pi_{t+n} + u_t \tag{14}$$

where u_t is a linear combination of exogenous error term and the expectation (forecast) error, which, under rational expectation, should be orthogonal to the information set, Ω_t, and for instruments $z_t \in \Omega_t$ we have the moment condition:

$$E[u_t \cdot z_t] = E[(r_t - \beta\pi_{t+n})z_t] = 0 \tag{15}$$

which is enough to identify β.

2.3 (Generalized) method of moments estimator

I now turn to the estimation of a parameter vector θ using moment conditions as given in (12). However, as we cannot calculate the expectations to solve the equation, the obvious way to proceed is to define the sample moments of $f(x_t, \theta)$:

$$f_T(\theta) = T^{-1} \sum_{t=1}^{T} f(x_t, \theta) \tag{16}$$

which is the Method of Moments (MM) estimator of $E\big(f(x_t, \theta)\big)$. If the sample moments provide good estimates of the population moments, then we might expect that the estimator $\widehat{\theta_T}$ that solves the sample moment conditions $f_T(\theta) = 0$ would provide a good estimate of the true value θ_0 that solves the population moment conditions $E\big(f(x_t, \theta)\big) = 0$ (Laszlo, 1999).

To find an estimator, we need at least as many equations – moment conditions - as we have parameters. Therefore, the order condition for the identification is $q \geq p$:

- $q = p$ is called exact identification. The estimator is denoted by the Method of Moments (MM) estimator, $\widehat{\theta_{MM}}$.

- $q > p$ is called over-identification. The estimator is denoted by the Generalized Method of Moments (GMM), $\widehat{\theta_{GMM}}$.

In the latter case, when we have more equations than unknowns, we cannot find a vector $\widehat{\theta_T}$ that satisfies $f_T(\theta) = 0$. Instead, we will find the vector $\widehat{\theta_T}$ that makes $f_T(\theta)$ as close to zero as possible. This can be done by defining:

$$\widehat{\theta_T} = argmin_\theta Q_T(\theta) \tag{17}$$

Where:

$$Q_T(\theta) = f_T(\theta)' W_T f_T(\theta) \tag{18}$$

and W_T is a stochastic positive definite weighting matrix. The GMM estimator therefore depends on the choice of the weighting matrix.

2.4 OLS as MM estimator

Consider the linear regression model

$$y_t = x_t' \beta_0 + u_t \tag{19}$$

where x_t is a $p \times 1$ vector of stochastic regressors, β_0 is the true value of a $p \times 1$ vector of unknown parameters β, and u_t is an error term. In the presence of stochastic regressors, we often specify:

$$E(u_t|x_t) = 0, \ so\ that\ E(y_t|x_t) = x_t'\beta_0 \tag{20}$$

that implies the q unconditional moments conditions:

$$f(\beta) = E[u_t x_t] = E[(y_t - x_t'\beta_0)x_t] = 0 \tag{21}$$

which can also be recognized as the minimal assumption for consistency of the OLS estimator. Notice that $E[u_t x_t] = 0$ consists of p equations since x_t is a $p \times 1$ vector. Since β is a $p \times 1$ parameter, these moment conditions exactly identify β and therefore we refer to the Method of Moment estimator.

Turning to estimation of the parameter vector, the sample moment conditions are:

$$T^{-1} \sum_{t=1}^{T} x_t \widehat{u_t} = T^{-1} \sum_{t=1}^{T} x_t \left(y_t - x_t'\widehat{\beta_T}\right) = 0 \tag{22}$$

Solving for $\widehat{\beta_T}$ yields:

$$\widehat{\beta_T} = (\sum_{t=1}^{T} x_t\, x_t')^{-1}(\sum_{t=1}^{T} x_t\, y_t) = (X'X)^{-1}X'y \tag{23}$$

which is the OLS estimator. Therefore, we can conclude that the MM estimator is one way to motivate the OLS estimator.

2.5 IV as a GMM estimator

To shed light on the case of over-identification and therefore the GMM estimator, consider the linear regression with $q > p$ valid instruments. The moment conditions are:

$$E[u_t z_t] = E[(y_t - x_t'\beta_0)z_t] = 0 \tag{24}$$

and the sample moment conditions are:

$$f_T(\beta) = T^{-1}\sum_{t=1}^{T} z_t\left(y_t - x_t'\widehat{\beta_T}\right) = T^{-1}(Z'y - Z'X\beta) \tag{25}$$

As I want to represent the case of over-identification, we have more moment conditions than parameters to estimate, we need to minimize the quadratic form in (18) and choose a weighting matrix. Suppose we choose:

$$W_T = (T^{-1}\sum_{t=1}^{T} z_t\, z_t')^{-1} = T(Z'Z)^{-1} \tag{26}$$

And further assume that by a weak law of large numbers $T^{-1}(Z'Z)$ converges in probability to a constant weighting matrix W. Then the criterion function is:

$$Q_T(\beta) = T^{-1}(Z'y - Z'X\beta)'\,(Z'Z)^{-1}(Z'y - Z'X\beta) \tag{27}$$

Differentiating with respect to β gives the first order conditions:

$$\frac{\partial Q_T(\beta)}{\partial\beta}|_{\beta=\hat{\beta}} = T^{-1}2X'Z(Z'Z)^{-1}\left(Z'y - Z'X\widehat{\beta_T}\right) = 0 \tag{28}$$

Solving for $\widehat{\beta_T}$ yields:

$$\widehat{\beta_T} = (X'Z(Z'Z)^{-1}Z'X)^{-1}X'Z(Z'Z)^{-1}Z'y \tag{29}$$

which is the standard IV estimator for the case where there are more instruments than regressors (Laszlo, 1999).

2.6 Weighting matrix

To see the purpose of the weighting matrix, consider a simple example with two moment conditions:

$$f_T(\theta) = \begin{pmatrix} f_a \\ f_b \end{pmatrix} \tag{30}$$

where the dependence of T and θ is suppressed.

First consider the simple case with a simple weighting matrix, $W_T = I_2$:

$$Q_T(\theta) = f_T(\theta)' W_T f_T(\theta) = (f_a \quad f_b) \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} \begin{pmatrix} f_a \\ f_b \end{pmatrix} = f_a{}^2 + f_b{}^2 \tag{31}$$

which is the square of the distance from $f_T(\theta)$ to zero. In such a case the coordinates are equally important. Alternatively, we can also use a different weighting matrix, which, for example, attaches more weight to the first moment condition:

$$Q_T(\theta) = f_T(\theta)' W_T f_T(\theta) = (f_a \quad f_b) \begin{pmatrix} 2 & 0 \\ 0 & 1 \end{pmatrix} \begin{pmatrix} f_a \\ f_b \end{pmatrix} = f_a{}^2 + f_b{}^2 \tag{32}$$

2.7 Optimal choice of weighting matrix

As we have seen previously, the GMM estimator depends on the choice of the weighting matrix. Therefore, what is the optimal choice for a weighting matrix?

Assume central limit theorem[7] for $f(x_t, \theta_0)$:

$$\sqrt{T} f_T(\theta) = \frac{1}{\sqrt{T}} \sum_{t=1}^{T} f(x_t, \theta_0) \; \rightarrow N(0, S) \tag{33}$$

where S is asymptotic variance. Then it holds that for any positive weighting matrix, W, the asymptotic distribution of the GMM estimator is given by:

$$\sqrt{T}\left(\widehat{\theta_T} - \theta_0\right) \rightarrow N(0, V) \tag{34}$$

where the asymptotic variance is given by:

[7] The central limit theorem states conditions under which the mean of a sufficiently large number of independent random variables, each with finite mean and variance, will be approximately normally distributed. It also requires the random variables to be identically distributed, unless certain conditions are met (Rice, 1995).

$$V = (F'WF)^{-1}F'WSWF(F'WF)^{-1} \tag{35}$$

Where

$$F = E\left[\frac{\partial f(x_t, \theta)}{\partial \theta'}\right] \tag{36}$$

is the expected value of the $q \times p$ matrix of first derivatives of the moments. From the equation (32) it follows that the variance of $\widehat{\theta_T}$ depends on the choice of the weighting matrix, W_T. It can be shown[8] that the optimal weighting matrix, W_T^{opt}, has the property:

$$plimW_T^{opt} = S^{-1} \tag{37}$$

With the optimal weighting matrix, $W = S^{-1}$, the asymptotic variance can be simplified to:

$$V = (F'S^{-1}F)^{-1}F'S^{-1}SS^{-1}F(F'S^{-1}F)^{-1} = (F'S^{-1}F)^{-1} \tag{38}$$

which is the smallest possible variance of the GMM estimator. Therefore, the efficient GMM estimator has the smallest possible (asymptotic) variance. Intuition for the latter results is quite straightforward, as a moment with small variance is more informative than moment with large variance and therefore the former should have greater weight. To summarize, for best moment conditions *S* should be small and *F* should be large; a small *S* means that the sample variation of the moment (noise) is small. On the other hand, large *F* means that the moment condition is much violated if $\theta \neq \theta_0$ – therefore, such a moment is very informative about the true values of θ_0.

An estimator of the asymptotic variance is given by:

$$\hat{V} = (F'_T S_T^{-1} F_T)^{-1} \tag{39}$$

where

$$F_T = \frac{\partial f_T(\theta)}{\partial \theta'} = T^{-1}\sum_{t=1}^{T}\frac{\partial f(x_t, \theta)}{\partial \theta'} \tag{40}$$

is the sample average of the first derivatives.

S_T is an estimator of $S = T \cdot V[f_T(\theta)]$. If the observations are independent, a consistent estimator is

[8] For a better treatment see Laszlo (1999), page 11-29.

$$S_T = T^{-1} \sum_{t=1}^{T} f(x_t, \theta)' f(x_t, \theta) \tag{41}$$

2.8 How to calculate the GMM estimator?

Above I showed that we can obtain the GMM estimator by minimizing $Q_T(\theta)$. Minimization can be done by:

$$\frac{\partial Q_T(\theta)}{\partial \theta} = \frac{\partial f_T(\theta)' W_T f_T(\theta)}{\partial \theta} = 0 \tag{42}$$

From the above equation we can observe that in order to estimate parameters we need an optimal weighting matrix, but at the same time W_T^{opt} depends on the parameters. Therefore, we need to adopt one of the three different procedures to obtain an asymptotically consistent[9] and efficient estimator.

2.8.1 Two-step efficient GMM:

As the name already suggests, we get the GMM estimator in two steps:

- We need to arbitrarily choose an initial weighting matrix, usually $W_{[1]} = I_q$, and find a consistent, but most probably inefficient first-step GMM estimator:

$$\widehat{\theta_{[1]}} = arg \min_{\theta} f_T(\theta)' W_{[1]} f_T(\theta) \tag{43}$$

- After obtaining consistent estimated parameters, $\widehat{\theta_{[1]}}$, we can use them to obtain an optimal weighting matrix, $W_{[2]}^{opt}$, and therefore find an efficient GMM estimator:

$$\widehat{\theta_{[2]}} = arg \min_{\theta} f_T(\theta)' W_{[2]} f_T(\theta) \tag{44}$$

It follows that the estimator is not unique as it depends on the initial weighting matrix. I use a similar procedure in the thesis[10].

3 SPECIFICATION TESTS

Until recently, monetary policy rules, approximated by backward-looking Taylor rules, were estimated by Ordinary least squares (in further text OLS). However, such an approach gives rise to so-called simultaneity bias – a correlation between right hand variables and residuals.

[9] To gain further insight about consistency of GMM estimator, see Laszlo (1999), page 12.
[10] Statistical package Stata which is used for estimation purposes uses slightly different approach - the initial weighting matrix is obtained from the residuals from the first step estimation by IV.

In other words, as right hand variables may not be exogenous, OLS estimates would produce biased and inconsistent estimates. An obvious way to proceed in such a case is to employ the Instrumental Variable approach (IV), in which right hand variables are instrumented by variables that are orthogonal to the error process. Nevertheless, by adopting the IV (and later GMM) estimation technique, researchers needs to check to main questions connected with such an approach:

- **Validity**: are instruments orthogonal to the error process?
- **Relevance**: are instruments correlated with endogenous regressors?

The first question can be answered in the case of an overidentified model. In that context, we may test the overidentifying restrictions in order to provide some evidence of the instruments' validity. In the GMM context the test of the overidentifying restrictions refers to the Hansen test, which will be presented first. Secondly, I will discuss some general statistics that can show the relevance of the instruments. Lastly, I will describe the problem of heteroskedasticy and autocorrelation.

In this section I will closely follow the paper of Bound, Jaeger and Baker (2003).

3.1 Hansen test of over-identifying restrictions

In practice, it is prudent to begin by testing the overidentifying restrictions, as the rejection may properly call model specification and orthogonality conditions into question. Such a test can be conducted if and only if we have surfeit of instruments – if we have more excluded instruments than included endogenous variables. This allows for the decomposition of the population moment conditions into the identifying and the overidentifying restrictions. The former represent the part of the population moment conditions which actually goes into parameter estimation and the latter are just the remainder. Therefore, the identifying restrictions need to be satisfied in order to estimate parameter vector and so it is not possible to test whether restrictions are satisfied at the true parameter vector. On the other hand, overidentifying restrictions are not imposed and so it is possible to test if this restrictions hold in the population.

In the context of GMM, the overidentifying restrictions may be tested via the commonly employed J statistic of Hansen (1982). This statistic is none other than the value of the GMM objective function $Q_T(\theta) = f_T(\theta)' W_T f_T(\theta)$ evaluated at the efficient GMM estimator:

$$J_T = TQ_T(\widehat{\theta_T}) \tag{45}$$

and it converges to a χ^2_{q-p} distribution under the null hypothesis (with the number of overidentifying restriction, *q-p*, as the degrees of freedom). A rejection of the null hypothesis implies that the instruments are not satisfying the orthogonality conditions required for their employment. This may be either because they are not truly exogenous, or because they are being incorrectly excluded from the regression.

The test can also be interpreted in the Clarida et al. framework – if the conditions of orthogonality are satisfied, this implies that central banks adjust the interest rate in line with the reaction function proposed above, with the expectations on the right hand side based on all the relevant information available to policy makers at that time. This implies parameter vector values that would mean the implied residual ε_t is orthogonal to the variables in the information set Ω_t.

However, under the alternative, the central bank adjust interest rate in response to some other variables, but not necessarily in connection that those variables have about expected inflation and output gap. In that case, some relevant explanatory variables are omitted from the model and we can reject the model (Clarida et al., 1998).

3.2 Relevance of instruments

The most straightforward way to check if excluded instruments are correlated with the included endogenous regressors is to examine the fit of the first stage regression. The most commonly used statistic in this regard is the partial R^2 of the first stage regression[11]. Alternatively, one can use an F-test of joint significance of the instruments in the first stage regression. The problem is that the latter two measures are able to diagnose the instrument relevance only in the case of a single endogenous regressor.

One measure that can overcome this problem is so-called Shea partial R^2 statistic[12]. Baum, Schaffer and Stillman (2003) suggest that a large value of the standard partial R^2 and a small value of Shea's partial R^2 statistic can indicate that our instruments lack relevance. Another rule of thumb used in research practice is that F-statistic below 10 can be a reason for concern. As excluded instruments with little explanatory power can lead to biased estimates, one needs to be parsimonious in the choice of instruments. Therefore, I employ only

[11] See Bound, Jaeger & Baker (1995).
[12] See Shea (1997).

instruments which have been proposed in the related literature and meet the above conditions[13].

3.3 Heteroskedasticy and autocorrelation of the error term

The two most important reasons why the GMM estimation technique may be preferred over that of IV is the potential presence of heteroskedasticity in the error process and that of serially correlated errors.

Although the consistency of the IV estimates is not affected by the presence of heteroskedasticity and serially correlated errors, the standard IV estimates of the standard errors are inconsistent, preventing valid inference.

3.3.1 Test for heteroskedasticy

The solution to the problem of heteroskedasticity of unknown form has been provided by the GMM technique, which, by itself, brings the advantage of the efficiency and consistency in the presence of arbitrary heteroskedasticity. Nevertheless, this is delivered at a cost of possibly poor finite sample performance, and therefore, if heteroskedasticity is in fact not present, standard IV may be preferable over GMM[14].

3.3.2 HAC weighting matrix

Another problem is that of a serially correlated error process. Similar to that of heteroskedasticy, this causes the IV estimator to be inefficient. It is important to notice that the econometric design proposed by CGG embodies autocorrelation of the error term, ε_t. Namely, by construction, ε_t follows an *MA(n-1)* process and will thus be serially correlated unless *n=1*[15].

The solution in such a scenario was offered by Newey and West (1987). They proposed a general covariance estimator that is consistent in the presence of heteroskedasticy and serially correlated errors – so-called HAC covariance estimators[16]. Therefore, I use HAC estimators, robust to autocorrelation or to both autocorrelation and heteroskedasticy, depening on which problem is present in the certain estimated model.

[13] The above measures and the Anderson canonical correlations likelihood-ratio test from the first stage regression can be delivered upon request.
[14] Upon request I can deliver the test of Pagan and Hall (1983) designed specifically for detecting the presence of heteroskedasticity for the baseline scenarios.
[15] The expectation error in current period about the expected inflation n-periods ahead implies such an error will persist for n-1 periods.
[16] Interested reader can explore Laszlo (1999), chapter 3.

4 DATA

In this section the historical data series used in the thesis and the databases where the data was obtained are described.

4.1 Euro area

The historical time series used in the study to represent the policy of the ECB span the period from the official start of European Monetary union (in further text EMU) to the present - from January 1999 till April 2010. As the time span is relatively short I use the monthly data to get more observables.

Most of the data relating to the Euro area was obtained from the Statistical data warehouse (in further text SDW) at the ECB and relates to the Euro area (changing composition) as defined by the ECB. The policy interest rate for ECB is represented by the EONIA[17] interest rate. To capture the inflation variable I use two different measures – the baseline measure is the yearly rate of change in the Harmonized Index of Consumer Prices (in further text HICP). However, as the period was marked by a significant oil shock, which might not have been accommodated by the central bank, I also use HICP excluding energy and unprocessed food prices. The measures used to capture the output gap will be described in detail below.

In the alternative specification I check if money growth directly affected monetary policy - M3 growth refers to the percentage change in the annual growth of M3 monetary aggregate[18]. The lags of the M3 growth are also included as instruments. The measures relating to stock market imbalances will be discussed in the separate section below.

Finally, I use three measures useful for prediction of inflation solely as instruments. Firstly, I use the real effective exchange rate as computed by the Bank of International Settlements (narrow group – 27 countries). The second one is the yearly change in the commodity spot price index constructed by Commodity Research Bureau (CRB spot index) and taken from

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[17] Eonia (Euro OverNight Index Average) is an effective overnight interest rate computed as a weighted average of all overnight unsecured lending transactions in the interbank market.

[18] Euro area (changing composition), Index of Notional Stocks, MFIs, central government and post office giro institutions reporting sector - Monetary aggregate M3, All currencies combined - Euro area (changing composition) counterpart, Non-MFIs excluding central government sector, Annual growth rate, data Working day and seasonally adjusted.

Datastream[19]. The last one is the spread between 6-month Euribor and benchmark bonds of 10-year maturity obtained from SDW.

4.2 United States

The data concerning interest rate setting by the Federal Reserve (in further text Fed) are divided in the three time-series. The first one is spanning from 1960-1980, the second one from 1980-1999 and the last period begins in 1999 and ends in April 2010 (the reasons for such distribution of the periods are explained below).

The policy interest rate of the Federal Reserve Fed is captured by the effective Fed funds rate taken from the Federal Reserve Economic Data (in further text FRED) – monthly figures are constructed as average of daily values. The baseline inflation variable is the Consumer Price Index (CPI). Once again, for the same reasons cited above, I also estimate equations using the CPI index excluding energy and food prices for the period from January 1999.

In order to check alternative reaction functions I again use the measure of money growth - M2 growth refers to the yearly percentage change in the M2 money stock from one year ago. The stock price measures will be discussed below in more detail.

The instrument set includes the real effective exchange rate taken from the Bank for International Settlements. I also use lags of the spread between 3-Month Treasury Bills and the 10-Year Treasury and the yearly change in the CDO commodity spot price index.

4.3 Germany

In order to get an historical perspective of the monetary policy conducted by the ECB – and equally to obtain a longer time series in order to check the consistency of the estimates given the brief duration of the ECB - I decided to approximate the monetary policy of the ECB as a continuation of the previous monetary policy of the German central bank. It is worth pointing out that it is not unusual in the related literature to argue that the ECB's conduct of monetary policy inherited the main characteristics of Bundesbank policy (see for example Issing 2006).

[19] The Spot Market Price Index is a measure of price movements of 22 sensitive basic commodities. The 22 commodities are combined into an "All Commodities" grouping, with two major subdivisions: Raw Industrials, and Foodstuffs. Raw Industrials include burlap, copper scrap, cotton, hides, lead scrap, print cloth, rosin, rubber, steel scrap, tallow, tin, wool tops, and zinc. Foodstuffs include butter, cocoa beans, corn, cottonseed oil, hogs, lard, steers, sugar, and wheat.

The data concerning the interest setting by the Bundesbank are divided into two time-series. The first spans1962-1980 and the second period begins in 1980 and ends in December 1998 (the reasons for such distribution of the periods are explained below).

The historical time series for Germany were obtained from the Bundesbank, Datastream, IMF and OECD time series databases. I use the money market interest rate (Overnight money-monthly average) as the policy instrument of the Bundesbank. Inflation dynamics are captured by the seasonally adjusted yearly percentage change in the Consumer Price Index (in further text CPI) on a monthly basis (up to 1994 index calculated only for Western Germany).

To control for the scenario in which, besides inflation and the output gap, monetary growth directly affected interest rate setting, I use the data on growth of the M3 money aggregate taken from the Bundesbank's database.

The instrument set includes M2 money growth, again taken from the Bundesbank's database. I also use the real exchange rate directly as computed by the BIS (narrow group – 27 countries). Additionally, the "spread" variable is approximated by the spread between yields on public debt securities of maturity of more than 1 year up to 2 years and yields on public debt securities of maturity of more than 7 years (data was obtained from the Bundesbank database). Again, lags of the yearly percentage change in the CDO commodity spot price index are included as instruments.

The exact instruments used in each specification are also reported below each table.

4.4 Potential output

The measure of the output gap is defined as the percentage deviation of actual from potential output. In this field of literature three main approaches for capturing the potential output have been proposed: i) simply taking the linear trend as an approximation of the potential output, ii) similarly, a quadratic trend can be used instead, iii) And lastly and most convincingly, a measure of the potential output can be obtained by so-called smoothing filters – most common between the latter filters is the Hodrick-Prescott filter (HP-filter), which I use to estimate the output gap. The HP-filter is applied to the index of industrial production – the index for the Euro area[20] was obtained from the SDW database, for Germany from the Datastream and for the US from the FRED database.

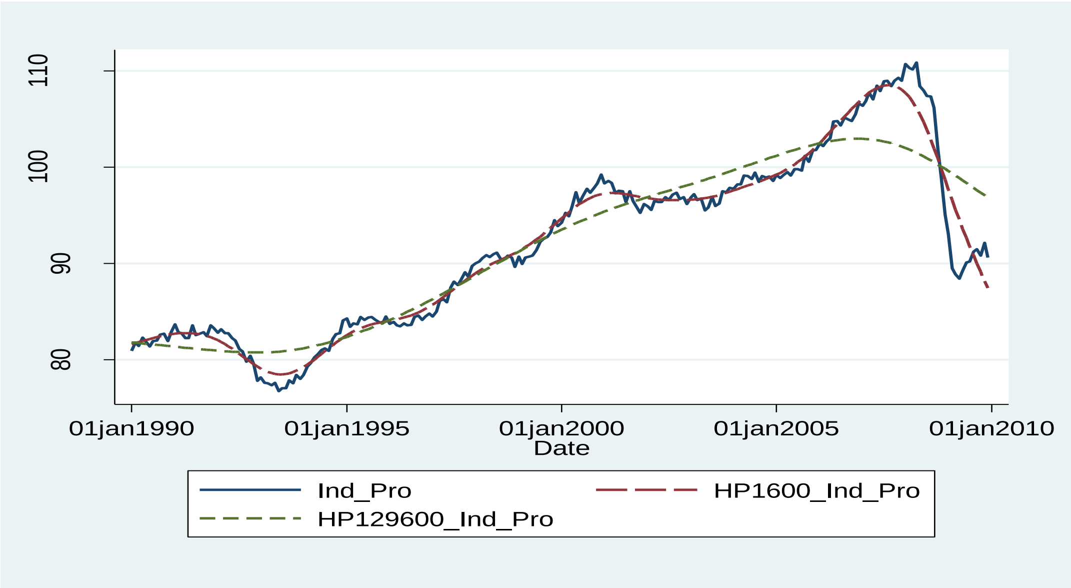
[20] Excluding construction

The HP-filter is the most commonly used smoothing method in macroeconomics to obtain a smooth estimate of the long-term component/trend of the time series. The filter was first applied by the economists Hodrick and Prescott (1997). Technically, the HP-filter is a two-sided linear filter that computes the smoothed series *s* of *y* by minimizing the variance of *y* around *s*, subject to the penalty that constrains the second difference of *s*. That is, the HP-filter chooses *s* to minimize (Gerdesmeier and Roffia, 2004):

$$\sum_{t=1}^{T}(y_t - s_t)^2 + \lambda \sum_{t=1}^{T}\left((s_{t+1} - s_t) - (s_t - s_{t-1})\right)^2 \quad (46)$$

where λ is the penalty parameter that controls the smoothness of the series σ – the larger the λ, the smoother the σ. As $\lambda \to \infty$, *s* approaches linear trend. Following common practice I chose $\lambda = 129600$ for monthly data. Graph 1 present the original time series of industrial production for EMU and its smoothed versions using two different penalty parameters. We can notice that applying smoothing parameter $\lambda = 1600$, which is used for yearly data, "fits" the smoothed to the the original time series really closely and therefore is not a good approximation for the trend level of industrial production.

Graph 1: Difference between smoothing parameter $\lambda = 1600$ and $\lambda = 129600$ for monthly data (EMU industrial production)



Source: Statistical data warehouse, 2009.

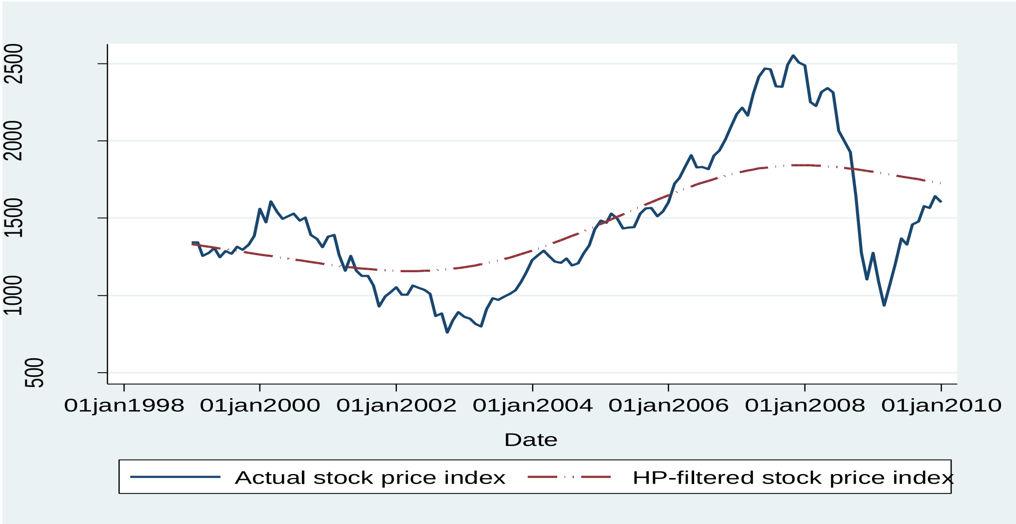
4.5 Stock returns data

The main goal of the thesis is to explore whether central banks react to stock price misalignments over and above their predictive power for future inflation and the output gap. In order to examine the latter hypothesis, I use different measures of stock price misalignments.

First of all, to capture stock price developments in a certain country/region I use the country/region specific index of stock prices as constructed by Datastream. However, as the latter indices are available only from 1973, I also use the most representative equity index for each country - the S&P 500 Composite for the US, the DAX30 Performance for Germany and the Dow Jones Euro Stoxx 50 for Euro area. All the data are taken from the Datastream database.

The next question concerns which measure is the best at indicating possible stock price misalignment and may therefore be the focus of central banks' attention. The most straightforward way is to include the yearly percentage change of some representative stock market index for a certain country, as done by Bernanke and Getler (1999). However, such a measure does not directly indicate a possible stock price misalignment. Therefore, I have constructed the measure of the "stock price gap" by applying the HP-filter to the time series of price index for the given stock market index. The latter measure closely resembles the construction of the output gap measure and may indicate periods of booms and busts in the stock markets. The "stock price gap" measures the percentage deviation of the current value of a certain stock price index from its "trend/potential" level calculated by applying the HP-filter with smoothing parameter 129600. In the Graph below can see the actual and the smoothed stock price index for the Euro area. We can notice the "stock price bubbles" around the year 2000 and 2007 and consequential "stock price bursts".

Graph 2: Actual and HP-filtered stock price index for Euro area



Source: Datastream, 2009.

In addition to the baseline measure, I utilize some measures from equity pricing theory which may also indicate the stock price misalignment – the price/earnings ratio (in further text PE), the price/cash earnings ratio (in further text PC) and the price/book value ratio (in further text PB).

4.5.1 PE ratio

P/E ratio is defined as the valuation ratio between the current share price and its per-share earnings. In order to get a P/E ratio for certain equity index we need to divide the market value of all shares included in a certain index by their total earnings, thus providing an earnings weighted average of the P/E ratio of the constituents. It is calculated as follows:

$$PE_t = \frac{\sum_1^n (P_t * N_t)}{\sum_1^n (E_t * N_t)} \tag{47}$$

where PE_t is the price to earnings ratio on day t, P_t is the price on day t, N_t is the number of shares in issue on day t, E_t is the earnings per share on day t (negative earnings per share are treated as zero) and n is the number of constituents of the index.

However, the main drawback of the simple P/E ratio is that it completely relates to the company's one-year earnings and therefore may not be the best proxy to capture stock market "imbalances", which central bank may want to influence. For example, if a potential stock market bubble is not only marked by high stock prices, but as a consequence also by (currently) high earnings, the ratio will not exhibit "non-normal" values. For that reason, I use two alternatives from pricing theory that may do a better job of capturing "non-normal" developments in the stock market.

4.5.2 PC ratio

The price/cash earnings ratio at any given date is the price divided by cash earnings per share for the appropriate financial year, adjusted for capital changes. It is derived by dividing the market value by the latest total cash earnings:

$$PC_t = \frac{\sum_1^n (P_t * N_t)}{\sum_1^n (CE_t * N_t)} \tag{48}$$

where PC_t is the price to cash earnings ratio on day t, P_t is the price on day t, N_t is the number of shares in issue on day t, CE_t is the cash earnings per share on day t and n is the number of constituents of an index.

In contrast to the basic PE index that looks at the net income of the company on a per share basis, the PC index looks at the cash flow generated by a company on a per share basis, which is more stable than the net earnings of a company.

4.5.3 PB ratio

The price to book value ratio is calculated as follows:

$$PB_t = \frac{\sum_1^n (P_t * N_t)}{\sum_1^n (BV_t * N_t)} \tag{49}$$

where PB_t is the price to book value ratio on day t, P_t is the price on day t, N_t is the number of shares in issue on day t, BV_t is the book value per share on day t and n is the number of constituents of an index.

5 FED'S AND BUNDESBANK'S RATE SETTING BEFORE 1999

In this section I present baseline estimates of the policy reaction function for the US Federal Reserve and the German Bundesbank. The section is structured as follows: first I estimate the basic scenario policy reaction function containing the expected inflation and the output gap as the only policy relevant variables of the FED and the Bundesbank over the two periods – the pre-Volcker and post-Volcker period. The latter sub-section serves more or less to compare the results I obtain from the results found in Clarida et al.'s papers.

The final sub-section is devoted to the results from estimation of the alternative specification of the Fed's and the Bundesbank's reaction functions. I consider the case of monetary targeting and therefore money growth as a policy relevant variable for the German central bank.

5.1 US and German monetary policy before and after Volcker

Before proceeding to the results, I owe an explanation as to why I chose to estimate the reaction functions over two periods and not simply over the whole period for which I have data. One of the main requirements for any model to be a relevant description of the real world is the need for parameter stability throughout the whole period of the estimation. Therefore, if based on prior information the researcher is convinced that the estimated underlying process (population) has changed at some point in time, it is advisable to estimate each period individually and then compare the results – if the parameters differ as expected then such a procedure is correct.

The years following the early 80's – at least till the present economic crisis - have been marked by macroeconomic stability – the so-called "Great Moderation". There are several competing explanations as to what contributed to the transition from "chaotic" 70's to this period of economic stability, but one of the most important and accepted explanations in academic word is the shift in the conduct of the monetary policy. As Goodfriend (2007) points out, the arrival of Paul Volcker as chairman of the Federal Reserve in 1979 stands out as a turning point – under Volcker the Fed brought the inflation rate down from above 10 percent to a mere 4 percent by 1984. Although this resulted in a severe recession – the economic costs of lowering inflation were less than had been expected in the 1970's. The Fed continued to gradually work the inflation rate down and by the early 2000s fell below 2 percent under Alan Greenspan. At the same time, the improved inflationary picture in the United States was accompanied by parallel developments around the world. Against this background I chose to separately estimate two sub-periods: the pre-Volcker period spans from the 1960 (1962 for Germany) till 1980. The post-Volcker period begins in the 1980 and ends in the 1999, when the third "ECB" estimation period begins – this third period is "artificially" constructed and is not a consequence of a structural brake in the conduct of monetary policy.

5.2 Baseline estimation results

Table 1 reports the results of the GMM estimation of the parameters for the Fed's interest rule. In the baseline scenario, I use the CPI index as an inflation variable and the HP-filtered industrial production as the output gap variable. The target horizon is assumed to be one year ahead for inflation and the current period for the output gap. This is in line with the empirical evidence that output gap leads inflation (see Gali and Gertler, 1999). The specification and the use of the instruments are reported below each table.

Table 1: Baseline US estimates

USA	α	β	γ	ρ	π^*	p
Pre-Volcker	3.19***	0.53***	0.47***	0.91***	4.84	1.000
	(0.35)	(0.06)	(0.02)	(0.01)		
Post-Volcker	2.44**	1.20***	0.57***	0.95***	4.30	1.000
	(0.89)	(0.26)	(0.08)	(0.00)		

The standard errors are reported in the parentheses. The right-most column right-hand reports the p-value associated with a test of the model's overidentifying restrictions. The set of instruments includes 8 lags (1-6, 9, 12) of the CPI inflation, output gap (HP-filtered industrial production), the effective Federal funds rate (7 lags), the short-long spread, the M2 growth, the EFF and the commodity price inflation.

There are several interesting results to be found in Table 1. First of all, the Hansen J-statistic shows that both models cannot be rejected at any conventional significant level and moreover all of the estimated parameters are highly statistically significant.

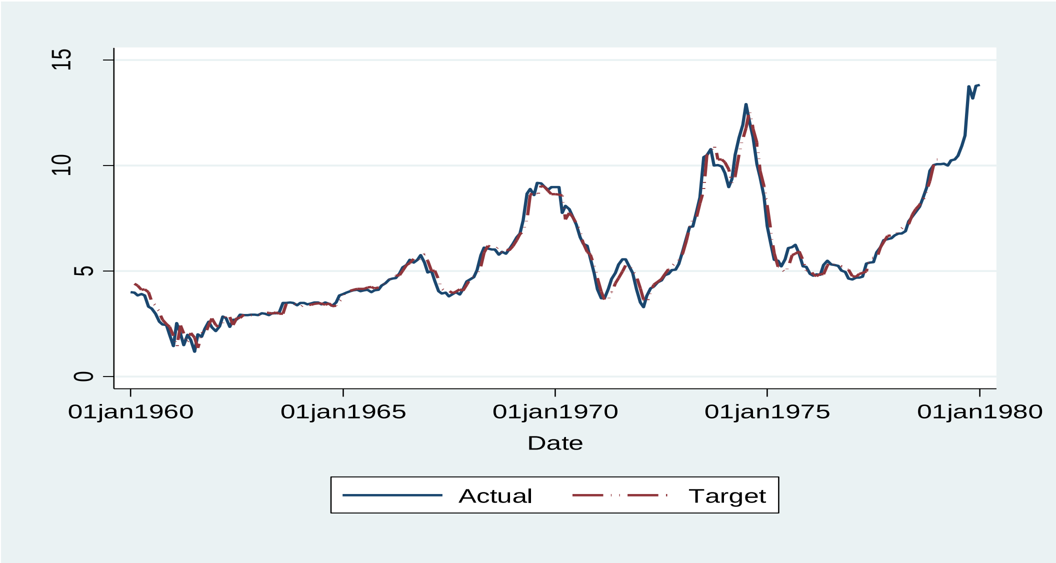
The estimated values for the parameters tell us more or less the story we expect. To begin with, the signs of all the parameters are positive. Moreover, the point estimate of "expected inflation coefficient", β, confirms our above story. In the pre-Volcker period, the point estimate of β is less than one, which according to the Taylor principle implies monetary policy plays a destabilizing role. On the other hand, the point estimate of β in the post-Volcker period, even if not statistically significantly greater than unity, suggests the Fed responded in a stabilizing manner, as a one point increase in expected inflation was accompanied by a greater than one point increase in the target interest rate.

The implied target interest rate also shows expected values – in the pre-Volcker period the model indicates the Fed's target interest rate was 4.84 percent and about half a percentage point less in the post-Volcker period, 4.3 percent[21]. Even if the estimated target interest rate is highly dependent on the sample average of inflation[22] the implied values seem quite plausible.

[21] Such a point estimate may still seems to be over the actual FED's target – however, this may be a consequence of the fact that the estimation period begins with high inflation and therefore for the more relevant estimate of the target inflation longer time-period may be preferable. See also next footnote.
[22] See 15th footnote in Clarida et al. (1998).

Below we can see the actual and fitted (target) values of the policy interest rate in the United States (in further text US).

Graph 3: Target vs. actual policy interest rate in US in the period 1960-80 – monthly data



The stabilizing manner of the Fed's monetary policy is also evident form the estimated value of the parameter γ – in both periods the coefficient, measuring the response to the output gap, is estimated to be over zero, which implies a stabilizing role of monetary policy regarding real economic cycles.

Comparing the above results with those obtained in Clarida et al.'s papers (1998 and 2000), two main differences can be extracted. To begin with, the estimated value of the "expected inflation" coefficient for the pre-Volcker period is in line with those found in Clarida et al.'s (2000) paper[23]. Contrary to this, we can observe a noteworthy difference in the point estimate of the parameter β in the post-Volcker period - their point estimate points to a considerably greater response to expected inflation ($\beta > 2$). The second difference concerns the parameter γ – Clarida et al.'s point estimates of the "output gap" coefficient are somewhat higher and sometimes also statistically insignificant. To summarize, my results suggest that the Fed put a somewhat higher weight on the output gap and therefore real economic activity, as suggested by Clarida et al.'s estimates.

Finally, the value of the smoothing parameter ρ points to high interest rate inertia – less than 10 percent of a change in the target interest rate was reflected in the "real world" effective

[23] I should emphasize that the estimation period in the thesis is not completely the same as in Clarida et al.'s paper and also variable used to capture output gap in my thesis differ from the one used in Clarida et al.'s paper.

funds rate. Therefore, confirming the conventional wisdom, a central bank is shown to have a strong incentive to smooth the adjustment of the policy interest rate.

Table 2: Baseline Germany estimates

Germany	α	β	γ	ρ	π^*	p
Pre-Volcker	1.89***	0.82***	0.43***	0.70***	4.25	1.000
	(0.33)	(0.09)	(0.06)	(0.02)		
Post-Volcker	2.69***	1.30***	0.65***	0.94***	2.12	1.000
	(0.24)	(0.11)	(0.04)	(0.00)		

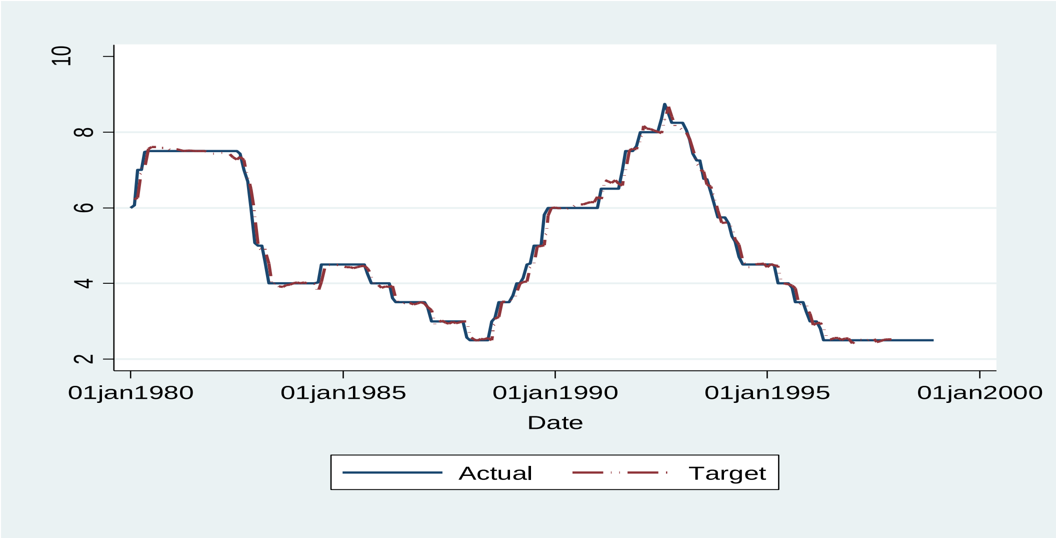
The standard errors are reported in parentheses. The right-most column reports the p-value associated with a test of the model's overidentifying restrictions. The set of instruments includes 8 lags (1-6, 9, 12) of CPI inflation, output gap (HP-filtered industrial production), the Bundesbank's policy rate (7 lags), M2 growth, EER, yearly percentage change in the German Mark/US Dollar exchange rate, short-long spread and the commodity price inflation. Due to lack of data, the short-long spread, ERR and M3 growth is dropped in the Pre-Volcker period.

A similiar story applies to the rate setting by the German Bundesbank. The shift in the conduct of monetary policy is again confirmed by the difference in the point estimate of the β coefficient. The point estimate of the coefficient β below unity suggests the destabilizing role of monetary policy in the pre-Volcker period regarding expected inflation. However, the latter coefficient is higher than that estimated for the Fed it is also not significantly lower than one, suggesting the Bundesbank conducted more rigorous monetary policy regarding expected inflation than the Fed. Moreover, the Bundesbank's response to expected inflation after the 80's appears to be even higher – the point estimate is higher than unity and implies that the German central bank responded to the rise in expected inflation with a rise in the real interest rate.

On the other hand, the response to the output gap is again found to be high. The highly statistically significant coefficient suggest that the Bundesbank, independently of the effect on expected inflation, responded to a one percentage rise in the output gap by almost half a percentage point increase in the target interest rate during the pre-Volcker period and by an average 0.65 percentage point increase in the post-Volcker period.

The estimates suggest that the German central bank had the lower inflation target compared with the Fed's inflation target in both periods. The latter result is in line with the common wisdom that the Germans have a strong preference for low inflation, due to the "painful" experience with hyper-inflation after World War 1. The target inflation rate estimated for the post-Volcker period is remarkably close to the official Bundesbank target of 2 percent. Below we can see the fit of the estimated model.

Graph 4: Target vs. actual policy interest rate in Germany in the period 1980-99 – monthly data



The smoothing parameter indicates higher degree of interest rate inertia in the post-Volcker period.

5.3 Did the Bundesbank really follow monetary targeting?

An interesting question to be answered is what was the perceived monetary policy of the German central bank? In the monetary literature, besides the Swiss central bank, the Bundesbank is usually presented as the most important central bank to have adopted a so-called monetary targeting (see Issing, 1997). The German central bank was the first bank to adopt monetary targeting with explicit targets for money growth in 1974.

Grounding my analysis in the established literature on monetary policy, I will assess whether or not the Bundesbank truly pursued monetary targeting in the "Post-Volcker" period. Namely, I check if money growth was a policy relevant variable to which the Bundesbank systematically responded, independently of its use for the forecasting of the expected inflation. I perform the same exercise for the Fed.

Table 3 presents the results of the alternative specification of the reaction functions in which the expected (one year ahead, n=12) difference between the actual and the target annual percentage change in the monetary base (M3) is included as a policy relevant variable.

To begin with, it is worth noticing that the slope coefficients of the other parameters do not change significantly after the inclusion of the alternative variables in the estimable equation and that the results are basically the same in each of the two specifications.

Table 3: Alternative specification for the Bundesbank's reaction function – money growth

Germany	α	B	γ	ξ	ρ	P
M3 growth	2.91***	1.36***	0.61***	-0.16***	0.94***	1.000
	(0.20)	(0.12)	(0.05)	(0.03)	(0.00)	

The standard errors are reported in parentheses. The right-most column reports the p-value associated with a test of the model's overidentifying restrictions. The set of instruments includes 8 lags (1-6, 9, 12) of CPI inflation, output gap (HP-filtered industrial production), the Bundesbank's policy rate, M2 growth, M3 growth, EER, yearly percentage change in the German Mark/US Dollar exchange rate , short-long spread and the commodity price inflation.

The main result is the point estimate of the coefficient concerning the money growth measure, ξ – contrary to perceived wisdom, the parameter enters the equation with the negative sign[24]. This implies that "most famous" central bank conducting monetary targeting actually responded in exactly the opposite way to what monetary theory predicts. It suggests that the Bundesbank responded with a decrease of the target interest rate when money growth exceeded the target set by the central bank.

Contrastingly to the results obtained by Clarida et al. (1998), who found the statistically insignificant coefficient on money growth, I find that the response to money growth is highly statistically significant, and so far the conclusion about the reason for the negative sign cannot be simply explained as the fact that money growth is not a policy relevant variable. However, as mentioned in paragraph 2.5 above, the statistical significance of the coefficient on money growth may also be seen as evidence that monetary policy is pursuing other objectives besides expected inflation and the output gap. The statistical significance of the coefficient may also indicate that money growth includes information about other objectives that the central bank may be pursuing but are not included in the reaction function.

The findings continue to contradict common assumptions when the significance of the money growth is analysed in relation to Federal Reserve policy. The results in table 4 suggest that the Fed responded aggressively to the yearly percentage change in money growth in the post-Volcker period. Contrary to the results obtained for the Bundesbank, the Fed increased the target interest rate when faced with an increase in the growth of the M2 money aggregate,, in

[24] I also perform calculations (not reported here) where instead of yearly change in the M3 growth, I include the average of the one year before, current and the one year ahead yearly M3 growth. The reasoning behind the latter measure is that central bank may be concerned more about mid-term developments in the money growth and may therefore not respond to short-term movements in the money growth. Nevertheless, the results stay qualitatively the same with the statistically negative point estimate of the coefficient on money growth. Lastly, also when expected inflation is excluded from the specification, the coefficient on the money growth stays negative.

line with established thinking. However, notice that constant in the model with included money growth become insignificant, which may suggest misspecification of the model.

Table 4: Alternative specification for the Fed's reaction function – money growth

USA	α	β	γ	ξ	ρ	p
M2 growth	-0.37	1.23***	0.31***	0.58***	0.88***	1.000
	(0.30)	(0.10)	(0.04)	(0.07)	(0.01)	

The standard errors are reported in the parentheses. The right-most column right-hand reports the p-value associated with a test of the model's overidentifying restrictions. The set of instruments includes 8 lags (1-6, 9, 12) of the CPI inflation, output gap (HP-filtered industrial production), the effective Federal funds rate (7 lags), the short-long spread, the M2 growth, the EFF and the commodity price inflation.

6 THE ECB'S AND THE FED'S ESTIMATION RESULTS

The following section repeats the exercise from the above section, but now in the case of the ECB and Fed's rate setting after the 1999. Firstly, the baseline reaction functions are estimated, followed by the robustness check's results. The end of the section is compromised with the calculation of the alternative specification of the reaction function where I check the importance of some alternative measures to which the central bank may directly react, independent of their predictive power for expected inflation and the output gap.

6.1 Baseline estimates

Firstly, I report the results for the baseline specification. This assumes that the central bank responds only to the HICP/CPI inflation index and to the HP-filtered industrial production index.

The most surprising results in Table 5 is the point estimate of the "expected inflation" coefficient which suggest that monetary policy of the ECB regarding the response to expected inflation was actually "accommodative". Namely, the prospect of a one point increase in expected inflation did not induce the ECB to respond with a more than one point increase in the nominal interest rate. This, according to the Taylor principle, implies that the ECB actually magnified the cyclical behavior of the economy, as such a response implies a decrease instead of an increase in the real interest rate in response to an increase in expected inflation.

Table 5: Baseline ECB and US estimates after 1999

	α	β	γ	ρ	π^*	p
ECB[1]	0.98***	0.79***	0.42***	0.92***	0.57	1.000
	(0.20)	(0.06)	(0.02)	(0.00)		
US[2]	-4.38***	2.47***	0.62***	0.96***	3.63	1.000
	(0.59)	(0.11)	(0.07)	(0.00)		

The standard errors are reported in the parentheses. The right-most column right-hand reports the p-value associated with a test of the model's overidentifying restrictions.

[1]The set of instruments includes 8 lags (1-6, 9, 12) of the HICP inflation, output gap (HP-filtered industrial production), the ECB's policy interest rate (7 lags), the short-long spread, the M3 growth, the EFF and the commodity price inflation.

[2]The set of instruments includes 8 lags (1-6, 9, 12) of the CPI inflation, output gap (HP-filtered industrial production), the Fed's policy interest rate (7 lags), the short-long spread, the M2 growth, the EFF and the commodity price inflation.

On the contrary, the ECB responded to business cycles in the real economy in a stabilizing manner – the point estimate of the "output gap" coefficient, γ, implies that the ECB, independently of expected inflation, responded to a one percentage point increase in the output gap with 0.42 percentage point increase in the nominal interest rate. The reported result for the target interest rate does not seem plausible, as the suggested value of the target inflation rate is considerably lower than the official ECB target of close to but below 2 percent.

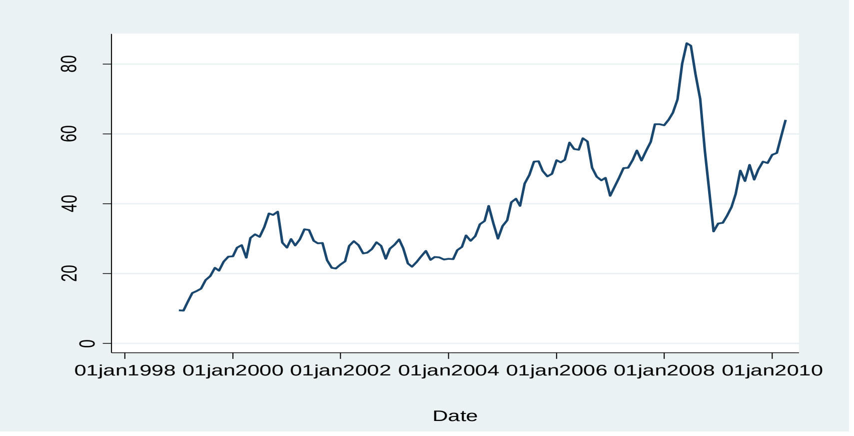
Contrary to the ECB, the Fed seems to have responded aggressively to inflation expectation in the period after 1999. The coefficient β even suggests that the Fed responded to the one percentage point increase in expected inflation by a greater than one percentage point increase in the target real interest rate. The Fed's countercyclical monetary policy is also confirmed by the value of the "output gap" coefficient. Moreover, the estimation returned plausible values for the Fed's inflation target, taking into account that the economy was hit by an oil price shock to which central bank might not have responded. The latter hypothesis is checked in the following sub-section.

6.2 Robustness check - base inflation

Substantial energy price hikes starting in 2007 induced a pronounced divergence between headline (HICP/CPI) and core inflation (HICP/CPI without prices of energy and food) in the subsequent period.

Some of the economic literature suggests that when the economy is hit by an oil price shock, monetary policy should rather focus on core inflation rather than headline inflation (see for example Bodenstein, Erceg and Guerrieri, 2008). As one of the members of the Executive Board of the ECB, Lorenzo Bini Smaghi (2005), pointed out at the time, the response of monetary policy to an oil price shock critically depends on the response of agents. If agents do not accept that an oil shock reduces their disposable income and try to be compensated in terms of higher wages or budgetary support measures, oil price increases might be passed through to higher wages and other prices. The latter, so-called second round effects, would show up in a jump in core inflation to which the central bank should react aggressively in order to counter inflationary pressures. Therefore, in the periods marked by oil price shocks, central banks may be more concerned about the stabilization of core inflation instead of headline inflation.

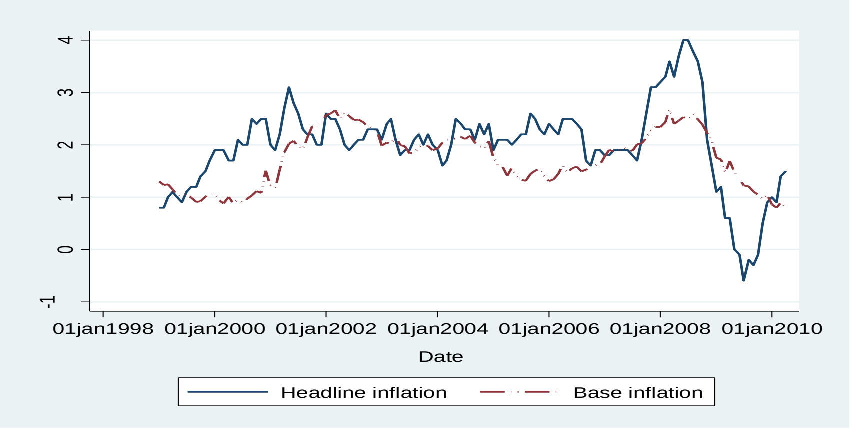
Graph 5: Oil price



Source: Statistical data warehouse, 2009.

The Graph above shows the price hikes of the oil, especially evident around the year 2006 and afterwards around the year 2007.

Graph 6: The divergence between headline and core inflation



Source: Statistical data warehouse, 2009.

The divergence between headline and core inflation is evident from the above graph – the difference is notable after 2004 when core inflation was significantly below the headline rate and then after 2008 when it rose above headline inflation.

Table 6: Robustness check - Base inflation

ECB & Fed	α	β	γ	ρ	π^*	p
Euro area[1]	0.75***	1.09***	0.30***	0.89***	4.25	1.000
	(0.14)	(0.10)	(0.01)	(0.01)		
US[2]	-7.87***	4.85***	0.15*	0.95***	2.28	1.000
	(0.56)	(0.35)	(0.06)	(0.01)		

The standard errors are reported in the parentheses. The right-most column right-hand reports the p-value associated with a test of the model's overidentifying restrictions.
[1]The set of instruments includes 8 lags (1-6, 9, 12) of the HICP base inflation, output gap (HP-filtered industrial production), the ECB's policy interest rate (7 lags), the short-long spread, the M3 growth, the EFF and the commodity price inflation.
[2]The set of instruments includes 8 lags (1-6, 9, 12) of the CPI base inflation, output gap (HP-filtered industrial production), the Fed's policy interest rate (7 lags), the short-long spread, the M2 growth, the EFF and the commodity price inflation.

The preceding theoretical considerations are confirmed by the results in Table 6. The replacement of headline with base inflation raised the point estimates of the β coefficient in both countries/areas. Nevertheless, the ECB's increase in the real interest rate in response to the expected increase in core inflation is still not confirmed by a statistically significant higher point estimate form unity. The most confusing results concern the ECB's target inflation rate. This appears larger than 4 percent and is implausible given the target of close to, but below 2 percent.

6.3 Is the ECB's two-pillar approach grounded in reality?

The central bank's most important asset in maintaining price stability is its credibility. The latter is always a reward for a central bank's commitment to price stability or even more importantly its achievement of price stability. This is often at the expense of a loss in output. The problem then is how to gain credibility when you do not have a history, be that good or bad. That is why the founders of the ECB tried to build the new central bank on the founding characteristics of the German Bundesbank. They hoped that markets would accept the ECB as the successor to the Bundesbank and therefore its credibility would be transmitted to the newly formed ECB. In order to be "credible", the ECB adopted some features which were the cornerstones of the Bundesbank's monetary policy. The most important feature was the special role given to money. The ECB therefore adopted the so-called two-pillar approach[25] . This was meant to be a mix of inflation and monetary targeting. The next exercise is thus dedicated to checking if the two-pillar approach was actually borne out in practice.

Table 7: Robustness check – M3 growth

ECB	α	β	γ	ξ	ρ	p
M3	0.96***	0.36***	0.44***	0.32***	0.94***	1.000
	(0.23)	(0.07)	(0.03)	(0.02)	(0.00)	

The standard errors are reported in parentheses. The right-most column reports the p-value associated with a test of the model's overidentifying restrictions. The set of instruments includes 8 lags (1-6, 9, 12) of CPI inflation, output gap (HP-filtered industrial production), the ECB's policy rate (7 lags), the difference between actual and target M3 growth, EER, short-long spread and the commodity price inflation.

The coefficient ξ measures the response of ECB to the expected difference (one year ahead, n=12) between target (4.5 percent) and actual yearly growth of the monetary aggregate M3 and it has a highly statistically significant positive sign. This is in line with common wisdom and suggests that the ECB truly conducted some kind of mixture between inflation and monetary targeting.

7 DO CENTRAL BANKS CARE ABOUT STOCK PRICES?

Should central banks react to stock price misalignments and try to prevent booms and busts in asset bubbles? Or, is the central bank's only task the stabilization of expected inflation and the possible output gap? The latter questions have received a lot of attention in the latest academic research. The last two decades of macroeconomic stability were marked by low inflation and relative stability in real economic movements, but on the other hand episodes of financial markets distress have provided the backdrop to reconsider these questions in a different light. As always, two "groups" of economists formed: the one with the positive answer to the first question (the most representative paper may be that of Cecchetti et al., 2000) and the other supporting the view expressed in the second question at the beginning of the paragraph (the most representative paper may be that of Bernanke and Gertler, 1999).

The purpose of this section is to offer an empirical investigation of central banks' responses to stock market price developments. The section is structured as follows: to begin with I present the baseline results for the pre-Volcker period using only the measure of the HP-filtered stock price index for the German and the US central bank. The next sub-section presents the results

[25] Interested readers can consult Issing (2006). See also Kahn and Benolkin (2007).

for the post-Volcker period and some robustness check with the alternative measures of the stock price misalignments. Finally, the results for the period from 1999 for the Fed and the ECB are offered.

7.1 The Fed's and the Bundesbank's reaction to stock prices

Let's begin the exploration of the central banks' reaction to stock prices in the pre-Volcker period. Table 8 reports the estimation results of the reaction function in which the most relevant HP-filtered stock price index is included as the policy relevant variable.

The most interesting result concerns the coefficient on the "stock price gap", λ. The statistically significant estimate of the coefficient λ suggests that the Bundesbank, independent of the predictive power of stock returns, responded to stock price misalignments. However, the point estimate is highly counterintuitive as it suggests the German central bank responded to stock price bubbles with a decrease in the target interest rate.

On the other hand, the Fed does not appear to have responded to the stock price misalignments as captured by the "stock price gap" measure before the 80's as the point estimate is statistically insignificant and also quantitatively low.

Table 8: CB's reaction to stock prices in pre-Volcker period

Pre-Volcker	α	β	γ	λ	ρ	p
Germany[1]	3.37***	0.53***	0.61***	-0.08***	0.57***	1.000
	(0.29)	(0.04)	(0.04)	(0.01)	(0.02)	
US[2]	2.38***	1.22***	0.56***	0.00	0.95***	1.000
	(0.79)	(0.21)	(0.06)	(0.02)	(0.00)	

The standard errors are reported in parentheses. The right-most column reports the p-value associated with a test of the model's overidentifying restrictions.
[1]The set of instruments includes 8 lags (1-6, 9, 12) of CPI inflation, output gap (HP-filtered industrial production), the Bundesbank's policy rate (7 lags), HP-filtered DAX30 index, M2 growth, yearly percentage change in the German Mark/US Dollar exchange rate, short-long spread and the commodity price inflation.
[2]The set of instruments includes 8 lags (1-6, 9, 12) of the CPI inflation, output gap (HP-filtered industrial production), the effective Federal funds rate (7 lags), the short-long spread, the M2 growth, the EFF and the commodity price inflation.

Comparing the baseline with the alternative specification of the reaction function estimated above, the estimated parameters do not change significantly. Moreover, the suggested value of the target interest rate (not reported in the table) also does not change noticeably.

The results in Table 9 suggest that the Bundesbank responded to the stock price misalignments in the post-Volcker period as well.

Table 9: Bundesbank's reaction to stock prices in post-Volcker period

Germany	α	β	γ	λ	ρ	p
DAX30[1]	2.66***	1.31***	0.67***	0.05***	0.95***	1.000
	(0.26)	(0.14)	(0.05)	(0.01)	(0.00)	
Country index[2]	2.65***	1.33***	0.67***	0.06***	0.95***	1.000
	(0.27)	(0.14)	(0.05)	(0.01)	(0.00)	
PE[3]	2.79***	1.25***	0.73***	-0.01	0.95***	1.000
	(0.20)	(0.12)	(0.06)	(0.01)	0.00	
PB[4]	3.00***	1.16***	0.76***	-0.01	0.95***	1.000
	(0.24)	(0.13)	(0.06)	(0.00)	0.00	

The standard errors are reported in parentheses. The right-most column reports the p-value associated with a test of the model's overidentifying restrictions. The set of instruments includes 8 lags (1-6, 9, 12) of CPI inflation, output gap (HP-filtered industrial production), the Bundesbank's policy rate (7 lags), M2 growth, M3 growth, EER, yearly percentage change in the German Mark/US Dollar exchange rate, short-long spread and the commodity price inflation.

[1] The HP-filtered DAX30 index.

[2] The HP-filtered country index as calculated by the Datastream is used as policy relevant variable and lags as instruments.

[3] The yearly percentage change in the PE ratio is used as policy relevant variable and lags as instruments.

[4] The yearly percentage change in the PB ratio is used as policy relevant variable and lags as instruments.

However, the estimated coefficient on both measures of the "stock price gap", λ, is positive and highly statistically significant and in contrast with the pre-Volcker period, in line with common wisdom.

On the contrary, the statistically insignificant point estimate of the coefficient λ when yearly percentage change in the PE ratio and PB ratio are included as policy relevant variables suggests the Bundesbank did not respond directly to stock prices. Again, the results concerning the response to expected inflation and output gap do not qualitatively change.

When considering the reaction of the Fed to the stock price movements, the arrival of Paul Volcker and later Alan Greenspan does not seem to change anything. That is to say, the point estimates on the all, except the first one, coefficients measuring the stock price misalignments remain statistically insignificant and with the wrong sign in the post-Volcker period. The only noticeable difference concerns the estimated response to expected inflation, which is lower in the alternative specification compared to the baseline specification.

Table 10: Fed's reaction to stock prices in post-Volcker period

US	α	β	γ	λ	ρ	p
S&P500[1]	3.07***	0.97***	0.61***	-0.06*	0.95***	1.000
	(0.64)	(0.23)	(0.06)	(0.02)	(0.00)	
Country index[2]	3.20***	0.94***	0.61***	-0.04	0.95***	1.000
	(0.61)	(0.21)	(0.07)	(0.02)	(0.00)	
PE[3]	2.68***	1.09***	0.67***	0.02	0.95***	1.000
	(0.74)	(0.21)	(0.07)	(0.01)	(0.00)	
PC[4]	1.68***	1.46***	0.97***	-0.02	0.96***	1.000
	(0.76)	(0.22)	(0.09)	(0.01)	(0.00)	
PB[5]	1.23*	1.52***	1.05***	0.01	0.97***	1.000
	(0.77)	(0.21)	(0.09)	(0.01)	0.00	

The standard errors are reported in the parentheses. The right-most column right-hand reports the p-value associated with a test of the model's overidentifying restrictions. The set of instruments includes 8 lags (1-6, 9, 12) of the CPI inflation, output gap (HP-filtered industrial production), the effective Federal funds rate (7 lags), the short-long spread, the M2 growth, the EFF and the commodity price inflation.

[1] The HP-filtered S&P500 index is used as policy relevant variable and lags as instruments

[2] The HP-filtered country index as calculated by Datastream is used as policy relevant variable and lags as instruments.

[3] The yearly percentage change in the PE ratio is used as policy relevant variable and lags as instruments.

[4] The yearly percentage change in the PC ratio is used as policy relevant variable and lags as instruments.

[5] The yearly percentage change in the PB ratio is used as policy relevant variable and lags as instruments.

7.2 Did the Fed and the ECB react to stock price booms and busts in the new millennium?

The beginning of the new millennium began with, a collapse in stock prices triggered by the burst of the so-called dot-com bubble and the terrorist attacks on the World Trade Center of September 11, 2001. Central banks responded aggressively by cutting interest rates and kept them low after the recovery of stock prices and subsequently the real economy recovered. The story was repeated after the collapse of the sub-prime mortgage bonds markets in the 2007 which has triggered the greatest economic crisis since World War 2.

The period after 1999 was thus marked by large variations in inflation and the output gap, but at the same time by booms and busts in the stock markets. This offers a great opportunity to explore whether or not central banks - independently of the predictive power of stock markets for expected inflation and the output gap - tried to influence stock prices through interest rate setting.

Table 11: Fed's reaction to stock prices after 1999

US	α	β	γ	λ	ρ	p
S&P500[1]	-4.85***	2.61***	0.73***	-0.02	0.97***	1.000
	(0.38)	(0.09)	(0.08)	(0.02)	(0.00)	
Country index[2]	-4.69***	2.56***	0.68***	-0.01	0.97***	1.000
	(0.39)	(0.09)	(0.09)	(0.02)	(0.00)	
PE[3]	-4.28***	2.54***	0.56***	0.05***	0.97***	1.000
	(0.43)	(0.09)	(0.07)	(0.01)	(0.00)	
PC[4]	-2.77***	2.10***	0.33***	0.11***	0.97***	1.000
	(0.53)	(0.09)	(0.08)	(0.02)	(0.00)	
PB[5]	-4.93***	2.74***	0.49***	0.06***	0.97***	1.000
	(0.49)	(0.10)	(0.09)	(0.01)	(0.00)	

The standard errors are reported in the parentheses. The right-most column right-hand reports the p-value associated with a test of the model's overidentifying restrictions. The set of instruments includes 8 lags (1-6, 9, 12) of the CPI inflation, output gap (HP-filtered industrial production), the effective Federal funds rate (7 lags), the short-long spread, the M2 growth, the EFF and the commodity price inflation.

[1] The HP-filtered S&P500 index is used as policy relevant variable and lags as instruments

[2] The HP-filtered country index as calculated by Datastream is used as policy relevant variable and lags as instruments.

[3] The yearly percentage change in the PE ratio is used as policy relevant variable and lags as instruments.

[4] The yearly percentage change in the PC ratio is used as policy relevant variable and lags as instruments.

[5] The yearly percentage change in the PB ratio is used as policy relevant variable and lags as instruments.

The results in Table 11 suggest that the US central bank did not respond to misalignments in the prices of stocks in the S&P index. To be exact, the point estimate of the coefficient on the "stock price gap", λ, is highly statistically insignificant and also negative which is in contrast with the common wisdom about how central banks may react to stock price misalignments. The same conclusions apply when a country specific index is included instead.

On the other hand, measures used in the equity pricing theory, reveal a different story. More specifically, the Fed's response to the yearly percentage change in the PE ratio is shown to be statistically significant and positive. An even stronger conclusion about the Fed's reaction to stock prices can be drawn when a PC ratio is used – the point estimate on the PC ratio, λ, suggests that in response to the yearly fall in the PC ratio by one percentage point, the Fed decreasedt he target interest rate by more than 0,1 percentage point. The response may seem quantitatively small, but knowing the yearly change in PC ratio can take large values, just the opposite is true - for example, after the the dot-com bubble burst, the PC ratio decreased by almost 40 percent from the previous year – this would imply a 4 percentage point reduction in the target interest rate. Qualitatively the same conclusion can be drawn when the PB ratio is used.

We saw that the Fed under Alan Greenspan and Ben Bernanke to some extent responded to stock market movements. What about the ECB's response to stock prices?

Table 12 reports some interesting results. The ECB is shown to have responded also to stock price misalignments as captured by the "stock price gap". The highly statistically significant point estimates of the coefficient on both HP-filtered stock's indexes implies that the ECB responded to the one percentage point increase in the "stock price gap" by a 0.05 percentage point increase in the target interest rate, independently of the predictive power of the stock return for expected inflation and output gap. Knowing the values of the "stock price gap" can take values up to 40 percent (deviation of the current stock price index from its potential level), the response is also quantitatively significant.

Table 12: ECB's reaction to stock prices

ECB	α	β	γ	λ	ρ	p
Euro Stoxx 50	2.08***	0.32***	0.21***	0.05***	0.90***	1.000
	(0.12)	(0.03)	(0.01)	(0.00)	(0.00)	
Country index[2]	1.56***	0.58***	0.18***	0.06***	0.93***	1.000
	(0.17)	(0.05)	(0.02)	(0.00)	(0.00)	
PE[3]	0.07	1.41***	1.38***	0.28***	0.98***	1.000
	(0.67)	(0.22)	(0.06)	(0.02)	(0.00)	
PC[4]	1.88***	0.30***	0.37***	0.07***	0.95***	1.000
	(0.24)	(0.08)	(0.02)	(0.00)	(0.00)	
PB[5]	1.26***	0.80***	0.46***	0.15***	0.97***	1.000
	(0.36)	(0.11)	(0.03)	(0.01)	(0.00)	

The standard errors are reported in parentheses. The right-most column reports the p-value associated with a test of the model's overidentifying restrictions. The set of instruments includes 8 lags (1-6, 9, 12) of HICP base inflation, output gap (HP-filtered industrial production), the ECB's policy rate (7 lags), the difference between actual and target M3 growth, EER, short-long spread and the commodity price inflation.

[1] The HP-filtered Euro Stoxx index is used as policy relevant variable and lags as instruments

[2] The HP-filtered country index as calculated by Datastream is used as policy relevant variable and lags as instruments.

[3] The yearly percentage change in the PE ratio is used as policy relevant variable and lags as instruments.

[4] The yearly percentage change in the PC ratio is used as policy relevant variable and lags as instruments.

[5] The yearly percentage change in the PB ratio is used as policy relevant variable and lags as instruments.

This conclusion is confirmed when I include the measures from pricing theory. The coefficients on the all three ratios are highly statistically significant and positive, which confirms that ECB tried to lean against stock price misalignments.

The interesting result concerns the implied target inflation rate by the ECB. In all the alternative specifications when measures of stock price misalignment are included, the implied target inflation rate (not reported here) is close to, but below 2 percent – exactly the official target published by the ECB.

CONCLUSION

In this thesis I have explored rate setting by the most important US and Europe central banks.

When considering rate setting by the Fed and the Bundesbank, results are in line with the commonly accepted facts. Paul Volcker's arrival at the head of the Fed changed the focus of the central banks in the direction of stabilizing expected inflation. This is reflected in the considerably higher point estimate of the coefficient on the expected inflation in the post-Volcker compared to pre-Volcker period. Nevertheless, compared to the results obtained by Clarida et al., my results offer less support for strict inflation targeting. I found the central banks did not focus exclusively on the expected inflation deviation, but that the variability of the output gap was still an important factor when considering the appropriate level of the interest rate.

After 1999 the Fed seems to have stuck to its policy of aggressively responding to expected inflation and the output gap. Different results are found for the ECB, implying that it has not responded aggressively to expected inflation. This "milder" version of inflation targeting may be the consequence of its two-pillar approach, as estimation revealed that the ECB also focuses on money growth. At the same time, the implied target inflation rate in the ECB's baseline reaction function is implausible, which may suggest that the ECB is also considering other factors when setting the interest rate.

The most interesting results concern the response by central banks to stock price misalignments, independently of the predictive power of stock price movements for expected inflation and the output gap. Counterintuitive results are found only for the German Bundesbank in the pre-Volcker period - results suggest that the Bundesbank actually decreased its target interest rate in response to a "stock price bubble". Somewhat surprisingly there is also evidence of a strong response to the "stock price gap" by the Bundesbank in the post-Volcker period.

On the other hand, till 1999, the Fed seems not to be, independently of its effect on the expected inflation and output gap, concerned with the possible development of bubbles in the stock markets. However, after the 1999, the Fed has started to focus also on stock price misalignments with its monetary policy. Namely, the results suggest that movements in the measures obtained from equity pricing theory, as price to earnings ratio, induced the Fed to change its target interest rate independently of the predictive power the latter measures have about the expected changes in inflation and output gap. The same conclusions are further strengthened in the case of ECB. Similarly to the Fed, the ECB is found to have responded to the "stock price gap". The results, therefore, offer strong evidence that the ECB has tried to affect stock price misalignments in a stabilizing manner.

On the one hand these findings correspond to the criticism by some economists that central banks, especially the Fed, responded too aggressively to the collapse of stock prices following the dotcom bust at the beginning of the millennium. According to leading critics they cut interest rates "too low" and kept them low for "too long". As a consequence, central banks induced further assets price bubbles, especially in the real estate market, ultimately resulting in the greatest economic crisis since World War 2. We can call such an interpretation of the results the "destabilizing" view. The latter interpretation would be appropriate if we assume that central banks react only to stock price crashes and not to stock price booms.

On the other hand, if we assume that the central banks' reaction to stock price misalignments is symmetrical - when there is a boom in the stock markets, central banks will increase interest rates - then they are also act as a stabilizer. Such a "stabilizing" interpretation of the results is more in line with economists who argue that central banks should react to stock price misalignments. As journal The Economist puts it "The evidence is clear that the clean-up costs after debt-financed bubbles are too high. Central banks and governments do have to intervene when credit growth and asset prices start dancing their toxic two-step". Therefore, if we want to draw more exact conclusions about the nature of central banks' response to stock prices, future research should look at the symmetry of the reaction to stock price misalignments.

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POVZETEK V SLOVENŠČINI

UVOD

Leta 1993 je John B. Taylor predlagal enostavno pravilo, ki naj bi odražalo kako in na podlagi katerih dejavnikov centralne banke vodijo monetarno politiko prek najpomembnejšega instrumenta, to je spreminjanja obrestne mere. Najprivlačnejša značilnost pravila je prav njegova enostavnost pa vendar sposobnost, da relativno natančno opiše obnašanje monetarne oblasti. Prav zaradi teh značilnosti je, tako imenovano Taylorjevo pravilo, postalo ključno v akademskih raziskavah o vodenju monetarne politike.

Napredek in nova spoznanja v monetarni teoriji so kljub temu odprla nekatera vprašanja o konsistentnosti Taylorjevega pravila – tovrstno pravilo ni mogoče izpeljati iz maksimizacijskega problema centralne banke, zato pravilo ni teoretično osnovano. Druga in mogoče večja težava pa so bile nekonsistentne ekonometrične tehnike uporabljene v prvih raziskovalnih nalogah, ki so poizkušale empirično oceniti Taylorjevo pravilo.

Nova spoznanja v teoriji monetarne politike in konsistentna ekonometrična metoda za ocenjevanje tako imenovanih reakcijskih funkcij centralnih bank - torej funkcij, ki opisujejo vedenje primarnega instrumenta centralne banke, t.j. določanja obrestne mere, - so bila združena v vplivni znanstveni publikaciji, ki so jo napisali Richard Clarida, Jordi Gali in Mark Gertler v letu 1998. Taylorjevo pravilo, ki vsebuje pretekle vrednosti spremenljivk so tako nadomestili s Taylorjevim pravilom, ki upošteva pričakovane vrednosti spremenljivk. Ocenjevanje tovrstnega pravila pa je izvedeno z metodo posplošenih momentov (angl. *Generalized method of moments*), ki je za razliko od metod prej uporabljenih v tovrstnih študijah, kot je metoda najmanjših kvadratov (angl. *Ordinary least squares*) in vektor avtoregresijska metoda (angl. Vector autoregression method), konsistentna ekonometrična metoda za ocenjevanje reakcijskih funkcij.

V magistrski nalogi se upiram na metodologijo, razvito s strani Claride, Galija in Getlerja, in jo uporabim za raziskavo nekaterih zanimivih a še ne raziskanih vprašanj, ki se tičejo vodenja monetarne politike centralnih bank. Več kot deset let obstoja Evropske centralne banke (v nadaljevanju ECB) kliče k empirični analizi njenega vodenja monetarne politike; Ali je ECB vodila monetarno politiko inflacijskih ciljev in torej agresivno reagira na spremembe v pričakovani inflaciji? So dogajanja v realnem gospodarstvo še vedno pomemben faktor, ko se

ECB odloča o višini obrestne mere. Je nemška centralna banka, Bundesbank, resnično vodila monetarno politiko s cilji glede rasti denarnih agregatov in ali je ECB tovrstno monetarno politiko prevzela? Katere so ključne razlike v vodenju monetarne politike s strani ECB in ameriške centralne banke, Fed? To so ključna vprašanja na katera skušam najti odgovore prek empirične analize.

Ključen del magistrske naloge pa se nanaša na vprašanje ali dogajanje na borzah oziroma spremembe cen vrednostih papirjev (delnic) direktno vplivajo na vodenje monetarne politike. Slednja tema je postala relevantna v času makroekonomske stabilnosti, zaznamovane s nizko inflacijo in relativno nizko variabilnostjo bruto domačega proizvoda. Tema je še pridobila na relevantnosti po izbruhu največje ekonomsko-gospodarske krize po tridesetih letih prejšnjega stoletja v letu 2007. Raziskave, ki so se ukvarjale s slednjo temo, so bila usmerjene predvsem k teoretični podpori oziroma nasprotovanju direktne reakcije monetarne politike na cene vrednostnih papirjev. Moj namen v magistrski nalogi ni prispevati k tej vrsti literature pač pa empirično preveriti ali so že do sedaj centralne banke reagirale na cene vrednostih papirjev.

Prvi del magistrske naloge je namenjen metodološkim razlagam. V drugem poglavju tako predstavim ekonometrični dizajn, razvit s strani Claride in drugih – poglavje se močno zanaša na njihovo raziskovalno nalogo z naslovom *»Monetary Policy Rules in Practice: Some International Evidence«*. V tretjem poglavju sledi predstavitev metode posplošenih momentov, ki jo uporabim za ocenjevanje reakcijskih funkcij – poglavje se močno nanaša na knjigo avtorja Matyas Laszla *"Generalized Method of Moments Estimation"*. Zadnje poglavje v prvem delu magistrske naloge pa je namenjeno predstavitvi najpomembnejših ekonometričnih testov, ki jih raziskovalec uporabi, ko ocenjuje modele z metodo posplošenih momentov.

Drugi del magistrske se začne z opisom podatkov in podatkovnih baz uporabljenih za namen ocenjevanja reakcijskih funkcij. Naslednja poglavje so namenjena predstavitvi rezultatov ocenjevanja reakcijskih funkcij. Naprej so predstavljeni rezultati ocenjevanja reakcijskih funkcij za nemško in ameriško centralno banko do leta 1999. Slednje poglavje služi predvsem za primerjavo mojih rezultatih z dobljenimi rezultati v raziskovalni nalogi, narejeni v strani Claride in drugih. Naslednje poglavje je namenjeno dobljenim empiričnim rezultatom pri raziskovanju reakcijskih funkcij ameriške in evropske centralne banke po letu 1999. V osmem poglavju so predstavljeni rezultati raziskovanja ali centralne banke reagirajo na cene vrednostih papirjev. Sledi zaključek, kjer povzamem in na kratko povzamem dobljene rezultate.

METODOLOGIJA IN REZULTATI

V tem delu povzetka v Slovenščini bom predstavil ključne metodološke stvari in ključne oziroma najzanimivejše rezultate magistrske naloge.

Spodaj je predstavljena že izpeljana enačba, ki jo ocenjujem prek metode posplošenih momentov:

$$r_t = (1-\rho)\alpha + (1-\rho)\beta\pi_{t+n} + (1-p)\,\gamma\,x_t + \rho r_{t-1} + \varepsilon_t \tag{6}$$

Če definiramo $\beta_1 \equiv (1-\rho)\alpha$, $\beta_2 \equiv (1-\rho)\beta$, $\beta_3 \equiv (1-\rho)\gamma$ in $\beta_4 \equiv \rho$, dobimo naslednjo enačbo, ki jo je mogoče oceniti z linearno metodo posplošenih momentov:

$$r_t = \beta_1 + \beta_2\pi_{t+n} + \beta_3\,x_t + \beta_4 r_{t-1} + \varepsilon_t \tag{7}$$

V enačbi r_t predstavlja tarčno obrestno mero centralne banke, π_{t+n} je pričakovana inflacija (v magistrski sem izbral kot horizont eno leto, torej n=12), x_t je tako imenovana »proizvodna vrzel« (v magistrski nalogi dobljena prek aplikacije HP-filtra na časovne serije industrijske proizvodnje za posamezno državo), r_{t-1} pa je odložena tarčna obrestna mera in ε_t neodvisna napaka modela. Vključitev odložene tarčne obrestne mere je posledica dejstva, da centralne banke tarčno obrestno mero prilagajajo postopoma.

Zgornja enačba implicira slednje momente:

$$E[r_t - \beta_1 - \beta_2\pi_{t+n} - \beta_3\,x_t - \beta_4 r_{t-1} |\, \mathbf{u}_t] = 0 \tag{8}$$

Za ocenitev vektorja parametrov $[\beta_1, \beta_2, \beta_3, \beta_4]$ uporabljam metodo posplošenih momentov (ang. Generalized Method of Moments). Kot osnovna specifikacija se razume specifikacija reakcijske funkcije v kateri sta le pričakovana inflacija in proizvodna vrzel spremenljivki na katere centralna banka neposredno reagira. Ob odloženih vrednostih inflacije in proizvodne vrzeli so v vseh specifikacijah reakcijske funkcije kot instrumenti uporabljeni odlogi cen surovin in letna rast denarnih agregatov. Ostali uporabljeni instrumenti so opisani pod vsako posamezno tabelo.

V magistrski nalogi sem se odločil za ocenjevanje reakcijskih funkcij prek treh obdobij. Prva ločnica je prihod Paula Volckerja na čela ameriške centralne banke, ki je pomenil prelom v vodenju monetarne politike. Prvo, pred-Volckerjevo, obdobje se začne v letu 1960 (oziroma 1962 za nemško centralno banko) in konča konec leta 1979. Drugo, post-Volckerjevo, obdobje se začne v letu 1980 in konča konec leta 1998. V slednjih dveh obdobjih ocenjujem reakcijske funkcije Feda in nemške Bundesbanke. Tretje obdobje pa se začne s uradnim pričetkom delovanja ECB, to je v začetku leta 1999. V zadnjem obdobju ocenjujem reakcijske funckije Feda in ECB.

Osnovna specifikacija reakcijske funckije Feda

USA	α	β	γ	ρ	π^*	p
Pre-Volcker	3.19	0.53	0.47	0.91	4.84	1.000
	(0.35)	(0.06)	(0.02)	(0.01)		
Post-Volcker	2.44	1.20	0.57	0.95	4.30	1.000
	(0.89)	(0.26)	(0.08)	(0.00)		

Standardne napake so navedene v oklepajih. P-vrednost v skrajno desnem robu se nanaša na stopnjo značilnosti Hansenovega testa. Set instrumentov vključuje osem odlogov (1-6, 9, 12) CPI inflacije, proizvodne vrzeli, obrestne mere effective Federal funds rate (7 odlogov), razliko med kratko in dolgoročno obrestno mero, rast denarnega agregata M2, efektivni devizni tečaj in rast cen surovin.

V zgornji tabeli so prikazani rezultati ocenjevanja osnovne specifikacije reakcijske funkcije. Rezultati potrjujejo hipotezo, da je bila politika Feda glede pričakovane inflacije bolj agresivna v post-Volckerjevem obdobju. Koeficient β, ki meri odziv centralne banke na pričakovano inflacijo, je namreč v post-Volckerjevem obdobju opazno višji kot v pred-Volckerjevem obdobju.

Na drugi strani je odziv ameriške centralne banke na dogajanje v realnem gospodarstvu med obdobji podobno – v odziv na povečanje »proizvodne vrzeli« za en odstotek, ki je zajet v koeficientu γ, je Fed zvišal obrestno mero za približno pol odstotne točke.

Koeficient postopnega prilagajanja obrestne mere, ρ, kaže, da je ameriška centralna banka v enem mesecu na obrestno mero, ki je definirana kot instrument monetarne politike, prenesla zgolj približno deset odstotkov spremembe v tarčni obrestni meri. Ocenjene vrednosti ciljne inflacije, π^*, so verjetne, čeprav je v post-Volckerjevem obdobju sugerirana vrednost nekoliko visoko, kar pa je najverjetneje posledica višja inflacije v začetku obdobja.

Podobne rezultate dobim tudi pri oceni osnovne specifikacije reakcijske funkcije nemške centralne banke. Razlika med oceno koeficient β med obdobjema potrjuje v ekonomski literaturi znano dejstvo, da so centralne banke v začetku osemdesetih let začele usmerjati svojo pozornost na stabilizacijo pričakovane inflacije. V post-Volckerjevem obdobju je za razliko od ocenjene reakcijske funkcije Feda koeficient β v primeru Bundesbanke statistično višji od cena, kar pomeni, da je nemška centralna banka v odziv na dvig pričakovane inflacije za en odstotek odgovorila z zvišanjem nominalne obrestne mere za več kot odstotno točko – tovrstni odziv, po tako imenovanem Taylorjevem principu, implicira, da je Bundesbanka v odziv na porast pričakovane inflacije zvišala realno obrestno mero in s tem izvajala stabilizacijsko vlogo monetarne politike.

Osnovna specifikacija reakcijske funkcije nemške Bundesbanke

Germany	α	β	γ	ρ	π^*	p
Pre-Volcker	1.89	0.82	0.43	0.70	4.25	1.000
	(0.33)	(0.09)	(0.06)	(0.02)		
Post-Volcker	2.69	1.30	0.65	0.94	2.12	1.000
	(0.24)	(0.11)	(0.04)	(0.00)		

Standardne napake so navedene v oklepajih. P-vrednost v skrajno desnem robu se nanaša na stopnjo značilnosti Hansenovega testa. Set instrumentov vključuje osem odlogov (1-6, 9, 12) CPI inflacije, proizvodne vrzeli, obrestne mere Overnight money (7 odlogov), razliko med kratko in dolgoročno obrestno mero, rast denarnega agregata M2 in M3, efektivni devizni tečaj in rast cen surovin. Zaradi pomanjkanja podatkov v pred-Volckerjevem obdobju, kot instrumenti niso uporabljeni razlika med kratko in dolgoročno obrestno mero, rast denarnega agregata M3 in efektivni devizni tečaj.

Ostali rezultati so kvalitativno enaki tem dobljenim za ameriško centralno banko in tudi ocenjene ciljne vrednosti inflacije so zelo verjetne. V post-Volckerjevem obdobju je ocenjena ciljna vrednost inflacije zelo blizu uradne dvoodstotne ciljne vrednosti inflacije Bundesbanke.

Iz rezultatov v spodnji tabeli lahko ugotovimo, da je ameriška centralna banka tudi po letu 1999 nadaljevala z agresivnim odzivom na pričakovano inflacijo. Drugačni rezultati pa zadevajo vodenje monetarne politike ECB. Ocenjena vrednost koeficienta β je manjša od ena, kar implicira, da ECB na porast pričakovane inflacije ni odgovorila z zvišanjem realne obrestne mere. Rezultati tudi kažejo, da je dogajanje v realnem gospodarstvo še vedno igralo veliko vlogo, ko sta centralni banki razmišljali o ustrezni višini obrestne mere. Ocenjena vrednost ciljne inflacije Feda se zdi v skladu s pričakovanji, medtem, ko je ocenjena vrednost ciljne inflacije ECB nekoliko nižja od uradnega cilja ECB to je inflacija nekoliko pod dvema odstotkoma.

Osnovna specifikacija reakcijske funkcije ECB in Feda po letu 1999

	α	β	γ	ρ	π^*	p
ECB[1]	0.98	0.79	0.42	0.92	0.57	1.000
	(0.20)	(0.06)	(0.02)	(0.00)		
US[2]	-4.38	2.47	0.62	0.96	3.63	1.000
	(0.59)	(0.11)	(0.07)	(0.00)		

Standardne napake so navedene v oklepajih. P-vrednost v skrajno desnem robu se nanaša na stopnjo značilnosti Hansenovega testa.
[1]Set instrumentov vključuje osem odlogov (1-6, 9, 12) HCPI inflacije, proizvodne vrzeli, obrestne mere Eonia (7 odlogov), razliko med kratko in dolgoročno obrestno mero, rast denarnega agregata M3, efektivni devizni tečaj in rast cen surovin.
[2]Set instrumentov vključuje osem odlogov (1-6, 9, 12) CPI inflacije, proizvodne vrzeli, obrestne mere effective Federal funds rate (7 odlogov), razliko med kratko in dolgoročno obrestno mero, rast denarnega agregata M2, efektivni devizni tečaj in rast cen surovin.

Pred letom 1999 se Fed neposredno s svojo monetarno politiko ni odzival na cene vrednostih papirjev oziroma na neravnotežja cen vrednostih papirjev, kot so zajeta z uporabljenimi kazalci (rezultati niso prikazani v povzetku v Slovenščini). Po letu pa se je odziv ameriške centralne banke na cene delnic spremenil. Kot kažejo rezultati v zgornji tabeli je Fed, neodvisno od napovedne moči, ki jo imajo cene delnic na pričakovano inflacijo, neposredno odzval na cene delnic s spremembo ciljne obrestne mere. Bolj specifično, koeficient λ, ki meri odziv centralne banke na različne kazalce iz teorije vrednotenja delnic in ki odražajo morebitne neravnotežne cene na delniških trgih, je statistično značilen in pozitiven. To implicira, da se je Fed na »podcenjene« cene delnic odzval z znižanjem obrestne mere in obratno z zvišanjem obrestne mere, ko so bile cene delnic »precenjene«.

Reakcija Feda na cene delnic po letu 1999

US	α	β	γ	λ	ρ	p
S&P500[1]	-4.85	2.61	0.73	-0.02*	0.97	1.000
	(0.38)	(0.09)	(0.08)	(0.02)	(0.00)	
Country index[2]	-4.69	2.56	0.68	-0.01*	0.97	1.000
	(0.39)	(0.09)	(0.09)	(0.02)	(0.00)	
PE[3]	-4.28	2.54	0.56	0.05	0.97	1.000
	(0.43)	(0.09)	(0.07)	(0.01)	(0.00)	
PC[4]	-2.77	2.10	0.33	0.11	0.97	1.000
	(0.53)	(0.09)	(0.08)	(0.02)	(0.00)	
PB[5]	-4.93	2.74	0.49	0.06	0.97	1.000
	(0.49)	(0.10)	(0.09)	(0.01)	(0.00)	

Standardne napake so navedene v oklepajih. P-vrednost v skrajno desnem robu se nanaša na stopnjo značilnosti Hansenovega testa. Set instrumentov vključuje osem odlogov (1-6, 9, 12) CPI inflacije, proizvodne vrzeli, obrestne mere effective Federal funds rate (7 odlogov), razliko med kratko in dolgoročno obrestno mero, rast denarnega agregata M2, efektivni devizni tečaj in rast cen surovin.

[1] HP-filtriran S&P500 indeks je vključen kot spremenljivka na katero je Fed direktno reagiral (odložene vrednosti so vključene kot instrumenti).

[2] HP-filtriran regionalni indeks je vključen kot spremenljivka na katero je Fed direktno reagiral (odložene vrednosti so vključene kot instrumenti).

[3] Letna sprememba PE kazalca je vključena kot spremenljivka na katero je Fed direktno reagiral (odložene vrednosti so vključene kot instrumenti).

[4] Letna sprememba PC kazalca je vključena kot spremenljivka na katero je Fed direktno reagiral (odložene vrednosti so vključene kot instrumenti).

[5] Letna sprememba PB kazalca je vključena kot spremenljivka na katero je Fed direktno reagiral (odložene vrednosti so vključene kot instrumenti).

*Statistično neznačilno

Iz spodnje tabele je razvidno, da se je tudi ECB s svojim ključnim instrumentom denarne politike neposredno odzival na cene delnic. Za razliko od ameriške centralne banke pa se je ECB odzival neposredno tudi na mero, ki sem jo sam skonstruiral, tako imenovano »vrzel cene delnic«.

Reakcija ECB na cene delnic

ECB	α	β	γ	λ	ρ	p
Euro Stoxx 50[1]	2.08	0.32	0.21	0.05	0.90	1.000
	(0.12)	(0.03)	(0.01)	(0.00)	(0.00)	
Country index[2]	1.56	0.58	0.18	0.06	0.93	1.000
	(0.17)	(0.05)	(0.02)	(0.00)	(0.00)	
PE[3]	0.07*	1.41	1.38	0.28	0.98	1.000
	(0.67)	(0.22)	(0.06)	(0.02)	(0.00)	
PC[4]	1.88	0.30	0.37	0.07	0.95	1.000
	(0.24)	(0.08)	(0.02)	(0.00)	(0.00)	
PB[5]	1.26	0.80	0.46	0.15	0.97	1.000
	(0.36)	(0.11)	(0.03)	(0.01)	(0.00)	

Standardne napake so navedene v oklepajih. P-vrednost v skrajno desnem robu se nanaša na stopnjo značilnosti Hansenovega testa. Set instrumentov vključuje osem odlogov (1-6, 9, 12) CPI inflacije, proizvodne vrzeli, obrestne mere Eonia (7 odlogov), razliko med kratko in dolgoročno obrestno mero, rast denarnega agregata M3, efektivni devizni tečaj in rast cen surovin.

[1] HP-filtriran Euro Stoxx 50 indeks je vključen kot spremenljivka na katero je ECB direktno reagiral (odložene vrednosti so vključene kot instrumenti).

[2] HP-filtriran regionalni indeks je vključen kot spremenljivka na katero je ECB direktno reagiral (odložene vrednosti so vključene kot instrumenti).

[3] Letna sprememba PE kazalca je vključena kot spremenljivka na katero je ECB direktno reagiral (odložene vrednosti so vključene kot instrumenti).

[4] Letna sprememba PC kazalca je vključena kot spremenljivka na katero je ECB direktno reagiral (odložene vrednosti so vključene kot instrumenti).

[5] Letna sprememba PB kazalca je vključena kot spremenljivka na katero je ECB direktno reagiral (odložene vrednosti so vključene kot instrumenti).

*Statistično neznačilno

ZAKLJUČEK

Rezultati empiričnega raziskovanja reakcijskih krivulj ameriške in nemške centralne banke v pred-Volckerjevem in post-Volckerjevem obdobju so v skladu s pričakovanji. Prihod Paula Volckerja na čelo ameriške centralne banke Fed je spremenil fokus ameriške centrale banke veliko bolj v smeri stabilizacije pričakovane inflacije. Slednja sprememba v monetarni politiki so odraža v opazno višjem koeficientu, ki meri odziv centralne banke na spremembo pričakovane inflacije. Temu vzgledu so sledile tudi ostale pomembnejše centralne banke po svetu, kar dokazujejo tudi rezultati, dobljeni za nemško centralno banko – odziv Bundesbanke na pričakovano inflacijo je v post-Volckerjevem obdobju opazno višji kot v pred-Volckerjevem obdobju. Kljub vsemu v primerjavi z znanstvenim delom, napisanim s strani Claride in drugih (1998), moji rezultati ponujajo nekoliko manj podpore za tako imenovano monetarno politiko striktnega ciljanja pričakovane inflacije. Ocenjeni koeficienti, ki merijo odziv centralne banke na dogajanje v realnem gospodarstvu, so opazno višji kot ti, ocenjeni s strani Claride in drugih. Moji rezultati torej namigujejo, da so centralne banke ob stabilizaciji pričakovane inflacije še vedno veliko pozornosti namenjale tudi dogajanju v realnem gospodarstvu.

Glede na rezultate se je Fed tudi po letu 1999 držal svoje politike agresivne reakcije na spremembe v pričakovani inflaciji in dogajanju v realnem gospodarstvu. Nekoliko drugačni rezultati pa so najdeni za monetarno politiko Evropske centralne banke (ECB). Rezultati kažejo, da odziv ECB na spremembo pričakovane inflacije ni bil tako agresiven. Ob tem rezultati razkrijejo, da je nekoliko milejši odziv ECB na pričakovano inflacijo najbrž posledica svojevrstnega pristopa ECB pri monetarni politiki – ECB je ena redkih centralnih bank, ki še vedno poudarja pomen rasti monetarnih agregatov. Rezultati tako kažejo, da se ECB neodvisno od napovedne moči, ki jo ima rast monetarnih agregatov za pričakovano inflacijo, odziva na rast monetarnih agregatov. Ob tem ocenjena ciljna vrednost inflacije v osnovni specifikaciji reakcijske funkcije ni najbolj verjetna, kar nakazuje, da ECB pri razmišljanju o spremembi obrestne mere vodijo tudi drugi faktorji in ne le pričakovana inflacija ter dogajanje v realnem gospodarstvu.

Najbolj zanimivi rezultati v magistrski nalogi se tičejo odziva centralnih bank na gibanje cen oziroma na neravnotežja na trgu lastniških vrednostnih papirjev. Rezultati v nasprotju z intuicijo so najdeni zgolj za primer nemške centralne banke v pred-Volckerjevem obdobju. Ti namreč sugerirajo, da je Bundesbank v odziv na rast cen delnic oziroma bolje rečeno na pozitiven balon na delniških trgih reagirala z znižanjem svoje tarčne obrestne mere, kar je v nasprotju z intuicijo. Nekoliko presenetljiv je tudi močan odziv Bundesbanke v post-Volckerjevem obdobju, ki pa je v skladu z ekonomsko intuicijo.

Na drugi strani rezultati kažejo, da se Fed s svojo monetarno politiko ni neposredno odzival na neravnotežja na delniških trgih. Vendar pa se je to spremenilo po letu 1999 – v tem obdobju se je Fed namreč pričel neposredno odzivati na neravnotežja na delniških trgih, zajeta v merah, pridobljenih iz teorije vrednotenja podjetij. Enaki zaključki so še okrepljeni v primeru ECB, saj se je ta odzivala tudi na »vrzel cene delnic«, ki odraža neravnotežje na delniškem trgu.

Najdeni rezultati na eni strani v veliki meri sovpadajo s kritikami monetarne politike glavnih centralnih bank s strani nekaterih ekonomistov. Ti namreč trdijo, da so centralne banke, še posebej ameriški Fed, preveč agresivno odgovorile na pok tako imenovanega dotcom balona na delniških trgih v začetku novega tisočletja. Bolj podrobno, kritiki trdijo, da so centralne banke obrestne mere spustile »prenizko« in jih na nizkih nivojih držale »predolgo« časa. S tem so centralne banke povzročile ostale premoženjske mehurčke, še posebno izrazitega na nepremičninskem trgu, kar je med drugim vodilo k največji krizi po drugi svetovni vojni, ki je izbruhnila v letu 2007. Tovrstno interpretacijo rezultatov imenujemo »destabilizativni« pogled.

Nasprotno pa v primeru, ko je bila reakcija centralnih bank na cene delnic simetrična – centralne banke so enako reagirale tako na »precenjene« kot na »podcenjene« cene delnic – ocenjeni koeficienti implicirajo monetarno politiko, usmerjeno na stabilizacijo cen delnic. V tem pogledu lahko rezultate razumemo kot potrditev, da so centralne banke v zadnjih letih poizkušale stabilizirati neravnotežja na delniških trgih. »Dokazi so jasni, da so stroški po zlomu precenjenih cen delnic zelo visoki. Centralne banke in vlade po svetu bi zato morale reagirati, ko previsoka posojilna aktivnost in previsoka rast cen delnic pričneta plesati »strupeni ples,« je med drugimi zagovorniki reakcije centralnih bank na cene delnic zapisal The Economist. Tovrstno interpretacijo rezultatov lahko imenujemo »stabilizativni« pogled.

Za trdnejše zaključke o naravi reakcije centralnih bank na cene delnic je zato v prihodnosti potrebno dodatno raziskati simetričnost odziva – v primeru, ko se centralne banke odzivajo zgolj na zlome cen delnic, lahko pritrdimo prvi interpretaciji, v primeru simetričnega odziva pa drugi.